

Integrated Manufacturing CLUSTER HISAR

**Design & Construction of Roads & Services/Utilities for
Integrated Manufacturing Cluster (IMC) at Hisar in Haryana
under Amritsar Kolkata Industrial Corridor (AKIC) Project on
Engineering, Procurement and Construction (EPC) basis**



VOLUME-II
SCOPE OF WORKS & TECHNICAL SPECIFICATIONS
(PART A)

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SCHEDULE A. SITE OF THE PROJECT

A.1. SITE

Urbanisation is creating tremendous pressures on the environment, the world's economies, and our social organisations. New urban patterns are emerging for the 21st century based on a strategy of sustainable, smart growth. These new global cities are economic regions that are interconnected on a world scale and follow the principles of sustainable development. Smart growth principles, good growth, or sustainable development with the goal - to preserve and enhance the quality of life for the citizens of a given region. INDUSTRIAL MANUFACTURING CLUSTER at Hisar in Haryana is one such proposed city to be developed on the principles of sustainable development.

Government of India (GoI) has taken up an ambitious initiative to develop several Industrial Corridors across the country as a part of National Industrial Corridor Development programme which aims at development of industrial cities thereby creating employment opportunities and economic growth leading to overall socio-economic development of India. The Amritsar Kolkata Industrial Corridor (AKIC) is one among the eleven corridors being developed by the GoI. AKIC is conceptualized along the high capacity, high-speed Eastern Dedicated Freight Corridor (EDFC) as the backbone and runs parallel to the Golden Quadrilateral.

Integrated Manufacturing Cluster (IMC) at Hisar is one of the seven Industrial Nodes under the AKIC. The development of AKIC is expected to leverage – (a) the EDFC, (b) the existing National Highway system and (c) National Waterway-1, connecting Allahabad with Haldia.

The Government of Haryana has envisaged development of an Integrated Aviation Hub (IAH) along with an international airport at Hisar. Development of the airport is expected to connect cities or towns such as Hisar, Bhiwani, Jind, Sirsa, Charkhi Dadri etc. to the national as well as global aviation network. This is also likely to boost industrialization, multi-modal-connectivity, and real estate development in the region as it would integrate various facilities in the hinterland to the national as well as global value chains. The proposed airport may also help in decongestion of Indira Gandhi International (IGI) Airport in Delhi, which is soon expected to reach its capacity. In December 2017, Department of Civil Aviation, Government of Haryana signed an MoU with the Airports Authority of India (AAI) for development of Integrated Aviation Hub (IAH) at Hisar. IMC Hisar has been conceived as a development built around and driven by the Hisar IAH.

The total area available for the development of Integrated Aviation Hub is 7,200 acre. Out of the total land area, Government of Haryana is currently in possession of approximately 4,200 acre of land; further land acquisition is to be considered at a later stage.

Further, these 2,988 acres will be developed in 2 phases: 1,573.9 acre as Phase I and 1,412 acre as Phase II. For the development of phase I (1,575.9 detail master planning has been carried out including trunk infrastructure planning, preliminary engineering & design and cost estimation and for Phase II preliminary concept plan has been developed. Initially, Phase I development is to be undertaken and Phase II will be developed subsequently. Phase II concept will be reassessed and detailed out before undertaking its development in future. However, project financial analysis has been carried out including both development phases with suitable revenue and cost assumptions.

A.2. LAND

The proposed site for IMC Hisar is at the junction of NH-52 (Sangrur, Punjab to Ankola, Karnataka) and NH-09 (Malout, Punjab to Pithoragarh, Uttarakhand). It is 170 km from Delhi, 104 km from Rohtak and lies in the north of Hisar city. There are 3 entries to the IMC Site. One entry along NH-09 is closest to Hisar railway Junction (4.3 km), Hisar bus terminal (2.8 km) and City centre & main market area of Hisar (4 km). The site lies adjacent to the proposed Integrated Aviation Hub Hisar (IAH). Under the NCR Proposed Transport Plan, Delhi-Hisar Regional Rapid Transit System (RRTS); a high-speed rail link is also planned. Major Class I Towns around IAH and IMC Hisar are Rohtak, Bhiwani, Kaithal and Jind; all located within 100 km radius from the site. Sonipat, Panipat and Karnal are within 150 km radius.



Figure A-1 Site Boundary

SCHEDULE B. SCOPE OF WORKS

B.1. DEVELOPMENT OF THE PROJECT (DESIGN CRITERIA, WORKS REQUIREMENT AND PERFORMANCE CRITERIA)

“Infrastructure works for Integrated Manufacturing Cluster at Hisar, Haryana” Development of the Project shall include design and construction of the Infrastructure Works as described in this Schedule-B and in Schedule-C.

B.2. CHANGE OF SCOPE

The work specified hereinabove shall be treated as an approximate assessment. The actual works as required on the basis of detailed topographical survey, Geotechnical investigation and design shall be determined by the Contractor in accordance with the Specifications and Standards. Any variations in the works specified in this Schedule-B shall not constitute a Change of Scope, save and except any variations in the works arising out of a Change of Scope expressly undertaken in accordance with the **provisions of this contract**.

B.3. ROAD

B.3.1. DESIGN AND CONSTRUCTION OF ROADS

The Design and Construction of Roads shall be in accordance with Schedule-B. Notwithstanding anything to the contrary contained in the Schedules, the Finished Road Level (FRL) shall be designed based on area drainage requirement, coordinate with nearby existing NH roads, airside crash gate entry access road, utility plant area internal roads, canal crossings and surrounding area ultimate phase - grading and development FGL levels, FGL @ minor bridge/culvert section shall be coordinate with nearby existing NH/railway culvert HFL levels to avoid water backflow/surcharging into adjoining low lying areas.

B.3.2. ROAD CLASSIFICATION

As per the proposed master plan roads are grouped into 18m, 24m, 32m, 36m and 45m row roads. Classification of Roads by RoW is given below in Table:

Table B-1: Classification of Roads

Sl. No	Type of road	ROW (m)	Carriageway configuration
1	Arterial Road	45	4 lane divided Carriageway

2	Sub Arterial Road	36	4 lane divided Carriageway
3	Sub Arterial Road	32	2 lane Carriageway
4	Collector Road	24	2 lane Carriageway
5	Collector Road	18	2 lane Carriageway

Road Break-up details as per master plan is shown below in the table,

Table B-2: Typical Cross Sections

SI. NO	ROAD NAME	LENGTH (m)	ROW (m)
1	18m-01	420	18
2	18m-02	320	18
3	18m-03	390	18
4	18m-04	320	18
5	18m-05	340	18
6	18m-06	880	18
7	18m-07	880	18
8	18m-08	830	18
9	18m-09	190	18
10	18m-10	460	18
11	18m-11	630	18
12	18m-12	200	18
13	24m-01	1080	24
14	24m-02	620	24
15	24m-03	590	24
16	24m-04	4280	24
17	24m-05	760	24
18	24m-06	1060	24
19	24m-07	520	24
20	24m-08	1100	24
21	24m-09	900	24
22	24m-10	460	24
23	24m-11	720	24
24	32m-01	210	32
25	36m-01	1870	36
26	36m-02	1850	36
27	36m-03	170	36
28	36m-04	2360	36
29	36m-05	600	36
30	36m-06	663	36
31	45m-01	1610	45

SI. NO	ROAD NAME	LENGTH (m)	ROW (m)
32	45m-02	730	45
33	45m-03	1030	45
34	45m-04	877	45
35	45m-05	190	45
36	45m-06	1344	45
Total Length in m		31454	
Total Length in km		31.45	

Note:

- The actual length of roads may vary as per detailed engineering design.
- Service roads shall be terminated before the bridges and junctions as per the standards, the tapers shall be provided as per the design standards.

B.3.3. GEOMETRIC DESIGN AND OTHER FEATURES

B.3.3.1. GENERAL

Geometric design and other features of the Project Roads shall be in accordance with the Standards and Specifications as per Schedule D.

B.3.3.2. DESIGN SPEED

The Design Speeds for different category of roads are given below in Table B-3

Table B-3: Design Speed

Sl. No	Type of road	ROW (m)	DESIGN SPEED
1	Arterial Road	45	60
2	Sub Arterial Road	36	60
3	Sub Arterial Road	32	60
4	Collector Road	24	40
5	Collector Road	18	40

Note: To contain roadway elements within ROW the speed may be reduced at curve and approach to junctions

B.3.4. JUNCTIONS (AT GRADE)

The road intersections / junctions are the most challenging aspect of the street design in an urban environment. Junctions are a focal point of activity & decision, and a critical part of the city streetscape & transportation network. The function of a designed intersection is to control conflicting and merging streams of traffic, to minimize the delay including pedestrian and bicycle traffic. Following junctions has been identified and shall be considered for design as per IRC-SP-41, IRC-65-2017 and other relevant codes.

Junction details are given below in Table B-4

Table B-4: Major Junctions

S. No.	Junction No.	Intersecting Roads	Type
1	3J - 01	24M- 04 & 36M-01	3
2	3J - 02	24M- 04 & 18M-01	3
3	3J - 03	24M- 04 & 24M-01	3
4	3J -04	24M- 01 & 18M-02	3
5	3J -05	18M-02 & 18M-03	3
6	3J -06	18M-02 & 36M-02	3
7	3J - 07	24M- 04 & 24M-02	3
8	3J - 08	24M- 04 & 24M-11	3
9	3J -09	18M-03 & 36M-05	3
10	3J – 10	18M-01 & 36M-05	3
11	3J – 11	36M-01 & 24M-04	3
12	3J - 12	24M- 01 & 45M-01	3
13	3J - 13	24M- 02 & 45M-01 & 24M-04	3
14	3J - 14	36M-01 & 36M-02	3
15	3J - 15	24M- 06 & 45M-02 & 45M-03	3
16	3J - 16	24M- 05 & 45M-03	3
17	3J - 17	45M-03 & 45M-04	3
18	3J - 18	45M-03 & 24M- 02	3
19	3J - 19	18M-06 & 18M-07	3
20	3J - 20	18M-07 & 18M-08	3
21	3J - 21	18M-12 & 18M-06	3
22	3J - 22	45M-04 & 45M-05 & 24M- 06	3
23	3J - 23	24M- 07 & 18M-04	3
24	3J - 24	24M- 07 & 18M-05	3
25	3J - 25	24M- 02 & 24M-05	3
26	3J - 26	36M-03 & 32M-01	3
27	3J - 27	45M-05 & 24M-08	3

S. No.	Junction No.	Intersecting Roads	Type
28	3J - 28	45M-05 & 36M-04	3
29	3J - 29	36M-04 & 24M-09	3
30	3J - 30	18M-10 & 18M-9	3
31	3J - 31	24M-10 & 24M-09	3
32	3J - 32	45M- 04 & 24M- 07	3
33	4J - 01	24M- 04 & 36M-02	4
34	4J - 02	24M- 02 & 24M-03 & 24M-11	4
35	4J - 03	24M- 11 & 36M- 05 & 36M-02	4
36	4J - 04	24M-01 & 36M-05	4
37	4J - 05	36M-01 & 45M-01	4
38	4J - 06	36M-02 & 45M-01	4
39	4J -07	24M- 03 & 45M-01& 45M-02	4
40	4J - 08	18M-08 & 18M-12& 36M-03	4
41	4J - 09	36M- 03 & 18M-07	4
42	4J - 10	24M- 06 & 18M-04 & 18M-05	4
43	4J - 11	36M-03 & 45M-05	4
44	4J - 12	36M-03 & 24M-08	4
45	4J - 13	18M-9 & 36M-04& 36M-03	4
46	4J - 14	24M-09 & 18M-10 & 24M-09	4

B.3.5. EMBANKMENT & PAVEMENT DESIGN

Construction of embankment and pavement shall conform to the Standards and Specifications as per Schedule D.

B.3.5.1. PAVEMENT DESIGN

Pavement design shall be carried out as per schedule D.

B.3.5.2. TYPE OF PAVEMENT

The pavement type for different roads and cross sections shall be as given below in Table:

Table B-5 Type of Pavement

Main Carriageway	Parking Lane/ Service Roads	Cycle Track	Pedestrian Pathway
Flexible	Flexible	paver block	Interlocking Cement Concrete paver blocks

B.3.6. DESIGN REQUIREMENTS

B.3.6.1. DESIGN PERIOD

Flexible pavement has been designed for period of 20 years.

B.3.6.2. DESIGN TRAFFIC

Notwithstanding anything to the contrary contained in the Schedules, the Contractor shall design the pavement for minimum MSA as given below in Table

Table B-6 Design Traffic

Sl. No.	Design Parameter	Values Considered for various ROW Roads		
		18m, 24m & 32m	36 m	45 m
1	Traffic Considered in CVPD	228	447	447
2	Effective CBR	8	8	8
3	Design life in Years	20 years		
4	Construction Period in Years	2	2	2
5	Vehicle Damage Factor (VDF)	3.9	3.9	3.9
6	Lane Distribution Factor	0.5	0.75	0.75
7	Design Traffic in MSA	17	40	40

Flexible pavement has been designed as per the elastic multilayer structure for effective subgrade CBR of 8 percent based on the designed traffic.

Table B-7 Adopted Pavement Crust for Flexible Pavements

S. No	Row	Effective Subgrade CBR (%)	Pavement Thickness					Road Coding
			BC	DBM	WMM	GSB	Subgrade	
1	45	8	40	105	250	200	500	45m-01, 45m-02, 45m-03, 45m-04, 45m-05
2	36	8	40	105	250	200	500	36m-01, 36m-02, 36m-03, 36m-04, 36m-05, 36m-06

S. No	Row	Effective Subgrade CBR (%)	Pavement Thickness					Road Coding
			BC	DBM	WMM	GSB	Subgrade	
3	32	8	40	60	250	200	500	32-01
3	24	8	40	60	250	200	500	24m-01, 24m-02, 24m-03, 24m-04, 24m-05, 24m-06, 24m-07, 24m-08, 24m-09, 24m-10, 24m-11
4	18	8	40	60	250	200	500	18m-01, 18m-02, 18m-03, 18m-04, 18m-05, 18m-06, 18m-07, 18m-08, 18m-09, 18m-10, 18m-11, 18m-12

Cycle Track Pavement

For cycle track finishing M-30 grade interlocking concrete paver block has been proposed considering the facts that, in future there shall be the maintenance of utilities and connections to the plots. Cycle track is combined with the footpath and same shall be distinguished with different color of paver blocks.

Cycle tracks are taken into account. Assumed subgrade material has an 8% CBR. Layer composition is shown below in Table:

Table B-8 Cycle Track Pavement

Pavement Layer	Thickness (mm)
M-30 Paver Block	60
Sand blanket	50
Granular Sub-Base (GSB)	200

Pedestrian Pathway Pavement

Pedestrian pathway Pavement shall be Interlocking M-30 Paver Blocks as per the guidelines given in IRC: SP: 63-2018. The proposed composition is as given in Table below:

Table B-9 Pedestrian Pathway Pavement

Pavement Layer	Thickness (mm)
M-30 Paver Block	60
Sand blanket	50
Granular Sub-Base (GSB)	200

Note: At locations where vehicles cross the footpath and cycle tracks (such as property entry/exit points, parking areas, etc.,) 80 mm thick M-40 grade interlocking cement concrete paver blocks shall be provided with suitable base layers in accordance with IRC:SP:63-2018.

PARKING LANES

- a. For Arterial and Sub-Arterial Roads as per IRC 86-2018, No parking on main carriageway is allowed. Service lanes can be used for parking and may be provided on any one or both sides of the carriageway as per available space. As arterial roads also serve the flow function, it is desirable that parking be limited to dedicated service lanes. Though some conditions may require provision of on street service / emergency parking as well parking for paratransit modes, which may be located between carriageway and bicycle track on each side. This provision should not be continuous for distances longer than 40m.
- b. As per IRC, parking lane width for parallel parking should be 3m, which may be reduced to 2.5 m where available space is limited. If sufficient carriageway is available, angle parking may be adopted if required.

In the project roads, paved shoulders are used for safe transit of two wheelers and vehicle lay bye in case of emergency for 45 and 36 ROW Roads.

B.3.6.3. BUS BAYS

- Bus bays provided is as per IRC 70- 2017 ("Guideline on Regulation and Control of Mixed Traffic in Urban Areas")
- Bus bays are provided at such locations which will not hamper the traffic flow at the intersections/ junctions near it.

Bus-Bays are proposed in 36m and 45m Row Roads.

- Bus bays should not be located too close to intersections. It is desirable that they are located 75 m from the intersection.

- Bus bays should be provided by recessing the kerb for a length of 15m for single bus stop. The taper should be 1:8 but not less than 1:6. The depth of the recess should be 4.5m for single bus stop and 7 m for multiple bus stops.

Bus Bays location in the plan is as below.

Table B-10 Bus Bays location

Road Code	Left	Right	Chainage
24m-02		✓	3+310
24m-04		✓	0+120
24m-04		✓	0+850
24m-04		✓	2+310
24m-08		✓	0+690
24m-09		✓	0+280
36m-03	✓		1+580
36m-03		✓	1+520
36m-03	✓		0+240
36m-03		✓	0+320
36m-05		✓	0+510
36m-05	✓		0+460
45m-01	✓		0+300
45m-01		✓	0+240
45m-01		✓	1+450
45m-01	✓		1+390
45m-02	✓		0+530
45m-02		✓	0+590

Road Code	Left	Right	Chainage
45m-03	✓		0+450
45m-03		✓	0+390
45m-05	✓		0+320
45m-05		✓	0+270
45m-05	✓		1+370
45m-05		✓	1+320

Typical Cross Section Drawings

Cross sectional elements

Cross-section features such as classification on road, design speed, and the traffic volume. Other considerations are requirements of parking lanes, bus-bays, occurrence of access points, movement of pedestrians and cyclists, water pipelines, width of drains, electricity cables and other public utility services.

Typical cross section drawings are part of tender drawing Volume III.

Sl. no	ROW road s(m)	Carriage way (m)	Shyness on both side (m)		Shoulder on both side (m)		Median (m)	Landscape corridor on both (m)		Green area both side (m)		Footpath on both side (m)		Cycle tack on both side (m)		Total width (m)
			LHS	RHS	LHS	RHS		LHS	RHS	LHS	RHS	LHS	RHS	LHS	RHS	
1	18	7	0.25	0.25	-	-	-	1.45	1.45	0	0	1.8	1.8	2	2	18
2	24	7	0.25	0.25	-	-	-	3.75	3.75	0.7	0.7	1.8	1.8	2	2	24
3	32	7	0.25	0.25	1.5	1.5	-	6.25	10.75	0.7	-	1.8	0	2	0	32
4	36	14	0.5	0.5	1.5	1.5	2.00	3.45	3.45	0.7 5	0.7 5	1.8	1.8	2	2	36
5	45	14	0.5	0.5	1.5	1.5	10	3.825	3.825	0.7 5	0.7 5	1.925	1.925	2	2	45

Cross - Fall

- 2.5% cross fall is proposed Bituminous surfaces is considered.
- 1.0% cross fall is proposed for Footpath and Cycle track

B.4. CIVIL WORKS

Standard Basic Specifications

The “Standard Specifications (civil works)” issued by the CPWD, set out the specification that shall be followed for construction of General Works under the National Industrial Corridor Development Corporation. Particular Technical Specifications for the works to be tendered are as set out in these Schedules.

In the event of any discrepancy between the provisions of the Standard Basic Specifications and the Particular Technical Specifications, the provisions of the Particular Technical Specifications will prevail.

Design Submissions

Contractor shall submit design basis report, design calculations, general arrangement drawings, reinforcement detail drawings and explanatory sketches, to the Engineer. Separate design calculations for foundations or superstructures submitted independent of each other shall be deemed to be incomplete and will not be accepted by the Engineer.

Submissions of detailed design calculations and Good for Construction drawings shall include the following as a minimum:

A. Detailed Design Calculations

1. One (1) Copy of a Compact Disc (CD) containing electronic files relevant to the structure's modelling, analysis and design calculations (Microsoft Excel, STAAD Pro, etc.). Files submitted shall be in editable format.
2. Print copy (6 Copies) of the contents as submitted in the Compact Disc.

B. Good for Construction Drawings

1. One (1) Copy of a Compact Disc (CD) containing AutoCAD files (Civil General Arrangement, Structural Dimensions and Reinforcement Details) pertaining to the structure. Files submitted shall be in editable format.
2. Print copy (6 Copies) of the contents as submitted in the Compact Disc. Prints to be submitted on A1 Size Sheet as a minimum or A0 Size Sheet when required by the employer.
3. Bar-bending schedule indicating the number, shape and size of the rebars shall be submitted as part of the Reinforcement Details

4. Detailed drawing showing the location, number and depth of inserts shall be included for any structural steel inserts/Metal inserts in the structure such as rungs, bolted connections for ladders/railings, etc.
5. Location of Construction Joints and pour sequence shall be included on the drawing for base slabs, walls and top slabs.

Revised drawings shall be submitted by clouding at the location with the latest revision number and also show the history of revisions in a table format just above the title block. The design considerations described hereunder establish the minimum basic requirements of plain and reinforced concrete structures, masonry structures and structural steel works. However, any particular structure shall be designed for the satisfactory performance of the functions for which the same is being constructed. The Contractor shall also ensure the stability of the partly completed structures.

B.4.1. DESIGN STANDARDS

All designs shall be based on the latest Indian Standard (IS) Specifications or Codes of Practice. The design standards adopted shall follow the best modern engineering practice in the field based on any other international standard or specialist literature subject to such standard reference or extract of such literature in the English language being supplied to and approved by the Engineer. In case of any variation or contradiction between the provisions of the I.S. Standards or Codes and the specifications given along with the submitted tender document, the provision given in this Specification shall be followed.

All reinforced concrete structural design shall generally conform to latest editions of the following publications of the Indian Standards Institution:

I.S. 456	Code of Practice for plain and reinforced concrete
I.S. 875	Code of Practice for design loads for buildings and structures (Part I to V)
I.S. 3370	Code of Practice for concrete structures for the storage of liquids (Part I to IV)
I.S. 1893	Criteria for earthquake resistant design of structures (Part-1)
IS:1893 (Part 2)-	Criteria for Earthquake Resistant Design of Structures (Part 2 – Liquid retaining tanks– Elevated and ground supported).
I.S. 2974	Code of Practice for design and construction of machine foundations (Part 1 to 4)
IS 5525	Code of Recommendations for detailing of reinforcement in reinforced concrete works
I.S. 13920	Ductile Detailing of Reinforced Concrete Structures subjected to Seismic forces- Code of Practice

IRC: 6	Standard specification and Code of Practice for road bridges - section-II Loads and Stresses
IRC112	Code of Practice for Concrete Road Bridges.
IRC89	Guidelines for Design and Construction of River Training and Control Works for Road Bridges.
IRC SP13 IRC 78	Code of Practice for Small Bridges and culverts. Standard Specifications and code of practice for road bridges
IS: 4701 IS-2911 all parts	Code of practice for earthwork on canals Code of Practice for design and construction of pile foundations.

All structural steel design shall generally conform to the following publications of the Indian Standards Institution:

- i. I.S. 800 : Code of Practice for general construction in steel
- ii. I.S. 806 : Code of Practice for use of steel tubes in general building construction

B.4.1.1. Design Life

The design life of all structures and buildings shall be 50 years.

B.4.1.2. Durability

The design life is specified as 50 years. The special considerations made to ensure the long life of the structures are presented below.

The reinforced concrete that will go into the construction will be exposed to moderate environment conditions.

The use of structural steel is to be bare minimum as it is prone to corrosion.

To achieve durability of concrete it is to be ensured that there is minimal cracking and has a very low permeability. Also the concrete should have high strength, should be dense and compact. To reduce permeability and cracking, proper and adequate curing techniques shall be adopted. The crack width shall be checked with respect to the allowable crack width. Reinforcement in RC structures shall be placed at closer spacing to reduce crack width. Further, sharp corners, edges are to be avoided. All edges of RC sections shall be chamfered or rounded to avoid cracking.

To achieve higher design life of 50 years,

- 1) It is recommended to use structural concrete of minimum Grade M30 using Portland Pozzolana Cement as per IS: 1489-1991 (Part -1) with minimum content of PPC to 350 kg/m³ and maximum water binder ratio of 0.45 for water retaining structures as per IS3370 part I.
- 2) It is recommended to use structural concrete of minimum Grade M25 using Portland Pozzolana Cement as per IS: 1489-1991 (Part -1) with minimum content of PPC to 350 kg/m³ and maximum water binder ratio of 0.5 for other reinforced structures as per IS456.
- 3) It is recommended to use structural concrete of minimum Grade M25 using Portland Pozzolana Cement as per IS: 1489-1991 (Part -1) with minimum content of PPC to 300 kg/m³ and maximum water binder ratio of 0.5 for Storm water drain as per IS456.

Incorporation of fly ash in concrete improves its long-term strength and modulus of elasticity, reduces its long term shrinkage and creep, decreases its permeability significantly at later stages and enhances its long term durability properties. Use of pozzolanic material like fly ash in concrete reduces the amount of heat generated in the concrete mass that in turn reduces the thermal gradients and thermal stresses in concrete. It also reduces its water demand. It also offers higher resistance to chloride ion penetration and higher resistance to sulphate attack, if exposed to such chemicals. Pozzolanic Material like fly ash shall be of approved quality (IS 1489 part 1)

Low permeability of concrete can be checked in the concrete mix design at site by conducting the Rapid Chloride Penetration Test as per AASHTO T277 (ASTM C1202) and the chloride ion penetration can be checked to be within the range of 1000 -2000 Coulomb ("low permeability" category). To reduce permeability and cracking we must ensure that proper and adequate curing techniques are adopted.

The reinforcing bars used in RC structures shall be Thermo – Mechanically Treated (TMT) bars, as these have better corrosion resistance as compared to ordinary cold twisted bars and have a longer life. Further, the steel used shall be provided with adequate cover so as to protect it from corrosion. From durability and 2 hours fire resistance considerations, reinforcement in the concrete shall be protected by adequate concrete cover. Also, rebars having an elongation of more than 14.5% shall be used to provide ductility Confirming to IS 13920.

As an additional measure of protection, PVC water stops shall be provided at the construction joints in the water retaining structures.

The roof slab shall be protected with a layer of thermal insulation in the form of cast-in-situ autoclaved concrete as per IS: 2185-1984 (Part 3). This will be further protected by the membrane water proofing treatment.

The measures mentioned above, will go in the long way to protect the structure for the desired long life.

The bidder shall submit a note in his bid, on how he proposes to achieve the durability in the works under this tender in terms of design, materials and construction practices to achieve leak proof and durable water retaining structures.

B.4.1.3. Geotechnical Data

Geotechnical report and calculations have been given in tender only for guideline purpose. Contractor shall carry detail geotechnical investigation and accordingly shall carry out detail design before starting the work. It is mandatory to contractor to get design and drawings approval from client engineer before start of work.

B.4.1.4. Design Loadings

All buildings and structures shall be designed to resist the worst combination of the following loads/stresses under test and working conditions; these include dead load, live load, equipment load, water pressure, soil pressure, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads:

B.4.1.5. Dead Load

This shall comprise all permanent construction including walls, floors, roofs, beams, columns foundations, partitions, stairways, fixed service equipment and other items of machinery. In estimating the loads of process equipment all fixtures and attached piping shall be included, but excluding contents, shall be considered.

The following minimum unit weights shall be considered in design of structures:

Loading Area	Load Intensity
Water	9.81 kN/m ³
Soil (irrespective of strata available at site and type of soil used for filling etc). However, for checking stability against uplift, actual weight of soil as determined by field test shall be considered	16.50 kN/m ³
Plain concrete	24.00 kN/m ³

Reinforced concrete	25.00 kN/m ³
Brickwork (exclusive of plaster)	20.00 kN/m ³
Siporex Blocks (exclusive of plaster)	8.00 kN/m ³
Plaster to masonry surface	20.00 kN/m ³
Granolithic terrazo finish or rendering screed, etc.	24.00 N/m ² per mm thickness
MS chequered plates	78.50 kN/m ³
Structural steel	78.50 kN/m ³

B.4.1.6. Live Load:

Live Load (LL) shall include the superimposed loads due to the use/occupancy of the structure/building not including dead, wind or earthquake load. Live loads shall be in general as per I.S. 875 Part (II). However, the following minimum loads shall be considered in the design of structures:

Loading Area	Load Intensity (KN/m ²)
Inaccessible Roof	0.75
Accessible Roof	1.50
For Sloping Roof with slope greater than 10 degrees (if applicable)	0.75 kN/m ² less 0.02 kN/m ² for every degree increase in slope over 10 degrees, subject to a minimum of 0.40 kN/m ²
Balconies, Corridors, passages, lobbies and staircases	5.00
Storage Area	5.00
Pantry	3.00
Kitchen	3.00
Cafeteria	4.00
Toilets	2.00
Electrical room (H T/ LT Panel room)	5.00 or as per actuals, whichever is higher.
AHU / HUB	5.00 or as per actuals, whichever is higher.
Mechanical room	5.00 or as per actuals, whichever is higher.
UPS rooms/Transformer/Battery room	10.00 or as per actuals, whichever is higher.
Lobby	5.00
floors supporting equipment such as pumps, valves etc.	10.00 or as per actuals, whichever is higher.
Control Panel	10.00 or as per actuals, whichever is higher.

DG room	10.00 or as per actuals, whichever is higher.
Parking/ Ramp	5.00 or as per actuals, whichever is higher.
Landscape/ Lawn	5.00 or as per actuals, whichever is higher.

In the absence of any suitable provisions for live loads in I.S. Codes or as given above for any particular type of floor or structure, assumptions made must receive the approval of the Engineer prior to starting the design work. Apart from the specified live loads or any other load due to material stored, any other equipment load or possible overloading during maintenance or erection/construction shall be considered and shall be partial or full whichever causes the most critical condition.

B.4.1.7. Wind Load:

All buildings and structures should be designed to withstand the forces of wind pressure, assumed in any horizontal direction with no allowance for the effect of shielding by other adjacent structures, in accordance with the appropriate provisions of IS: 875 (Part 3).

Basic Wind speed for Hisar:	$V_b = 47$	
Design Wind Speed at any height:	$V_z = K_1 K_2 K_3 V_b$	Clause 5.3
Where, K_1 = Probability factor = 1.0		
K_2 = Terrain height & structure size factor		
For Category 1 and Class of structures - Class B, Values of Table 2 of IS: 875-Part 3 to be referred.		
K_3 = Topography factor = 1.0		
Design Wind Pressure at any height:	$P_z = 0.6 \times V_z^2$	Clause 5.4

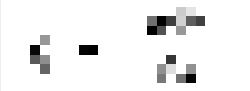
Based on the above wind pressure and exposure of the building, further load calculations will be carried out with respect to profile of building as per IS: 875 (Part 3).

B.4.1.8. Earthquake Load:

All buildings, structures, foundations should be designed to resist the effects of earthquakes in accordance with IS: 1893 - Criteria for Earthquake Resistant Design of Structures for Design Basis Earthquake. The frames are to be designed to carry lateral loads but do not fulfill the requirements of 'dual systems' as per Table 7.

Seismic design forces should be determined based upon the following parameters. Buildings of different materials of construction and lateral force resisting systems shall be investigated separately.

Table B-11 Seismic Parameters

Item	Value	Reference
Seismic Zone :	Zone – III	Fig.1 - Map Showing Seismic Zones of India. (IS 1893 – Part 1)
Zone Factor (z):	0.16	Table 2 (IS 1893-Part 1)
Importance Factor (I):	1.0 (For Frame Structures) 1.5 (For MRSS)	Table 6 (IS 1893-Part 1)
Response Reduction Factor (R):	5.0 (For Frame Structures)	Table 7 (IS 1893-Part 1) CL.No.6.4.2
Fundamental Natural Period (T_a)		Clause No: 7.6.2 – IS: 1893 (Part 1).

Item	Value	Reference
Average Response Acceleration Coefficient (S_a/g): For Rocky or Hard soil	$S_a/g \begin{cases} 1+15T & 0.00 \leq T \leq 0.10 \\ 2.5 & 0.10 \leq T \leq 0.40 \\ 1.00 / T & 0.40 \leq T \leq 4.00 \end{cases}$	Fig. 2 Response Spectra for Rock & Soil Sites for 5 percent damping.
Damping Coefficient	0.05 for RCC Structure	Clause No: 7.8.2.1 – IS: 1893 (Part 1).
Design Spectrum The design horizontal seismic coefficient (A_h)	$\frac{Z I S_a}{2 R g}$	Clause No: 6.4.2 – IS: 1893 (Part 1).
Design Seismic Base shear	$V_B = A_h W$	Clause No: 7.5.3 – IS: 1893 (Part 1).

Contribution of permanent dead loads and live loads as specified in IS: 1893 (Part 1); Clause No: 7.3 shall be considered while calculating nodal masses. Live load on the roof should not be accounted in the calculation of nodal masses.

B.4.1.9. Impact Loads

Dynamic loads due to working of plant items such as pumps, travelling cranes, etc. shall be considered in the design of structures.

B.4.1.10. Water Pressure

Water pressure is the horizontal pressure of the water acting on the structure. The water pressure shall be calculated as follows:

$$P = \gamma_w h$$

Where

P = water pressure

h = depth of water pressure

γ_w = Unit weight of water (kN/m³)

Hydrodynamic forces due to water shall be considered for water retaining structures as per IS1893-PART2-2014.

B.4.1.11. Earth Pressure

Earth pressure means the horizontal pressure of the soil acting on the underground structure and foundation. Earth pressure for all underground structures (walls of basement / tanks) shall be calculated using coefficient of active earth pressure or pressure at rest.

The earth pressure of submersed soil shall be calculated as follows:

$$P = K(\gamma_{sub}) h + \gamma_w h$$

Where

P = Submerged soil weight (kN/m³)

h = depth of earth pressure

γ_w = Unit weight of water (kN/m³)

K = Earth pressure coefficient

γ_{sub} = Submersed soil weight (kN/m³)

The earth pressure of saturated soil shall be calculated as follows:

$$p = K (\gamma_{sat}) h$$

Where

γ_{sat} = Saturated soil weight (kN/m³)

h = depth of earth pressure

K = Earth pressure coefficient

B.4.1.12. Uplift pressure

Ground water table shall be considered as per geotechnical investigation. Appropriate seasonal variation shall be considered while calculating ground water table.. Uplift pressure due to ground water on foundation is calculated as follows:

$$p = \gamma_w H$$

Where

H = depth of foundation bottom from water table level (m)

γ_w = Unit weight of water (kN/m³)

B.4.1.13. Surcharge Load:

Minimum surcharge of 10KN/m² shall be considered for design of all underground structures to take in to account the construction load and vehicular traffic in the vicinity of structure. The soil parameters and ground water table will be considered as per soil investigation report. If structure is near the road, surcharge shall be considered as per latest IRC-6 code.

B.4.1.14. Vehicular Load

For any structure or pipeline below roads, shall be designed for Class A , Class AA or 70R whichever is governing of IRC loading

B.4.1.15. Load Combinations

The individual members of the frame shall be designed for worst combination of forces such as bending moment, axial force, shear force and torsion as applicable. Permissible stresses for different load combinations shall be taken as per latest IS 456 & relevant IRC codes. Structural Steel Building shall be designed in accordance with latest IS 800.

B.4.1.16. Collapse/Strength Load Combinations

For the strngth design, factored load combinations as specified in latest IS 456, IS 875-part V & relevant IRC codes shall be used.

B.4.1.17. Serviceability Load Combinations

For ascertaining safety under service load conditions, the Serviceability load combinations shall be used as per latest IS 456 & relevant IRC codes.

B.4.1.18. Load Combinations for Structural Steel Frames

The design load combinations for Structural Steel Frames shall be used as per latest IS800.

B.4.1.19. Joints

Location of Construction joints and shrinkage strips shall be designed & planned by the contractor and only be used in locations pre-approved by Engineer. All construction joints for water retaining structures in RCC shall be made watertight using approved make water stops. PVC water-stops of 230 mm width shall be provided in all construction joints below ground level in addition to any joint which may be detailed on the drawing. To avoid segregation of concrete in walls, horizontal construction joints shall be provided at maximum 2.0 m spacings.

B.4.1.20. Expansion Joint

To relieve the structure from temperature stresses, appropriate expansion joints shall be provided as per design requirements & as agreed by the Client Conforming to IS codes. This spacing may vary depending of the Geometry & lateral load resisting system adopted for the structure. Gap for the expansion / separation joint shall be provided as per the provisions mentioned in IS 1893 part IV. The gap in between shall be filled by approved board & sealant with proper treatment to make the joint leak proof. Dual column system supported on single foundation shall be provided at the expansion joint. For Liquid Retaining Structures Various Joints as per Design Requirement Shall be Provided Confirming to IS 3370: Latest Revision.

B.4.1.21. Permissible Deflections

Permissible deflections shall be as per IS: 456 clause 23.2. Total deflection of various structural members shall be calculated as per ANNEX C of IS 456. Provisions of IS 1893 and IS 875 shall be followed for lateral deformations.

B.4.1.22. Crack Width

Water retaining elements like tank walls, base slab, cover slab etc. shall be designed for limiting crack width of 0.1 mm and elements in contact with soil like foundation shall be designed for limiting crack width of 0.2 mm and non-water retaining elements like building floor slabs, beams shall be designed for limiting crack width of 0.3 mm as per IS 3370 and IS 456 respectively.

Design Conditions for Underground or Partly Underground Liquid Retaining Structures

All underground or partly underground liquid containing structures shall be designed for the following conditions:

- (i) Liquid depth up to full height of wall: no relief due to soil pressure from outside to be considered.
- (ii) Structure empty (i.e., empty of liquid, any material, etc.): full earth pressure and surcharge pressure as applicable but minimum of 10 kN/m² shall be considered.
- (iii) Partition wall between dry sump and wet sump: to be designed for full liquid depth up to full height of wall on one side.
- (iv) Partition wall between two compartments: to be designed as one compartment empty and other full;
- (v) Structures shall be designed for uplift in empty conditions with the water table till the finished ground level;

- (vi) Underground or partially underground structures shall also be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab. A minimum factor of safety of 1.25 shall be ensured against uplift or floatation. Where uplift force acts on unsymmetrical structure, the loss of stability may be due to tilting or rotation. In such a case, factor of safety should be not less than 1.4 against rotational stability.
- (vii) All the liquid retaining structures shall be designed for maximum design crack widths of 0.1 mm for direct tension and flexure.
- (viii) All the structures wherever applicable shall be checked for overturning. Minimum factor of safety of 1.4 For Dead Load + Live Load Condition and 1.2 times for wind/seismic action. Overturning shall be checked for empty condition.
- (ix) All the structures wherever applicable shall be checked for sliding. Minimum factor of safety of 1.4 against sliding shall be considered. Sliding shall be checked for empty condition.
- (x) All liquid retaining structures shall be designed for Seismic effects latest IS 1893 part 2 -2014.

B.4.2. STRUCTURAL ANALYSIS

General: The structural analysis will be carried out as three-dimensional space frames with finite elements using commercially available software STAAD Pro / ETABS

Mathematical Modelling of Structure: pump houses, office building, substation buildings etc., shall be modelled analyzed and using STAAD.Pro. Tank Structures shall be modelled analyzed and designed using Finite Element Method. Pump house, office building, substation buildings etc., shall be modelled, analyze and design as frame structures.

Analytical Result: Bending moments, Axial forces, Shear forces, Support reactions, Support displacements, Base pressures etc., shall be considered while extracting force envelope.

B.4.3. FOUNDATIONS

- (i) The minimum depth of foundations for all structures, equipment, buildings and frame foundations and load bearing walls shall be as per IS 1904.
- (ii) Maximum safe bearing capacity of soil strata shall be taken as indicated in geotechnical reports.
- (iii) Care shall be taken to avoid the fouling with the foundations of adjacent buildings or structure foundations, either existing or not within the scope of this Contract. Suitable adjustments in depth, location and sizes may have to be made depending on site conditions. No extra claims for such adjustments shall be accepted by the Employer.

- (iv) Special attention is drawn to danger of uplift being caused by the ground water table. All underground structural slabs shall be designed for uplift forces due to ground water pressure.

B.4.4. GENERAL DESIGN REQUIREMENTS

The following are the design requirements for all reinforced or plain concrete structures:

- a) All blinding and leveling concrete shall be a minimum 100 mm thick in concrete grade or M15 as shown in the drawing.
- b) For all Water retaining reinforced concrete structures, concrete shall be of a minimum M30 grade with a maximum 20 mm aggregate size for sections having 300 or minimum thickness and with a maximum 40 mm aggregate size for sections having thickness more than 300 mm and for all other reinforced concrete structures, reinforced concrete shall be of a minimum M25 grade with a maximum 20 mm aggregate size for sections having 300 or minimum thickness and with a maximum 40 mm aggregate size for sections having thickness more than 300 mm. Reinforced concrete shall have minimum slump of 100 mm with maximum water cement ratio of 0.45.
- c) For all reinforced concrete structures, Portland Pozzolana Cement (PPC) shall be use confirming to latest IS: 1489
- d) The minimum clear cover to all reinforcement including stirrups and links shall be 50 mm for all water retaining structures. As design consideration to control crack, though general requirements of IS 3370 shall be followed, permissible crack width shall be limited to 0.1 mm for water retaining structures.
- e) The amount of reinforcement in each of the two directions at right angles within each surface zone should not be less than 0.35% of the surface zone cross section (As per Clause 8.1 of IS 3370-2-2009) for water retaining structures. For slabs, minimum of 10 mm diameter bars shall be used to avoid any deformation of lesser diameter bars under loads prior to construction.
- f) The clear cover to the main reinforcing bars for different members shall be as per latest IS codes.
- g) For reinforced concrete structures, reinforcement shall be HYSD TMTBARS of grade Fe 500 With 14.5% Elongation Length Confirming to IS 331920.
- h) All buildings shall have a minimum 1 meter wide, 100 mm thick plinth protection paving in M10 grade concrete or stone slabs/tiles. All plinth protection shall be supported on well compacted strata.
- i) All pipes and ducts laid below the structural plinth and road works shall be encased on all sides with concrete of grade M20 minimum.

- j) Any structure or pipeline crossing below roads shall be designed for Class A loading conforming to IRC-6.
- k) To relieve the upward ground water pressure, pressure release valves shall not be used.
- l) Maximum 40mm aggregate size shall be used for footings and rafts and maximum 20mm aggregate size for all other structural members.
- m) Grade slabs of liquid retaining structures shall have the following:
 - (i) Minimum thickness of 200 mm.
 - (ii) Minimum percentage of distribution reinforcement shall be as per clause no 8 of IS 3370 (Part II).
 - (iii) Maximum length of pour panel considering partial or complete contraction joints shall be 7.5 meters.
 - (iv) Panels shall be poured in sequence and not in chessboard fashion.
- n) Walls of liquid retaining structures shall have the following:
 - (i) Minimum thickness of 200 mm.
 - (ii) Minimum percentage of distribution reinforcement shall be as per clause no 8 of IS 3370 (Part II).
 - (iii) Maximum length of pour panel considering partial or complete contraction joints shall be 7.5 meters.
 - (iv) Panels shall be poured in sequence and not alternately.
- o) Floors of water retaining structures shall have 50 mm thick Indian Patent Stone (IPS) finish of grade 1:1 ½:3. Joints in IPS shall be staggered from those in floor slab.
- p) For non-liquid storage structures, expansion joints shall be located at a distance of about 45m, these expansion joints shall have appropriate & approved joint filler with sealing compound. Expansion joints for x for liquid retaining structures shall be spaced at 30 m maximum.
- q) At all inner faces of construction and contraction joints in walls and floor slabs, a groove shall be provided. This groove shall be filled with joint seal compatible with water.
- r) Water test of water retaining structures shall be done in accordance with IS: 3370 (Part I). The depth of water for testing shall be upto the soffit of the top slab of the tank.
- s) Curing period shall conform to IS456 and IS3370.

The following minimum thicknesses shall be used for different reinforced concrete members, irrespective of design thicknesses:

(i) Walls for liquid retaining structures	:	200 mm
(ii) Roof slabs for liquid retaining structures	:	150 mm
(Other than flat slabs)		

(iii) Bottom slabs/Raft for liquid retaining structures	:	200 mm
(iv) Floor slabs including roof slabs, walkways,		
(v) canopy slabs	:	125 mm
(vi) Walls of cables / pipe trenches,		
(vii) underground pits etc.	:	200 mm
(viii) Column footings	:	300 mm
(ix) Parapets, chajja	:	100 mm
(x) Precast trench cover	:	75 mm
(xi) Column Dimension	:	300 mm

B.4.5. STEEL STRUCTURES

B.4.5.1. General

The requirements for design, material and fabrication including connections of steel framing for buildings, steel structures supporting equipment, pipe supports and miscellaneous structural steelwork like staircases, hand railing etc. are covered in this section.

B.4.5.2. Design Method

Design of all steel structural members shall conform to IS-800-2007.

B.4.5.3. Connections

All shop connections shall be welded (minimum structural weld 4mm throat thickness) except for shop connections for light platform framing etc. which may be bolted. Field connections may be bolted or welded. In case of welding, welders will be certified before they are allowed to work.

B.4.6. MATERIALS IN GENERAL

The term "materials" shall mean all materials, goods and articles of every kind whether raw, processed or manufactured and equipment and plant of every kind to be supplied by the Contractor for incorporation in the Works.

Except as may be otherwise specified for particular parts of the works the provision of clauses in "Materials and Workmanship" shall apply to materials and workmanship for any part of the works. All materials shall be of approved quality and sourced from the manufacturer. Relevant documents supporting the sources of the purchased material shall be submitted to the client.

Contractor shall supply the names of the supplier before the start of the work and place order only after the approval of the client. Approval of the material shall be done only after the samples identified by the Engineer is tested as. The Contractor shall thereafter keep the Engineer informed of the delivery dates of all materials.

Materials shall be transported, handled, and stored in such a manner as to prevent deterioration, damage or contamination failing which such damaged materials will be rejected and shall not be used on any part of the Works under this contract. Appropriate and safe storage and stacking of all material is the sole responsibility of the contractor.

Material, Workmanship and Design Criteria

Materials specified will confirm to the latest edition of the relevant Indian Standard or other accepted standards. Specifications for materials will include sampling and testing as stipulated in the design standards. Detailed material specifications will be included in the Technical Specifications.

B.4.6.1. Concrete

a) Cement

Generally Ordinary Portland cement (OPC) conforming to IS: 8112 or Portland pozzolana cement (PPC) conforming to IS: 1489 shall be used for superstructure. It is recommended to use Portland pozzolana cement (PPC) as per IS 1489 for all structures.

b) Reinforced Cement Concrete (RCC)

Reinforced concrete conforming to Table 2; IS 456-2000 shall be used with 20mm and downsize graded crushed stone aggregate unless noted otherwise. The Minimum grade of reinforced cement concrete shall be M25 for moderate conditions of exposure for different structures and foundations as per Table 5 of IS456-2000. The Minimum grade of reinforced cement concrete shall be M30 for water retaining structures as per Table 1 of IS3370 latest Revision.

The contractor has to submit the detailed methodology including quality control measures for the manufacture and supply of concrete to the project site and take prior approval of the engineer before proceeding.

c) Lean Concrete

Concrete of minimum 100 mm thickness of lean concrete grade M15 (by weight, using 20mm and downsize grade crushed stone aggregate) shall be provided under all RCC foundations.

d) Reinforcement Bars

- a) High Strength Deformed Thermo mechanically treated (TMT) Steel bars of grade Fe 500, conforming to IS: 1786 with minimum elongation of 14.5% and of approved make listed in the tender document shall be used.
- b) No re-rolled reinforcement bars shall be used.
- c) Couplers shall be used for laps of bars higher than 32 mm diameter.

B.4.6.2. Aggregates

Selected aggregates of proper sizes shall conform to IS: 383.

B.4.7. STRUCTURAL DESIGN OF RCC ELEMENTS

The design aims to achieve an acceptable probability that structures being designed will perform satisfactorily during their intended life. With an appropriate degree of safety, they should sustain all the loads and deformations of normal construction and use and have adequate durability and resistance to the effects of earthquake, wind as well as misuse and fire. Structures and structural elements will be designed by Limit State Method. Due consideration will be given to the accepted theories, experience and modern design philosophy and practices.

B.4.8. SAMPLES AND TESTS OF MATERIALS

The Contractor shall submit samples of such materials as may be required by the Engineer and shall carry out the specified tests directed by the Engineer at the Site, at the supplier's premises or at a laboratory approved by the Engineer.

Samples shall be submitted, and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Engineer.

The Contractor shall give the Engineer seven days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory approved by the Engineer. The Engineer shall attend the test at the appointed place within seven days of the said date on which the materials are expected to be ready for testing or inspection according to the Contractor, failing which the test may proceed in his absence unless instructed by the Engineer to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to Engineer within seven days of every test such number of certified copies (not exceeding six) of the test results as the Engineer may require.

Approval by the Engineer as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer's powers under the Contract.

The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

B.4.9. GENERAL ARRANGEMENT OF STRUCTURES

The following general guidelines shall be followed in the preparation of general arrangement of structures.

- Sufficient room shall be allowed between components of pumping stations, ESR, substations, administrative buildings, transfer stations and adjacent fixed structures to permit safe and convenient access for operation and maintenance.
- An area adjacent to all structures area shall be provided as maintenance lay down area.
- Fixed runways, lifting eyes or other means shall be provided to permit the removal of units that may be required to be removed during the course of its normal operational life for maintenance or any other purpose.

B.4.10. ORIENTATION

The works shall be laid out within the confines of the Site in order to interface to the existing infrastructure of roadways and inlet and outlet pipe work. Underground services shall be relocated to accommodate the site layout after the approval of the Engineer.

B.4.11. BUILDINGS AND STRUCTURES

All the building and structure works shall generally comply with the following Employer's Requirements unless otherwise specified elsewhere.

1. All building works shall be of reinforced concrete framework.
2. All external walls above ground shall be in brick/ RC block masonry and shall be minimum 230 mm thick.
3. All internal partition walls shall be in brick/ RC block masonry. All internal walls shall be minimum 230mm thick. Toilet block internal partition walls shall be in 115 mm thick brick masonry.
4. All internal masonry surfaces finish shall have 12 mm thick plain faced cement plaster in cement mortar (1:4) with neat cement finish on top. Over this, one coat of primer and two coats of plastic emulsion paint of approved quality and shade shall be provided.
5. All external masonry surfaces and concrete surfaces with rough board finish shall have 20 mm thick sand faced cement plaster in two coats, base coat 12 mm thick in cement mortar

- 1:4 and finishing coat 8 mm thick in cement mortar 1:3. Waterproofing compound of approved make and quality shall be added to the cement mortar in proportions as specified by the manufacturer.
6. All RCC surfaces below ground shall be treated with anti-carbonation treatment
 7. All external surfaces above ground level shall have one coat of primer and two coats of waterproof cement-based paint of approved quality and shade. A coat of silicone water repellent paint shall also be applied thereon.
 8. Toilet areas, walls and ceilings, shall have one coat of primer and two coats of plastic emulsion paint.
 9. Toilet floor slab shall be filled with brick bat coba (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.
 10. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.
 11. The flooring along with skirting in office building shall be of vetrified tiles of approved shade. 150mm high skirting shall be provided in these areas. Granite stone shall be provided for laboratory platforms fixed over double sandwiched cuddappah support as directed and the edges of granite is to be embedded into the wall.
 12. Toilet areas shall be of ceramic tiles of approved shade. 1500 mm high dado, in 150 mm x 150 mm x 6 mm thick glazed tiles placed in cement mortar shall also be provided in these areas.
 13. The toilet facilities shall include at least :
 - (i) 1 No. Water closet with white porcelain Orissa pan minimum 580 mm long with flushing cistern of 10 liters capacity.
 - (ii) 1 No. Urinal of sizes 600 mm x 400 mm x 300 mm flat back type in white porcelain separated by a marble partition of size 680 mm x 300 mm.
 - (iii) 1 No. wash basin of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
 - (iv) 1 No. mirror of size 400 mm x 600 mm wall mounted type fitted over wash basin.
 - (v) 1 No. plastic liquid soap bottle
 - (vi) 1 No. chromium plated brass towel rails minimum 750 mm long.
 - (vii) All stopcocks, valves and pillar cocks shall be heavy duty chromium plated brass.
 - (viii) All fittings such as 'P' or 'S' traps, floor traps, pipes, etc.
 14. All floor cut-outs and cable ducts, etc. shall be covered with precast concrete covers in outdoor areas and mild steel chequered plates of adequate thickness in indoor areas. All uncovered openings shall be protected with MS hand railing with minimum Class B pipes.

15. All staircases shall be provided with Stainless MS hand railing for protection with minimum Class B pipes.
16. The reinforced concrete roofs shall be made waterproof by application of an approved cement-based roof waterproofing providing brick bat coba with IPS finish. The finished roof surface shall have adequate slope to appropriately drain the storm water at the quick rate.
17. For roofing drainage, uPVC rainwater down-take with all uPVC accessories shall be used. For roof areas up to 40 sq.m minimum two nos. 100 mm diameter down-take pipes shall be provided. For every additional area of 40 sq.m or part thereof, at least one no. 100 mm dia. down-take pipe shall be provided.
18. Top surfaces of chajjas and canopies shall be made waterproof by providing a screed layer of adequate slope or application of an approved roof membrane and sloped to drain the rainwater.
19. Building plinth shall be minimum 450 mm above average finished ground level around building.
20. All Lintels over the openings shall be RCC with a cantilever canopy (Chajja). Minimum Chajja projection shall be 750 mm for rolling shutters, 600 mm for doors and 450 mm, with the width of the chajja larger than the opening by 150 mm on either side.
21. All windows and ventilators shall have 25 mm thick Granite stone sills/ jambs bedded in cement mortar (1:3).
22. All doors, windows and ventilators including all required accessories & frames shall be of aluminium conforming to IS: 1948 (latest).. Aluminium grills shall be provided in all the windows. Doors shall be in two panel and both panels shall be glazed/unglazed. Minimum weight of aluminium doors & windows shall be as follows.

I. Single Glazed Window: (Weights indicated shall be aluminium)

a) Openable

Outer Frame	:	Weight 0.70 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.97 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt

Fixing Louvers windows/ventilators

Outer Frame	:	Weight 0.46 kg/Rmt

II. Double Glazed Window

Outer Frame	:	Weight 0.72 kg/Rmt
Shutter Frame	:	Weight 0.97 kg/Rmt
Intermediate Mullion	:	Weight 0.98 kg/Rmt
Beading	:	Weight 0.31 kg/Rmt

III. Sliding Windows

Bottom & Top Frame	:	Weight 0.70 kg/m
Shutter Frame	:	Weight 0.42 kg/m
Interlocking Section	:	Weight 0.47 kg/m

IV. Aluminum Door

Outer Frame	:	Weight 2.508 kg/Rmt
Shutter Frame	:	Weight 2.508 kg/Rmt
Bottom Stile	:	Weight 2.508 kg/Rmt

Glazing shall be 6.0 mm thick glass.

23. Openings of the windows & ventilators shall be minimum 25% of the floor area.
24. Ventilator shall be provided where height of floor is more than 3m. All windows and ventilators shall have wire mesh. Doors, Windows and Ventilators shall be of size as per schedule to be submitted by the Contractor for approval of Engineer. The minimum opening size shall be as below:
25. Door of opening size 1.2m x 2.1m
26. Door of opening size 0.75m x 2.1m for toilets
27. Glazed windows of minimum size 1.2m x 1.2m
28. Ventilators of minimum size 0.6m x 0.6m
29. Rolling shutters shall be made of 80 x 1.25 mm MS laths. Rolling shutter shall be of minimum size 2.5m wide x 3.0m high. Rolling shutter shall be provided in MCC cum panel room, chlorine tonner shed, at entry and exit of the pump house for access to pumps, motors, valves, panels and as wherever required.
30. All structural steel members shall be painted with two coats of enamel paint over one shop and one field coat of Zinc Phosphate primer.
31. All concrete channels and ducts used for conveying liquid shall have inside finish of type F2. The width of concrete channels shall not be less than 500 mm. All open channels shall be provided with MS hand railings.
32. Concrete Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factory Act.
33. All units shall be provided with appropriate sign boards of approved material indicating the function of the rooms involved.
34. Wherever equipment and machinery are to be moved for inspection, servicing, replacement etc., suitable movable EOT crane as required shall be provided.
35. The design of buildings shall reflect the climatic conditions existing on site. Office buildings shall as far as possible permit the entry of natural light, preference given to window openings protected by weather canopies.
36. All the walkways shall have minimum 1.0 m width.

B.4.12. VALVE CHAMBERS

All valve chambers, manholes are to be of adequate size to facilitate maintenance and operation. The base slab of valve chambers, manholes shall slope towards a sump pit from which water can be pumped to keep the chamber dry. All valve chambers, manholes shall be constructed in reinforced concrete. Chambers shall have removable cast iron / reinforced concrete covers, as appropriate, approach ladders and valve support.

B.4.13. ROADWAYS, PATHWAYS & HARD STANDINGS

A comprehensive network of roads shall be provided around the specific utility area to link in with the existing road network and permit access to the specific utility area for necessary maintenance, delivery of consumables and personnel access. All roads shall be of asphalt macadam and minimum 5 meters wide. Vehicular access shall be provided for all specific utility area structures and buildings. All roads shall be constructed to prevent standing water.

Hard-standing areas shall be provided to permit the parking of vehicles involved in the delivery of consumables from blocking site roadways during unloading or loading. The road system shall be designed such that vehicles involved in the delivery of consumables can follow a continuous route through the works and out again without the need to reverse or carryout complicated manoeuvres in order to exit the site.

B.4.14. STORM WATER DRAINAGE

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of that area, allowing for 100% runoff. Drains adjacent to roads shall be in reinforced concrete of M20 grade minimum. However, 500 mm x 500 mm size or smaller trenches may be constructed in brick/ Concrete Blocks and internally flush pointed in cement mortar (1:4), 20 mm thick. The minimum width of drain shall be 450mm. The storm water drainage system shall also be designed to cater the run-off from the existing plot areas and structures, if necessary depending upon the site topography.

B.4.15. CABLE AND PIPE WORK TRENCHES

Cable and pipe work trenches shall generally be constructed in reinforced concrete. However, 500 mm x 500 mm size or smaller trenches, not on fill may be constructed in brick/Concrete Blocks. The trenches will be plastered internally with cement mortar (1:4) and externally in cement mortar (1:3).

Trenches within the buildings or specific utility area areas shall be covered with M.S chequered plates, suitably painted and those outside the buildings shall be covered with M20 precast R.C.C covers. The trenches shall be suitably sloped to drain rain water.

Layout of trenches outside the buildings shall allow space for construction of future trenches, where necessary with due consideration for planning for future developments. This aspect shall be brought to the notice of the Engineer, while planning the works.

B.4.16. COMPOUND WALL, GATE AND GUARD ROOMS

Designing and Construction of Compound wall in brick wall with column post at 2.5m spacing, 2 m height above finished ground with Razor Wire security fencing , Gate Ways with proper openable decorative mechanized MS gates with wicket gate ,Guard rooms with vitrified tile flooring, Aluminum doors & windows including internal wiring, lighting fixtures, switches, breakers access control system, boom barriers and provision for communication system & control systems, CCTV & Surveillance system ,with provision for Ascent lights highlighting the Gate Ways ,with provision for waiting room and parking for Visitors, and aesthetically appealing landscaping in forecourt of gate ways. The design and pattern of the gate with drawing shall be submitted for approval.

B.4.17. OFFICE BUILDING, SUBSTATIONS BUILDINGS

The building shall comply with the requirements of various items given in section above. The architectural design concept of buildings structure shall be evolved considering the functional, technological and other requirements for efficient operation, ensuring comfortable working environment for personnel, satisfying the aesthetic requirements. Special care shall be taken to provide elegance and aesthetics, with effective use of appropriate treatment, materials fittings and finishes. Location and size has been provided in tender drawings.

B.5. WATER SUPPLY

B.5.1. BACK GROUND

For greater water security two sources are identified for raw water supply. The primary identified source of water for IMC is an existing Irrigation Canal, known as “Rana Minor” which is flowing through the site for a length of about 1.1 km, passing through both the IMC and Airport sites. The canal currently caters to the demands of irrigation and drinking water in its command area. The combined demand of water for Hisar Airport, IMC, and any future development), is planned to be met from the canal. The Irrigation Department has already initiated planning for diversion/realigning/re-sectioning of the canal stretch within Airport/IMC site and IAH had allocated fund for carrying out these works. The augmented carrying capacity of the canal is planned to be 51MLD as per discussion Irrigation Department.

The second source of water is proposed directly from Rajli head through a cross country pipeline to be laid along Rana Minor in future by State Government. The pipeline shall discharge the water in common bulk storage reservoir.

The demand of water supply will be met from the existing Rana minor irrigation canal which is currently flowing across the sites of Airport & IMC which is planned to be diverted & realigned from its current location. The canal will supply water intermittently for 8 days, followed by closure for 16 days. Referring to the letter No. 5074-76/28-W/Gen from Executive Engineer W/s Hisar, Rana Minor has been designed by considering the 51 cusecs discharge for Airport area which is more than the required demand for IMC area i.e. 15.00 MLD or 6.13 cusec.

Since the water from canal will be continuously released for 8 days, followed by closure for 16 Days. Hence, it will be necessary to create on-site storage reservoir. Assuming a storage to cater about 16 days water demand of IMC, the volume of storage is estimated to be 240 ML. Allowing natural losses like evaporation, percolation and considering other operational requirements of the reservoir, the requirement of gross storage of the reservoir will be about 300 ML.

As per discussion with CA & IAH it was finalised that bulk storage reservoir will be developed in Airport area which will have combined storage for Airport and IMC area to save the IMC area which can be utilized for industrial purpose. In bulk storage reservoir 300ML shall be reserved for IMC. From the bulk storage reservoir, the water will be pumped to IMC raw

water reservoirs for further treatment and distribution of water. Construction of the Bulk Reservoir will be done by PHED/Irrigation Dept.

The raw water supply tap-off point for IMC shall be from Bulk Storage Reservoir. The raw water shall be supplied through a transmission main to be laid along the northern boundary of Airport and IMC area. Raw water will be transmitted by pumping main. The pump house shall be located in a bulk storage area. As per the meeting dated 12-05-2022 with CAD officials this pumping main along with pump house will be constructed by the Public Health department, Haryana.

The raw water from bulk storage reservoir shall be pumped to water treatment plant within IMC. Since the WTP is not in the present scope of work the technology shall be finalized after analyzing the water quality data by the vendor identified to execute this work. It is clear as per discussion with NICDC/CAD treated water of required quantity as per CPHEEO standards would be made available for the project area.

B.5.2. DESCRIPTION OF THE WORKS

B.5.2.1. POTABLE WATER SYSTEM

- Design, Construction, commissioning, and maintenance of potable Water rising main from Clear Water Reservoir to respective UGT.



- Design, Construction, commissioning, and maintenance of Clear Water Reservoir of Capacity 11250 KL (RCC reservoir)
- Design, Construction, commissioning, and maintenance of potable Water Pumping station at CWR location to pump water from CWR to three UGT.
- Design, Construction, and maintenance of UGTs of Capacity
- UGT 1- 1300 KL

UGT 2- 1550 KL

UGT 3- 1100 KL

- Design, Construction, commissioning, and maintenance of potable Water distribution system (DI -K-7 material) of pipe diameters varying from 100mm to 450 mm diameter for a length of 39 Km.
- Design and installation of vacuum type online chlorination system including construction of chlorination building as per approved design.
- The entire distribution zone shall be planned into different DMA (District Metered Area) so that total incoming flow to a particular area can be measured.
- Complete automation of the system including flow measurement, water level in reservoirs, pressure monitoring, leakage detection including all required equipment and instrumentation system
- House service connection for individual plot including smart water meter, communication pipe, meter chamber and valves.
- Complete electrical works like transformer, MCC, cabling upto motors, lighting, earthing and lightning protection for pump house.
- One pumping station has been planned for the potable water supply distribution network inside the project area. It is located near the CWR (CWPS-Potable) which pumps water to the respective UGT.
- For the water supply system, there will be one combined pumping station which will supply water to UGT-1, 2 & 3. One set of pumps (2W+1S) with their auxiliary equipment shall supply water to UGT-1 & 3, while other set of pumps (2W+1S) with their auxiliary equipment shall supply water to UGT-2.

B.5.2.2. RECYCLE WATER SYSTEM

- Design, Construction, commissioning, and maintenance of Recycle Water transmission system from Recycle Water Reservoir inside the project area.
- Design, Construction, commissioning, and maintenance of Recycle Water Reservoir (two in nos) of Capacity 900 KL and 5000 KL (RCC reservoir) inside the project area.
- Design, Construction, commissioning, and maintenance of Recycled Water Pumping station at Recycle Water Reservoir location to pump water from recycle water tank to distribution system.
- Design, Construction, commissioning, and maintenance of Recycled Water distribution system (HDPE- PE 100 – PN10 / DI -K-7 material) (direct pumping) of pipe diameters varying from 63 mm to 600 mm diameter for a length of 66 Km,

- Complete automation of the system including flow measurement, water level in reservoirs, pressure monitoring, leakage detection including all required instrumentation system
- House service connection for individual plot including smart water meter, communication pipe, meter chamber and valves.
- Complete electrical works like transformer, MCC, cabling up to motors, lighting, earthing and lightning protection for pump house.

B.5.3. GENERAL

- Design, Construction and maintenance of Water Transmission / Distribution Main allied works such as thrust blocks, anchor blocks, concrete encasing of pipes, valve chambers, nalla crossings etc.
- Design, Construction and maintenance of Control and instrumentation systems (Motor & allied electrical, cabling & Instrumentation work), SCADA and mechanical systems (Pumps & Valves) with Valves.
- Surge protection system is proposed with a view to control the maximum and minimum pressures within specified limits following the transient event. The maximum pressure inside the transmission main restricted to pump shut-off head, which is expected to be less than the stipulated maximum pressure under transient conditions and also less than the pipeline internal design pressure. The maximum pressure anticipated should be less than the pipeline internal design pressure which about 1.5 times the working pressure.
- Design and construction of House service connections for Potable (590 Number) and non-potable system (627 Number). The scope includes laying of pipeline up to the road edge and fixing suitable end cap.
- Design and installation of Bulk flow meters at all Reservoirs, Pump station inlet and outlet locations.
- Design and installation of pressure gauges at all Reservoirs, Pump station and at strategic locations in the network.
- Pipeline markers shall be provided along the pipeline. ID tags shall be provided for all pipeline appurtenances.

B.5.4. WATER SUPPLY APPURTENANCES

The water supply system (transmission and distribution system) shall be provided with the following appurtenances and specials etc as per the criteria given below,

- a) The mains shall be provided with sluice valves, particularly near pump header, near delivery at pump house for isolation purpose. The size of the valve shall be same as pipe diameter.

- b) The scour valves shall be provided at low points or at natural drainage for emptying the pipe when necessary. The drainage arrangement will consist of a DI special having drainpipe at bottom and a sluice valve connecting to the nearby drain. The size of the drain valve will be as per CPHEEO guidelines.
- c) The pipeline shall be provided with air valves at every summit point and also at about 1 Km distance, suitably. The size of the air valve will be as per CPHEEO guidelines.
- d) All the valves shall be enclosed in valve chambers with manhole cover and frames as per relevant standard and codes.
- e) At bends and gaps suitable specials shall be provided. The use of specials shall be kept to minimum possible.
- f) Concrete anchor and thrust blocks in M20 concrete will be provided at bends and below valves to avoid movement of pipe as per the standard.
- g) At crossing of roads, concrete encasing with re-filling and compaction along with necessary WBM and bitumen layers shall be provided.
- h) Clear identifications of Potable water and Recycled water pipeline shall be made by adopting different colour pipes as per relevant standards.
- i) Above information is for guidance of the bidder. It is Contractor's responsibility to complete the work in all respect. Any additional work, if required, to complete the work shall be done by contractor at no extra cost and the same shall be deemed to be included in his Price Bid. Such additional work shall be as per design criteria and specifications as mentioned in Tender document and as approved by Employer.

B.5.5. WATER DEMAND

Total water demand is computed for both potable and non-potable uses separately for various types of users such as domestic, commercial, and industrial areas.

The same is appended in the table below:

Table B-12 Total Water Demand

S.No	Category	Unit Water Demand				Total			
		Unit	Total	Potable	Non Potable	Population/Area	Total Water Demand (MLD)	Potable Water Demand (MLD)	Flushing Water Demand (MLD)
1	Housing	LPCD	135	90	45	12564	1.78	1.187	0.59
2	Industrial work force	LPCD	45	25	20	43663	2.063	1.146	0.917
3a	Commercial workers	LPCD	45	25	20	7354	0.347	0.193	0.154
3b	Floating/visiter population	LPCD	15	5	10	11032	0.174	0.058	0.116
4	ADM + CC	LPCD	45	25	20	1292	0.061	0.034	0.027
5a	Hospital (100 Beds)*	L/B/day	450	300	150	100	0.047	0.032	0.016
5b	Institution	LPCD	135	90	45	2772	0.393	0.26	0.13
6	Public Utilities	LPCD	45	25	20	187	0.0088	0.0049	0.0039
7a	Open space/parks	L/ac/day	20230		20230	242	4.90		4.90
7b	Green spaces within industrial (considering 20% will be green area)	L/ac/day	20230		20230	191.3	3.87		3.87
8	Industrial demand (70% potable, 30% non potable)	L/ac/day	18219	12753.04	5466	765.4	13.94	9.76	4.18
9a	3 star Hotel (300 beds)*	L/B/day	180	120	60	75	0.0567	0.0378	0.0189

S.No	Category	Unit Water Demand				Total			
		Unit	Total	Potable	Non Potable	Population/Area	Total Water Demand (MLD)	Potable Water Demand (MLD)	Flushing Water Demand (MLD)
9b	5 star Hotel (500 beds)*	L/B/day	320	260	60	400	0.1680	0.1365	0.0315
10	Office Block	LPCD	45	25	20	13336	0.6301	0.350	0.280
11	PARKING	L/ac/day	10000	3000	7000	22.73	0.2273	0.068	0.159
12	ROADS	L/ac/day	2000	0	2000	231.15	0.4623	0.000	0.462
	Sub Total						29.13	13.27	15.86
	Fire demand (population based)						0.99	0.99	
	Net Demand						29.13	13.27	15.86
	Gross Total including 6% distribution Losses						30.88	14.07	16.82
	Gross Demand including Raw water Treatment losses @3%							14.50	
	Total water Demand						31.32	14.50	16.82

B.5.6. DESIGN CRITERIA

A. Potable Water Supply Infrastructure

B.5.6.1. CLEAR WATER RESERVOIR (CWR)

The storage capacity of underground CWR is proposed for 18 Hours capacity which shall be constructed in RCC. The treated water from this tank shall be pumped to the respective UGTs after disinfection with chlorine. Necessary appurtenances such as inlet, outlet, overflow, vent pipes etc., shall be provided.

B.5.6.2. CLEAR WATER PUMP HOUSE

One pumping station has been planned for the potable water supply distribution network inside the project area. It is located near the CWR (CWPS-Potable) which pumps water to the respective service reservoir.

For the water supply system, there will be one combined pumping station which will supply water to UGT-1, 2 & 3. One set of pumps (3W+1S) with their auxiliary equipment shall supply water to UGT-1 & 3, while other set of pumps (3W+1S) with their auxiliary equipment shall supply water to UGT-2.

Horizontal split case pumps have been considered instead of End suction centrifugal pumps due to the following advantages.

- Higher efficiency than end suction pumps of same size.
- Lower NPSHR due to dual suction impeller design
- Top half of casing can be removed easily for maintenance and inspection of rotor without removing the motor or piping.
- Low deflection due to short shaft length.

Each pump shall be complete with suction and discharge isolating valves. Check valve shall be also installed downstream of each water pump. Dismantling joints/flange adaptors shall be provided upstream of isolation valves and check valves to allow for removal of components for maintenance.

The pump house shall be provided with an electric overhead traveling crane rated for a lifting capacity equivalent to the heaviest part of the pump-motor set with an additional 25% safety margin. The crane bridge shall be capable of traversing the entire length of the pump house and shall be equipped with a hoist trolley which shall traverse the width of the pump room.

Two Submersible drain pumps shall be provided to pump the leakage water from pumps, pipes and valves which is collected in drain sump.

All mechanical and electrical rooms shall be provided with firefighting systems as per the requirements of the NFPA / NBC. Adequate ventilation shall be provided and shall be designed considering 15 air changes per hour.

The pumping configuration is as follows:

Table B-13 Pumping details of Potable water supply

Sr. No	Location	Zone	Details			Pump house size	Remarks
			Demand	Pump capacity	Head		
1	CWPS (Clear water pumping station)	Single Zone	8.79 MLD (20 hours pumping)	Capacity - 220 m ³ /hr (2W+1S) pumping to UGT-1 & 3	29m	Approx. 24.50m x 13.70m	Potable water pumping station near CWR (Plot-U2); Pumps water to UGT-1, 2 & 3.
			5.76 MLD (20 hours pumping)	Capacity - 144 m ³ /hr (2W+1S) pumping to UGT-2	42m		

Three pumping stations have been planned for the potable water supply distribution network inside the project area. It is located near the respective UGTs which pumps water from each UGT to plot owner consumers.

Each Pumping station near UGT consists of 2W+1S pumps with their auxiliary equipment and shall supply water to plot owner consumers.

Table B-14: Potable Water Supply Network			
Sr. No	Location	Zone	Remarks
1	CWPS (Clear water pumping station)	Single Zone	Potable water pumping station near CWR (Plot-U2); Pumps water to UGT-1, 2 & 3.
2	UGT-1	Single Zone	UGT-1 is located near Plot-U1 and Plot-U2.
3	UGT-2	Single Zone	UGT-2 is located near Plot-U3 and Plot-U4.
4	UGT-3	Single Zone	UGT-3 is located near Plot-U5 and Plot-U6.

B.5.6.3. CHLORINATION UNIT

The chlorination plant shall be installed near the Clear water Pumping station so that chlorine can be injected directly in the feeder main upstream side of UGTs.

Table B-14 Design Parameters for Chlorination

Sr. No.	Design Parameters	Value
1	Chlorine dose	1 – 2 mg/l
2	Contact time	>15 min
3	Residual chlorine	0.2 mg/l

B.5.6.4. POTABLE WATER RISING MAIN FROM CWR TO UGTs

Potable water from tapping point (from CWR) shall be conveyed to 3 UGTs by laying rising main pipe.

The limit for detailed design and implementation starts from the tapping point to Inlet of UGT including required interconnections. The design parameters shall be as follows:

Table B-15 Design Parameters for Water Conveyance from CWR to UGT

Sr. No.	Design Parameters	Value
1	Pumping hours	20 hours (To be coordinated with CAD/NICDC prior to designing)
2	Design Velocity	1.0 m/sec - 1.5 m/sec
3	Max. Unit head loss in the Pipe	4 m/Km.
4	Hazen's William coefficient	130 / 140
5	Pipe Material	DI K-9

The rising main should be designed based on economical size of rising main and water hammer calculations with reference to CPHEEO Manual and relevant IS codes.

B.5.6.5. UNDERGROUND SERVICE RESERVOIR FOR POTABLE WATER SUPPLY

The design parameters for the Potable water UGT shall be as follows:

Table B-16 Design Parameters for UGTs

Sr. No.	Design Parameters	Value		
		UGT 1	UGT 2	UGT 3
1	Minimum storage capacity of UGT	6 Hours of average daily water requirement of the project area.	6 Hours of average daily water requirement of the project area.	6 Hours of average daily water requirement of the project area.

2	Maximum storage capacity of Zone wise UGT	1300	1550	1100
3	Type	Rectangular – RCC reservoir	Rectangular – RCC reservoir	Rectangular – RCC reservoir
4	Foundation	Raft foundation / Pile Foundation	Raft foundation / Pile Foundation	Raft foundation / Pile Foundation

B.5.6.6. POTABLE WATER DISTRIBUTION SYSTEM

The design parameters for the Potable water distribution system shall be as follows:

Table B-17 Design Parameters for distribution system

Sr. No.	Design Parameters	Value
1	Minimum Residual Pressure at all nodes in the D/S system during Peak hours	7 m
2	Peak factor for design of water distribution system	3
3	Losses	8% losses
5	Bedding: for pipe diameters up to 400 mm for pipe diameters greater than 400 mm.	Minimum Depth of Bedding below the pipe 150 mm 200 mm
6	Clear cover above the crown of pipe	1 m (minimum)
7	Basis of supply to the consumers	24 x 7
8	Hazen's William coefficient	130 (DI/MS) 140 (HDPE Pipe)
9	Pipe Material	DI K-7
10	Software for designs	Water GEMs
11	Network type	Loop network

B. Recycle Water Supply Infrastructure

B.5.6.7. RECYCLE WATER RESERVOIR (RWR)

The storage capacity of underground RWR is proposed for 8 Hours capacity which shall be constructed in RCC with RCC roof. The recycle water from this tank shall be pumped to recycle water distribution system for various non potable uses such as flushing, gardening, non-domestic industrial purpose etc... Necessary appurtenances such as inlet, outlet, overflow, vent pipes etc. shall be provided.

B.5.6.8. RECYCLE WATER PUMP HOUSE (RWPS)

Two pumping stations has been planned for the non-potable water supply distribution network inside the project area. which is used to pump water from UGT to the end users.

Horizontal split case pumps have been considered instead of End suction centrifugal pumps due to the following advantages.

- Higher efficiency than end suction pumps of same size.
- Lower NPSHR due to dual suction impeller design
- Top half of casing can be removed easily for maintenance and inspection of rotor without removing the motor or piping.
- Low deflection due to short shaft length.

Each pump shall be complete with suction and discharge isolating valves. Check valve shall be also installed downstream of each water pump. Dismantling joints/flange adaptors shall be provided upstream of isolation valves and check valves to allow for removal of components for maintenance.

The pump house shall be provided with an electric overhead traveling crane rated for a lifting capacity equivalent to the heaviest part of the pump-motor set with an additional 25% safety margin. The crane bridge shall be capable of traversing the entire length of the pump house and shall be equipped with a hoist trolley which shall traverse the width of the pump room.

Two Submersible drain pumps shall be provided to pump the leakage water from pumps, pipes and valves which is collected in drain sump.

All mechanical and electrical rooms shall be provided with firefighting systems as per the requirements of the NFPA / NBC. Adequate ventilation shall be provided and shall be designed considering 15 air changes per hour.

The pumping configuration is as follows:

Table B-18 Pumping Details of Non-Potable Water

S. No	Location	Zone	Details			Pump house size	Remarks
			Demand	Pump capacity	Head		
1.	RWPS - 1 (Recycle water)	Zone-1 (Residential)	2.65 MLD (8 hours pumping)	Capacity - 166 m ³ /hr (2W+1S)	23m	Approx. 12.00m x 13.50m	

	pumping station) - 1						
2.	RWPS - 2 (Recycle water pumping station) - 2	Zone-2 (Industrial)	14.25 MLD (20 hours pumping)	Capacity - 595 m ³ /hr (3W+1S)	18m	Approx. 20.00m x 17.00m	

B.5.6.9. DESIGN CRITERIA FOR RECYCLE WATER PUMP HOUSE

Criteria adopted in the design of Recycle water Pump House are as follows: -

- i. Velocity in suction and delivery pipes shall be restricted to 1.0 m/s to 2.5 m/s respectively.
- ii. Velocity in pumping main range from 0.6 m/sec (minimum) to 2.5 m/sec (maximum).
- iii. Hazen William's Coefficient will be considered as 130 for DI pipe.
- iv. Safe working load of lifting equipment will be at least 50% higher than maximum weight required to be handled at the pumping station.
- v. The preferred range of specific speed shall be 3000 to 4000 USCU.
- vi. Type of pumps shall be horizontal split case.
- vii. Design head shall include static head, friction loss in suction, delivery and rising main and head loss in valves and fittings.
- viii. The sizes of valves shall be same as size of individual pipes.

B.5.6.10. RECYCLE WATER DISTRIBUTION SYSTEM

The design parameters for the Recycled water distribution system shall be as follows:

Table B-19 Design parameters for distribution network

Sr. No.	Design Parameters	Value
1	Minimum Residual Pressure at all nodes in the D/S system during Peak hours	7m
2	Peak factor for design of water distribution system	3
3	Losses	8 % losses
4	Bedding: for pipe diameters up to 400 mm for pipe diameters greater than 400 mm.	Depth of Bedding 150 mm 200 mm
5	Clear cover above the crown of pipe	1 m
6	Basis of supply to the consumers	24 x 7
7	Hazen's William coefficient	130 (DI/MS) 140 (HDPE Pipe)
8	Pipe Material	HDPE PE 100, PN 10/ DI K-7 /MS

Sr. No.	Design Parameters	Value
9	Software	Water GEM
10	Network type	Loop Network-Pumping

B.5.7. TRAINING

The Contractor shall provide on-site training on HDPE/DI pipe laying, jointing, testing, maintenance, operation, leak detection etc., to the personnel authorized by EMPLOYER.

B.5.8. SUPPLY OF EQUIPMENTS

It will be under obligation of Contractor to supply following brand-new equipment of approved makes and specification to employer before handing over of project:

The equipment shall be procured only after obtaining necessary QAP approval from employer.

B.5.9. PERFORMANCE REQUIREMENT

The contractor shall achieve the following Performance guarantees during the maintenance period.

- **Unaccounted for Water (UFW)- Less than 5%**

Unaccounted for Water (UFW) is the difference between the total amount of water entering the distribution system and the total amount consumed (billed). This is the total volume of water in litres lost during the month.

- **Quality compliance- 95%**

Quality Compliance in 24x7 Area" shall mean the proportion measured in percentage terms of the number of water samples conforming to the water quality measured near the tapping point out of the total water samples tested for checking the quality both in terms of residual chlorine content, chemical quality and bacteriological quality during the six months under review in the project area. Water samples shall be measured at every fortnightly at the locations specified by the SPV.

- **Minimum Pressure compliance-95%**

Pressure Compliance means the proportion of pressure measurements complying to 7 m residual pressure at customer tap or 10m residual pressure at the critical measurement point as the case may be out of the total pressure measurements undertaken during the months under review in the project area. Pressures shall be measured at the critical points every fortnightly at the locations specified by the Owner / at the installed pressure gauge locations.

B.5.10. COMMISSIONING OF THE SYSTEM

On completion of the Trial Run, commissioning of the System shall be done by the Contractor. The total time allotted for commissioning of the full system is 30 days. The commissioning of the system shall be considered as fully achieved after the entire system has run continuously for a period of 7 days without any breakdown to the satisfaction of Engineer. If continuous run is not achieved fully to the satisfaction of Engineer, the Contractor has to do the needful to achieve the same at his cost.

All the Costs including the cost of staff, water, electricity, chemicals, other consumables that are required for Operation & Maintenance of System during Commissioning period shall be borne by Contractor. It is the obligation of contractor to dispose off the water from the pipeline, if required as per the direction of employer to the nearest water body/ drain in an environmentally friendly manner without affecting the project area.

B.5.11. DOCUMENTS TO BE SUBMITTED BY CONTRACTOR

Contractor shall submit following documents/drawings for approval from employer before execution of work.

- Topographical survey and drawing
- Geotechnical Investigation report
- Hydraulic Design of all components
- Structural Design of all RCC structures
- Design, general arrangement and drawing for instrumentation and automation system.
- Design Calculations of all components
- Drawings for all components

B.6. INSTRUMENTATION & AUTOMATION TECHNICAL SPECIFICATION & SCOPE OF WORKS FOR POTABLE WATER & RECYCLE WATER SYSTEM

B.6.1. GENERAL

The scope of work covers the design, engineering, supply, installation, testing & commissioning of all the Control, Instrumentation and Automation equipment/system as specified for Sewer Treatment Plant, Common Effluent Treatment Plant, Ground Service Reservoir cum pump house, , Distribution line & AMR type asset service connection metering with automatic Billing generation system along with required accessories. The offer shall comply with the latest applicable codes and standards as prevailing on the date of submission of the bids.

Adequate instrumentation, control & automation facilities shall be envisaged for the proposed system, with a view to achieve safe, reliable & trouble-free operation of the equipment and safety of the operating personnel through user-friendly man-machine communication.

Any equipment/accessories not explicitly indicated in this specification but considered essential for proper functioning of process shall be included in Bidder's scope of work and supply.

B.6.2. SCOPE OF WORK:

Bidder's scope of work & supply shall include, but not limited to, the following:

- a) Design, engineering, supply, storage, erection, testing and commissioning of all the field instruments, control room & automation equipment.
- b) Bidder shall execute complete Instrumentation & Control package on turnkey basis to the satisfaction of Purchaser/ Engineer. Bidder shall comply with all the requirements of scope of work and supply.
- c) All field instruments (gauges, sensors, transmitters, switches, flow meters, Analysers) as required for monitoring /control / alarm/ interlocking functions shall be provided.
- d) All hardware and accessories like branch cable trays from field sensors to Junction boxes & from junction boxes to PLC cabinets, impulse tubes with fittings & accessories, drain/vent valves, root valves, cable glands, structural frames/supports, expander & reducer etc. as required for complete & proper installation of the instrumentation & control equipment, are included in bidder's scope of supply & work.

- e) PLC based control system complete with cabinets, processor modules, I/O modules, power supply modules, communication modules & networks and other associated hardware. PLC based automation system shall be designed using adequate redundancy features. HMIs along with PLC panel & other peripherals shall be installed in the control room.
- f) Supply of UPS of adequate capacity, with battery backup (SMF Lead -Acid batteries) of minimum one (1) hour. AC/DC power distribution with adequate number of wired spares (minimum 20% after commissioning) breakers and 230V AC/ 24V DC converters (redundant) for I&C Equipment and System.
- g) Supply, laying & termination of Instrumentation, Control, Power & any other special cables as required for entire system shall be under Bidder's scope. Scope shall also include preparation of engineering documentation like cable schedule and Inter- connection schedule.
- h) PC, consoles & other peripherals shall be of industrial grade & of latest available configurations.
- i) Electronic earth pits, as per applicable standard & also meeting automation vendor's requirement and including supply & laying of earthing cables with required accessories shall be under Bidder's scope.
- j) Bidder's scope shall also include supply of spares & consumables for successful commissioning and establishment of performance guarantee of the offered plant equipment & system.
- k) Submission of drawings & documentation as specified in this bid document.
- l) Bidder shall arrange for training of Purchaser's personnel for automation & special instrumentation items at manufacturer's works and at site and shall be included in his scope. Details & modalities of which will be mutually discussed and finalised later.
- m) Bidder's scope also includes arranging visits by respective instrumentation & automation equipment manufacturer's competent representatives at site, as & when required, during erection & commissioning.
- n) It is not the intent to completely specify all details of design and construction herein. Nevertheless, the Instrumentation & Control system shall conform to high standard of

engineering, design and workmanship in all respects and shall be capable of performing satisfactorily in continuous commercial operation under the specified environmental conditions.

- o) Bidder shall include all necessary and supplementary items & equipment in his proposal, required for completeness, safe & efficient operation of the offered system, even though these may not have been mentioned in this specification.

B.6.3. GENERAL DESIGN REQUIREMENTS

- i. Instrumentation, control & automation (ICA) system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation. All electronic components shall be adequately rated, and circuits shall be designed so that change of component characteristics shall not affect plant operation.
- ii. Electronic instruments shall utilize solid state electronic components, integrated circuits, microprocessors, etc., and shall be of proven design.
- iii. All digital outputs from the instruments shall be volt free. The relay/switch contacts shall be rated for the voltage of the circuit in which they are to be wired.
- iv. All analogue displays shall be of the digital type with no moving parts.
- v. Zero and span adjustments shall be provided for all instruments.
- vi. After a power failure, when power supply resumes, the instruments and associated equipment shall start working automatically.
- vii. The instruments shall be designed to permit maximum inter-changeability of parts and ease of access during inspection and maintenance.
- viii. The field instruments i.e. the instruments mounted outside the control panel shall be mounted at a convenient height of approximately 1.2 meters above grade platform.
- ix. The instruments shall be designed to work at the ambient conditions of temperature, humidity, and chlorine contamination that may prevail. The instruments shall be given enough protection against corrosion and all the wetted parts of the instruments shall be non-corrosive.

- x. All field instruments and cabinets/panel mounted instruments shall have tag plates/name plates permanently attached to them.
- xi. The performance of all instruments shall be unaffected for the $\pm 10\%$ variation in supply voltage and $\pm 5\%$ variation in frequency simultaneously.
- xii. Unless otherwise specified, SS 304 double compression glands with PVC shroud shall be used for glanding the cable in field instruments and instrument control panel.
- xiii. The monitoring and control system for the proposed plant shall be designed & implemented through a Programmable Logic Controller (PLC) based automation system, covering the total functional & operational requirements of the system involving measurement, control, alarm & interlocking functions. All the process & electrical parameters shall be monitored in SCADA system. PLC system selected shall be OPC compatible.
- xiv. A Centralized Control Room (CCR) shall be provided for the Centralized SCADA System, in which the automation equipment will be installed. PLC system shall be provided with hot redundancy features, one no. of Engineering-cum-Operator station (ES-cum-OS) along with a printer, peripherals & accessories, as required. PLC based automation system shall be of latest industrially available configuration.
- xv. The PLC system shall be provided with hot redundant (for the locations where Redundant PLC has been required as mentioned in further section of the document), fault-tolerant features, redundancy in processor, power supply modules, communication modules (I/O bus as well as HMI bus) and communication network, bump less switchover from the active system to the standby system in the event of a fault.
- xvi. The PLC I/O modules shall be hot swappable (for the locations where Redundant PLC has been required as mentioned in further section of the document), i.e. card changeover, card wiring removal or communication cable change shall be possible on-line (PLC running) without causing any process interruption, bump or nuisance trip or any loss of fidelity during such action. In case of hot swap of I/O card or card wiring removal, the interruption shall be limited to the subject card related I/Os only. Online PLC programme modification shall be possible without stopping the processor.
- xvii. All analog cards shall be differential type. The cards and processors shall be of same family and series. I/O modules shall have 3 levels of Isolation- a) Channel to Channel Isolation, b) Channel to power Isolation & c) Channel to Ground Isolation.

- xviii. Channel level diagnostic features shall be available in HMI. The engineering station forms the focal point of the control system design and acts as container of the complete control system application.
- xix. The operation & status monitoring of the motorized valves shall be performed from the PLC.
- xx. Local instruments like pressure gauges, pressure switches, temperature gauges, level gauges, level switches etc. shall be provided as per the process requirement for proper functioning of the plant.
- xxi. All the field-mounted transmitters shall be 'Smart' type. The instrumentation system shall be based on 4-20 mA DC signals, generally working on two-wire signal system with superimposed digital signal as per HART protocol. In addition to required measurements and controls, adequate sequential and safety interlocks, monitoring and display of all process parameters shall also be provided. All the signals/contacts between field & automation equipment shall be connected by suitable cables. The instrumentation & control equipment to be provided shall be suitable for continuous duty & for round-the-clock operation of the plant throughout the year.
- xxii. All the instrumentation & automation equipment and their accessories shall be supplied from approved manufacturers, whose successful performance has been established by record of satisfactory operation in process plants.
- xxiii. Separate electronic earthing system with dedicated earth pit shall be provided by the bidder for ICA equipment. Bidder shall also be responsible for the laying of the network of electronic earthing cables including all the applicable accessories.
- xxiv. Bidder shall be responsible for engineering, selection and connection of all components and sub systems to form a fully complete system whose performance is in accordance with functional, parametric and other requirements of this specification. It is not the intent to specify all individual system components since the bidder has full responsibility for engineering and furnishing of a complete system meeting the monitoring and control requirements of all equipment associated with the system.
- xxv. Bidder shall support for spares & services for PLC including HMI software and operating System for at least next fifteen (15) years from the date of commissioning.
- xxvi. The tagging, numbering & colour philosophy shall be as per as per ISA standard.

- xxvii. Instrumentation, Control & Automation (ICA) system shall be designed, manufactured, installed and tested to ensure the high standards of operational reliability. Instruments mounted in field and on panels shall be suitable for continuous operation. All electronic components shall be adequately rated, and circuits shall be designed so that change of component characteristics shall not affect plant operation.
- xxviii. All ICA equipment shall be suitable for continuous operation. Unless otherwise specified, all instruments shall be tropicalized. The outdoor equipment shall be designed to withstand tropical rain. Wherever necessary, space heaters, dust and waterproof cabinets shall be provided. Instruments offered shall be complete in all respect with all the necessary mounting accessories.
- xxix. Unless otherwise specified, the normal working range of all indicating instruments shall be between 30% and 70% of the full-scale range.
- xxx. Unless otherwise stated, degree of protection for field mounted electrical and electronic instruments shall be IP 65. All instruments of submersible type shall be protected to IP 68.
- xxxi. Unless otherwise stated, overall accuracy of all measurement systems shall be $\pm 1\%$ or better of the measured value.
- xxxii. Dual redundant SMPS shall be used for powering 24 V DC Instrumentation, Control & Automation equipment.
- xxxiii. For all the field mounted transmitters, output signal shall be 4-20 mA DC isolated with HART Protocol (version 6 & above) and field transmitters shall be provided with the back lit LCD/LED display.
- xxxiv. Lockable & tamperproof enclosure shall be provided for all the field mounted instruments.
- xxxv. FRP Canopy shall be provided for all the field instruments to protect the instruments from rain, sunlight and weather conditions.

B.6.4. MAJOR COMPONENTS TO BE PROVIDED FOR THE SCHEME

The water supply (Both Potable and Recycle) automation system includes PLC control panels for different plant units and reservoir cum pumping stations, PLC based Remote Terminal Units (RTU) for complete distribution network, specific transducers and actuators distributed on complete distribution area. The reliable instruments connected to

PLC or RTU assure real time monitoring of the main technical parameters of complete water distribution networks. The data acquired by SCADA system (Supervisory Control and Data Acquisition) represent the support for optimization of the process and data driven Decision Support System. The system uses HMI to ensure the process supervision and remote-control functions based on wireless communication components. The complete SCADA system for water distribution enable the user to get a high operation safety of the network, a cost-effective use of equipment, theft or leakage detection, energy efficiency and optimize the daily operation and maintenance procedures.

B.6.5. BRIEF DESCRIPTION OF WORK

- Centralized Monitoring & Control System of Water Supply & Distribution System (Potable & Non- Potable Water) & Different Process Plant
- Automatic Flow Measurements at different distribution networks
- Automatic Flow Control at different distribution networks
- Smart water Metering for Asset service connection
- Automated Water Consumption Billing Generation & Management

B.6.6. DETAILS OF DIFFERENT UNITS & NETWORKS

In below tables different units for Potable Water Supply System Components has been reflected.

Table B-20 Detail of Potable Water Reservoir & Pumping System

Sl. No.	Unit	Pumping Destination	Pump Details
			Quantity. (Nos.)
1	Clear Water Reservoir cum Pump House	PUGT-1	3
2		PUGT-2	
3		PUGT-3	
4	PUGT-1 cum Pump House	Potable Water Distribution	3
5	PUGT-2 cum Pump House		3
6	PUGT-2 cum Pump House		3

Table B-21 Detail of Potable Water Distribution System

Sl. No.	Unit	Quantity. (Nos.)
1	Electromagnetic Flow Meter-DN 20 mm	574
2	Electromagnetic Flow Meter-DN 40 mm	7
3	Electromagnetic Flow Meter-DN 80 mm	6

4	Electromagnetic Flow Meter-DN 100 mm	2

In below tables different units for Non- Potable Water Supply System Components has been reflected.

Table B-22 Detail of Recycled Water Reservoir & Pumping System

Sl. No.	Unit	Pumping Destination	Pump Details	
			Qty. (Nos.)	Common Discharge Dia. (mm)
1	RUGT-1 cum Pump House	Recycled Water	3	600
2	RUGT-2 cum Pump House		4	600

Table B-23 Detail of Non-Potable Water Treatment Process Plant

S. No	Unit	Capacity (MLD)
1	Common Effluent Treatment Plant (CETP)	15
3	Sewage Treatment Plant (STP)	2.76

Table B-24 Detail of Recycled Water Distribution System

Sl. No.	Unit	Quantity. (Nos.)
1	Electromagnetic Flow Meter-DN 20 mm	581
2	Electromagnetic Flow Meter-DN 25 mm	6
3	Electromagnetic Flow Meter-DN 32 mm	8
4	Electromagnetic Flow Meter-DN 40 mm	17
5	Electromagnetic Flow Meter-DN 80 mm	13
6	Electromagnetic Flow Meter-DN 100 mm	1

B.6.7. UNDERSTANDING THE WATER SUPPLY SCHEME

POTABLE WATER SUPPLY:

Potable water from 15 MLD WTP (Not in the scope under this RFP) is supplied to Clear water Reservoir cum Pump house (CWPS). From CWPS water is pumped to 3 nos. Underground Tanks (PUGT 1,2,3) and pump house. From PUGT potable water is further

pumped and distributed to different assets. Potable water distribution is controlled and monitored through automatic operated sluice valves and Flow meter.

Bidder can refer Automation System Architecture for Potable Water System drawing for further information.

RECYCLE WATER SUPPLY

Wastewater & Sewage water is collected at 15 MLD CETP and 2.76 MLD STP. Recycled water from these plants is supplied to RUGT1 and RUGT 2 respectively. From RUGT recycle water is further pumped and distributed to different assets. Recycle water distribution is controlled and monitored through automatic operated sluice valves and Flow meter.

Bidder can refer Automation System Architecture for Recycle Water System drawing for further information.

B.6.8. INSTRUMENTATION & AUTOMATION REQUIREMENT FOR DIFFERENT AREAS

General Automation Scheme with list of measurements have been briefed in below sections. Bidder to comply these basic requirements.

GENERAL AUTOMATION DETAILS OF POTABLE & RECYCLED WATER RESERVOIR CUM PUMP HOUSE

Typical Measurement & Control Requirement of Clear Water Reservoir and Potable water PUGT 1,2,3 & Recycled water RUGT 1,2 with Pumping Station is briefly mentioned in below section.

A. MEASUREMENTS REQUIRED TO BE MADE ARE-

- a) Flow at the common discharge header of pumps
- b) Pressure at the Common header of pumps
- c) Local Pressure at the discharge side of individual pump.
- d) Water Level of Reservoir

B. INSTRUMENTATION REQUIRED TO BE INSTALLED-

- a) Electromagnetic flow meter at the common header of the pumps
- b) Pressure transmitter at the common header
- c) Pressure switch at the discharge of individual pump.
- d) Pressure gauge at the discharge of individual pump

e) Ultrasonic Type level transmitter at Reservoir

Control system will continuously monitor the flow, pressure, and level value.

STARTING, RUNNING & TRIPPING CONDITION FOR PUMPS:

A. PUMP STARTING CONDITION:

Following Process and Electrical Parameters will be checked from Control system prior to Start of Pumps

- Water level in the Reservoir is above low set point
- Pump is not in Running Condition
- Control Signal healthy feedback from MCC
- Discharge Valve Closed feedback

B. PUMP RUNNING & TRIPPING CONDITION:

After receiving above feedback signals Pump Start command triggers from PLC for Starting the Pump. During Pump Run Following Process and Electrical Parameters will be continuously checked from PLC.

- a) Discharge Valve Open feedback after a preset time from Start command Initiation from PLC
- b) Discharge Pressure is below High Set Point feedback
- c) Water level in the Intake well is above low set point
- d) Control Signal healthy feedback from MCC
- e) Pump Running feedback from MCC

In absence any of the above-mentioned feedback signals PLC will immediately Initiate Trip Signal to Stop the Pump for protecting pumping machineries.

C. CONDITION FOR CHANGE OVER BETWEEN PUMPS.

Changeover between running and standby pumps will be automatically performed in the pumping system due to following conditions.

- a) Pump not started after Start Command received from PLC
- b) Pump is not running/ tripped
- c) Running Pump completed continuous operating hours

PLC will initiate changeover signal to start the Standby pump after checking all Starting conditions mentioned above.

Level readings shall be continuously displayed at Panel Mounted Process Indicator at pumping station. Low-Low & High-High level alarms shall be annunciated at HMI/SCADA. The pump shall operate in level/timer-based auto mode i.e. start at set high level and

stop/close at set low level or at set times as finalized during detailed engineering. The working and standby pump shall be selected by operator at HMI or shall be determined by operating hours of pump such that pump with minimum operating hours shall start first & so on and in case of pump trip, pump with maximum operating hours shall stop first and so on. Operating hours of pump shall be logged in PLC.

Dedicated Non-Redundant PLC System with HMI Module to be provided for Pumping Station Location for Monitoring and Control of the pumping system.

- a. During any AUTO operation, control system will continuously monitor all the parameters and process. These parameters will be displayed on Main SCADA & Pump House HMI.
- b. Normal Mode: -In Normal mode control system will continuously monitor the Level of the water in reservoir sump at the Main SCADA and HMI in Pumping Station, water level of the reservoir, pressure at the common header and the flow at the common header of the pump.

Level instrument will measure the level of water at reservoir and its water level low alarm will be shown in Main SCADA & Pump House HMI.

Electromagnetic flow transmitter will continuously measure the flow at the outlet of the pumping station and will be shown in the Main SCADA & Pump House HMI

Pressure transmitter will continuously measure the pressure of the common header & will be shown in the Main SCADA & Pump House HMI

There will be a standalone PLC System which will communicate through GSM with the Main PLC in the control room situated at Clear Water Pumping Station (CWPS) Main SCADA & PLC Room.

B.6.9. INSTRUMENTATION & AUTOMATION REQUIREMENT OF SEWAGE TREATMENT PLANT (STP)

Requirement of Measurement & Automation System of STP and all of its area are briefly described in below section. The plant shall be provided with required instrumentation equipment for measurement & control functions, indicated below as a minimum, but not limited to the following: As per Technology provider recommendation some of the instruments may be deleted or included in detail engineering stage in accordance to the approval from client.

FIELD INSTRUMENTATION:

Following Measurements have been envisaged in following process areas of the plant.

- Ultrasonic Type Level transmitter will be used for Measuring of Level at
 - o All Tanks/Reservoirs

- Ultrasonic Type Level transmitter (2 Nos.) at Inlet and Outlet will be used for Measuring of Differential Level across
 - o All /Motorised Screens
- Float/Capacitance/Conductivity/Displacer Type Level Switch will be used for Protection of Pumps at Low-Low Level
 - o All Tanks/Reservoirs having Pumping System
- Ultrasonic Type Open Channel Flow meter with Parshall Flume /Weir will be used for Measuring of Flow at
 - o Sewage Water Inlet at Inlet Channel
- Full Bore Type Electromagnetic Type Flow meter will be used for Measuring of Flow at
 - o Treated Sewage Water Common Discharge
 - o Common Discharge of All Pumps
- Online/Bypass Type Rotameter will be used for Measuring of Flow Locally at
 - o Common Process Air Line
- Diaphragm sealed/Bourdon type Pressure Gauge will be used for Local Measurement of Pressure at
 - o Individual discharge of all pumps
- Pressure Switch will be used for Local Measurement of Pressure at
 - o Individual discharge line of all Pumps
- Piezoelectric/Capacitive type Pressure Transmitter will be used for Remote Measurement of Pressure at
 - o Common Discharge line of all Pumps
 - o Common Process Air Line
- Online Dissolved Oxygen (DO) Analyser Instrument will be used for Measurement of Dissolved Oxygen Level at of Sewage Water at
 - o Aeration tank/ Biological reactor
- Online Free Residual Chlorine Analyser Instrument will be used for Measurement of Residual Chlorine at
 - o Treated Sewage Water Outlet at Chlorine Contact Tank (CCT) discharge.
- Online TSS Analyser Instrument will be used for Measurement of Total Suspended Solid of Sewage Water at
 - o Sewage water Inlet
 - o Treated Sewage Water Outlet
- Online BOD & COD Analyser Instrument will be used for Measurement of Biological & Chemical Oxygen Demand of Water at (Normally same instrument is used for measurement both parameters. BOD is measured and COD values is shown by

multiplying some factor with BOD value)

- o Sewage water Inlet
- o Treated Sewage Water Outlet

PLC & SCADA SYSTEM:

Independent dedicated Redundant PLC and SCADA system is to be provided for the following action of Sewage Treatment Plant

- Continuous monitoring of process parameters from field instruments
- Control & Interlock of Pumps for protection
- Operation of the Motorized Valves as per the process requirement
- Operation of the Treatment & Chlorination System
- Monitoring & Control of Plant Electrical System

B.6.10. INSTRUMENTATION & AUTOMATION REQUIREMENT OF COMMON EFFLUENT TREATMENT PLANT (CETP)

Requirement of Measurement & Automation System of CETP and all of its area are briefly described in below section. The plant shall be provided with required instrumentation equipment for measurement & control functions, indicated below as a minimum, but not limited to the following. As per Technology provider recommendation some of the instruments may be deleted or included in detail engineering stage.

FIELD INSTRUMENTATION:

Following Measurements have been envisaged in following process areas of the plant.

- Ultrasonic Type Level transmitter will be used for Measuring of Level at
 - o All Tanks/Reservoirs
- Ultrasonic Type Level transmitter (2 Nos.) at Inlet and Outlet will be used for Measuring of Differential Level across
 - o All /Motorised Screens
- Float/Capacitance/Conductivity/Displacer Type Level Switch will be used for Protection of Pumps at Low-Low Level
 - o All Tanks/Reservoirs having Pumping System
- Ultrasonic Type Open Channel Flow meter with Parshall Flume /Weir will be used for Measuring of Flow at
 - o Effluent Water Inlet at Inlet Channel
- Differential Pressure Transmitter/Differential Pressure Switch will be used for Measuring of Differential Pressure across

- o Various Filtration Unit
- Full Bore Type Electromagnetic Type Flow meter will be used for Measuring of Flow at
- o Treated Effluent Water Common Discharge
- o Common Discharge of All Pumps
- Online/Bypass Type Rotameter will be used for Measuring of Flow Locally at
- o Common Process Air Line
- Diaphragm sealed/Bourdon type Pressure Gauge will be used for Local Measurement of Pressure at
- o Individual discharge of all pumps
- Pressure Switch will be used for Local Measurement of Pressure at
- o Individual discharge line of all Pumps
- Piezoelectric/Capacitive type Pressure Transmitter will be used for Remote Measurement of Pressure at
- o Common Discharge line of all Pumps
- o Common Process Air Line
- Online Dissolved Oxygen (DO) Analyser Instrument will be used for Measurement of Dissolved Oxygen Level at of Sewage Water at
- o Aeration tank
- Online Free Residual Chlorine Analyser Instrument will be used for Measurement of Residual Chlorine at
- o Treated Effluent Water Outlet
- Online TSS Analyser Instrument will be used for Measurement of Total Suspended Solid of Effluent Water at
- o Effluent water Inlet
- o Treated Effluent Water Outlet
- Online BOD & COD Analyser Instrument will be used for Measurement of Biological & Chemical Oxygen Demand of effluent Water at (Normally same instrument is used for measurement both parameters. BOD is measured and COD values is shown by multiplying some factor with BOD value)
- o Effluent water Inlet
- o Treated Effluent Water Outlet

PLC & SCADA SYSTEM:

Independent dedicated Redundant PLC and SCADA system is to be provided for the following action of Sewage Treatment Plant

- Continuous monitoring of process parameters from field instruments
- Control & Interlock of Pumps for protection

- Operation of the Motorized Valves as per the process requirement
- Operation of the Treatment & Chlorination System
- Monitoring & Control of Plant Electrical System

Notes-

- a) Bidder may propose additional instruments & control equipment for safe, reliable & efficient operation of STP process proposed by them.
- b) Required quantities and application of the above instruments shall be provided as per approved P&ID to meet the requirement of the process.
- c) Necessary alarms, status signals along with the measurements of process parameters etc. shall be displayed in HMI.

B.6.11. INSTRUMENTATION & AUTOMATION REQUIREMENT OF DISTRIBUTION SYSTEM & ASSET CONNECTION

REMOTE VALVE CONTROL:

PLC based Remote Terminal Units with GSM/GPRS connectivity provisions to be provided for controlling (open/close) the valve from Main SCADA location for potable and non-potable water supply system.

ASSET FLOW DATA MONITORING:

GSM/GPRS based electromagnetic type flowmeters have been to be provided for potable and non-potable water consumption. Flow data from meters are to be provided to be transferred directly to Main SCADA location respectively for potable and non-potable water supply system respectively.

Notes-

- Bidder to assess the installation location of valves and meters on the network and accordingly consider number of RTU's for implementing proposed operation.
- Flow meters and Valves at nearby area can be clubbed in single RTU unit as per availability and meeting technical requirements.

B.6.12. DATA COMMUNICATION & CONTROL SCHEME TO BE ESTABLISHED

Independent Non-Redundant PLC Systems with HMI are to be provided for following areas for monitoring and control of corresponding system.

For Potable Water Supply System: -

- a. Clear Water Reservoir cum Pump House

- b. PUGT-1 cum Pump House
- c. PUGT-2 cum Pump House
- d. PUGT-3 cum Pump House

For Non-Potable Water Supply System: -

- a. RUGT-1 cum Pump House
- b. RUGT-2 cum Pump House

Independent Redundant PLC System are to be provided for following areas for monitoring and control of corresponding system.

For Non-Potable Water Supply System: -

- a. 2.76 MLD STP
- b. 15 MLD CETP 1

Independent Non-Redundant PLC based RTU Systems are to be provided for following areas for monitoring and control of corresponding system as described in previous sections of this document.

For Potable Water Supply System: -

- a. Motorised Sluice valve at distribution

For Non-Potable Water Supply System: -

- a. Motorised Sluice valve at distribution

In addition to above Electromagnetic type Flow meter with GSM/GPRS connectivity is to be provided to be installed in following areas for metering purpose

For Potable Water Supply System: -

- a. Different Asset connection

For Non-Potable Water Supply System: -

- b. Different Asset connection

Main SCADA cum Automatic Water Metring software for potable water system is to be provided to be kept at CWPS location. For non-potable water system, Main SCADA cum Automatic Water Metring software is to be provided to be kept at 15 MLD CETP. The system also should have Data acquisition and billing software for generating automatic billing as per water consumption by different asset. All the PLC Systems of different areas (STP & CETP) and Distribution RTU and Asset Flow meters are to be connected to Main SCADA system through GSM/GPRS connectivity.

B.6.13. PROPOSED AUTOMATION SYSTEM ARCHITECTURE

Following image represents automation system architecture of proposed for potable and non-potable water system. Components shown in image is for reference purpose only and for understanding basic connectivity scheme. Bidder to submit actual System Architecture drawing during detail engineering stage for approval.

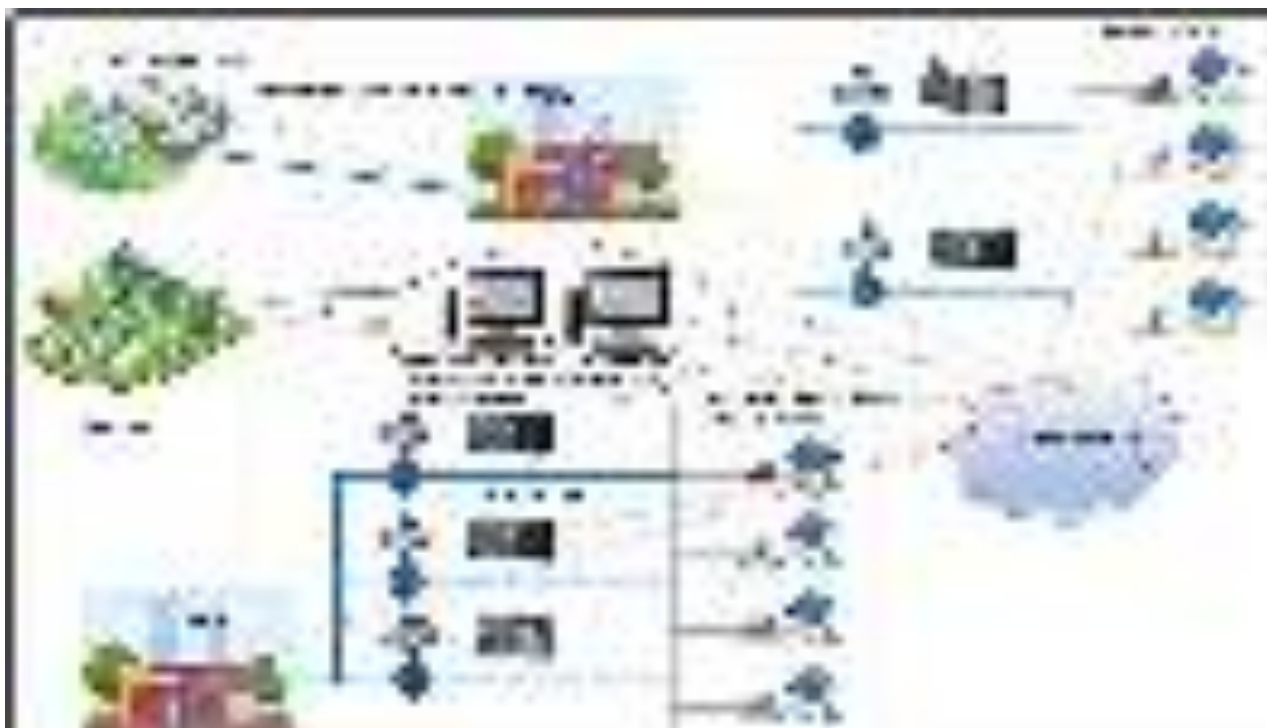


Figure B-1 Automation System Architecture for Potable Water System

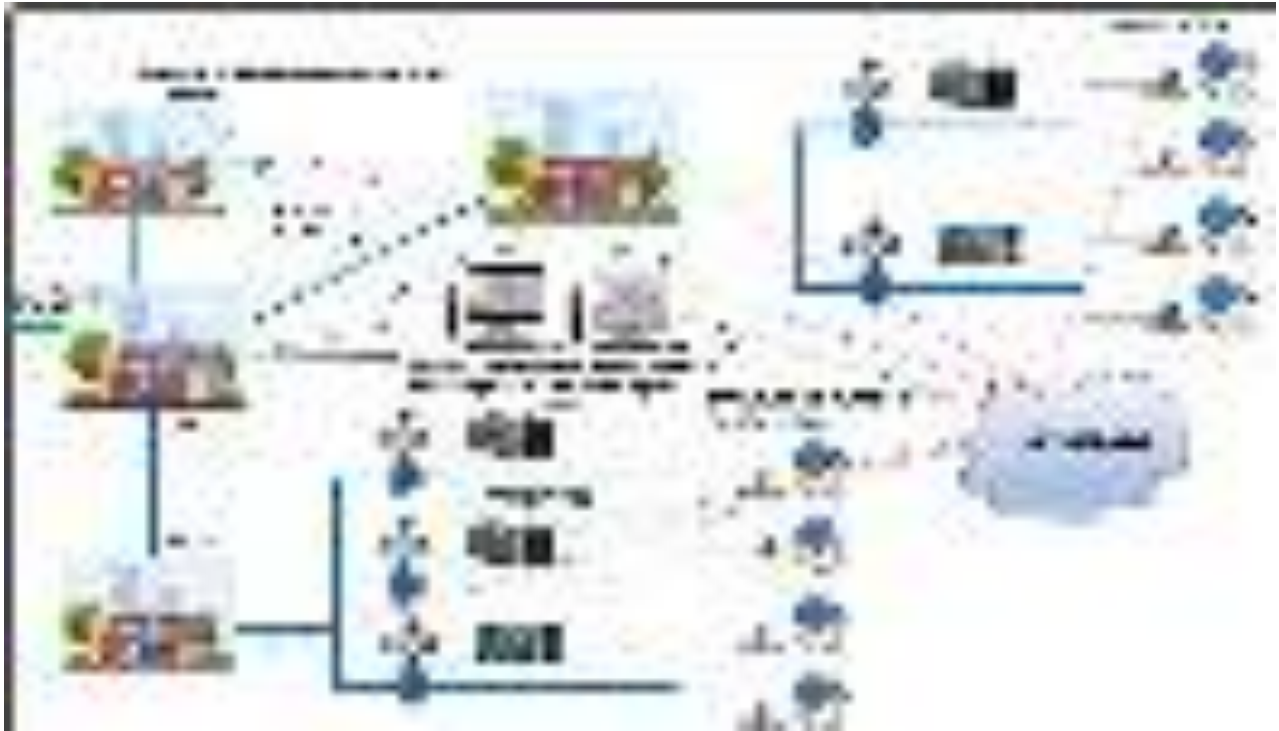


Figure B-2 Automation System Architecture for Recycle Water System

B.6.14. REFERENCE SPECIFICATIONS AND STANDARDS

All ICA equipment shall comply with all applicable international and local laws regulations and standards, as mentioned in the bid document.

B.6.15. SUBMISSION OF DRAWINGS & DOCUMENTS:

Instrumentation Design & Drawings to be submitted by bidder

- With Technical Bid
 - o Basic Engineering write up of Overall Instrumentation & SCADA work, Data Acquisition & Billing work
 - o Proposed Basic SCADA, Data Communication System Architecture drawing
 - o List of Items proposed for the system
 - o Proposed power supply requirement and UPS sizing with Calculation
- After award of Contract for approval
 - o Operation & Control Philosophy of Overall Instrumentation, SCADA & Billing System work
 - o Proposed Detail SCADA, Data Communication System Architecture drawing
 - o Vendor Datasheet & QAP for all Instrumentation Items
 - o PLC Panel Wiring Drawings
 - o Cable Schedule
 - o Instrument Hook up Diagram

-
- o Operation & Maintenance Manual

Notes-

- a) The List of Drawings & Documents furnished above is for information only. Eligible Bidder to submit Detail List of Drawings and Documents required for the project after award of the job for approval of EIC. Submission of Drawings and Documents after the award of contract will be as per the approved list of Drawing and Documents.

B.7. MECHANICAL

B.7.1. TECHNICAL DATA SHEETS

Following are the Technical Data for Clear water and Recycle water pumping station. The Bidder shall furnish the following details as a part of technical bid. Bidder shall furnish all relevant catalogues relevant to the equipment.

B.7.1.1. HORIZONTAL SPLIT CASE PUMP

SR. NO	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	DESIGNATION	-	
2	NUMBER OFFERED	-	
3	TAG NUMBERS	-	
4	PUMP MAKE AND MODEL NUMBER	-	
DESIGN DATA			
5	LIQUID PUMPED	-	
6	TEMPERATURE	°C	
7	SPECIFIC GRAVITY	-	
8	VISCOSITY	cP	
9	SOILDS IN SUSPENSION	-	YES / NO
10	% SOLID BY WEIGHT	-	
11	DESIGN CAPACITY	M ³ /Hr	
12	DIFFERENTIAL HEAD	MLC	
13	SHUT-OFF HEAD	MLC	
14	MINIMUM SUCTION HEAD	MLC	
15	MAXIMUM SUCTION HEAD	MLC	
16	MINIMUM DISCHARGE HEAD	MLC	
17	DESIGN CODE	-	
18	HYDROSTATIC TEST PRESSURE	Kg/cm ² (g)	
19	PUMP EFFICIENCY AT DUTY POINT	%	
20	PUMP SPEED	RPM	
21	PUMP BKW	KW	
22	MAXIMUM PUMP POWER REQUIREMENT	KW	
23	POWER INPUT TO DRIVER AT DUTY POINT	KW	
24	MINIMUM CONTINUOUS FLOW	M ³ /Hr	
25	NPSH REQUIRED	MLC	
26	DRIVER SPEED	RPM	
27	DRIVER EFFICIENCY	%	
28	MINIMUM CAPACITY FOR CONTINUOUS OPERATION	M ³ /Hr	
CONSTRUCTION FEATURES			
29	DESIGN PRESSURE	Kg/cm ² (g)	
30	DESIGN TEMPERATURE	°C	

31	IMPELLER	-	OPEN/ SEMI-OPEN/ CLOSED
32	SEAL	-	
33	BEARING TYPE	-	
34	FLANGE DRILLING STANDARD	-	
35	FLANGE FACE	-	
36	NUMBER OF STAGES	-	
37	METHOD OF LUBRICATION	-	
38	TYPE OF CONSTRUCTION	-	
39	DRIVE TRANSMISSION DETAILS	-	
40	DRIVER RATING	KW	
41	DIRECTION OF ROTATION FROM THE DRIVER END	-	CLOCKWISE / ANTI CLOCKWISE
42	MOMENT OF INERTIA OF PUMP ROTOR	Kg-M ²	
43	SUCTION NOZZLE	-	
43.1	ORIENTATION	-	
43.2	SIZE	mm NB	
44	DISCHARGE NOZZLE	-	
44.1	ORIENTATION	-	
44.2	SIZE	mm NB	
45	TYPE OF STRAINER & SIZE	NB	
46	TYPE AND MAKE OF MECHANICAL SEAL	-	
47	TYPE OF COUPLING	-	
48	MAXIMUM ALLOWABLE SIZE OF SOLIDS	mm	
49	EXTERNAL WATER REQUIREMENTS FOR COOLING	-	
49.1	FLOW RATE	M ³ /Hr	
49.2	PRESSURE	Kg/cm ² (g)	
50.3	ARRANGEMENT OF COOLING SYSTEM	-	
51	EXTERNAL WATER REQUIREMENT FOR SEALING	-	
51.1	FLOW RATE	M ³ /Hr	
52.2	PRESSURE	Kg/cm ² (g)	
53	WEIGHT OF BARE PUMP	Kg	
54	WEIGHT OF DRIVER	Kg	
55	WEIGHT OF COMMON BASE PLATE	Kg	
56	NOISE LEVEL AT 1.0 M	dB	
57	MAXIMUM TORQUE (100 %) SPEED	-	
58	VIBRATION LEVEL	-	
59	OUTLINE DIMENSIONAL DRAWING TO BE ENCLOSED	-	WHETHER ENCLOSED YES / NO

60	FOUNDATION DRAWING WITH STATIC AND DYNAMIC LOADS TO BE ENCLOSED	-	WHETHER ENCLOSED YES / NO
61	CROSS-SECTION DRAWING OF PUMP WITH PART LIST AND MATERIALS OF CONSTRUCTION AND RELEVANT STANDARDS TO BE ENCLOSED	-	WHETHER ENCLOSED YES / NO
62	PERFORMANCE CURVES FLOW RATE Vs HEAD, BkW, EFFICIENCY, NPSHR AND TORQUE-SPEED CURVE TO BE ENCLOSED	-	WHETHER ENCLOSED YES / NO
PERFORMANCE GUARANTEE			
63	CAPACITY	M ³ /Hr	
64	DIFFERENTIAL HEAD	MLC	
65	POWER CONSUMPTION	KW	
MATERIAL OF CONSTRUCTION			
66	CASING	-	
67	IMPELLER	-	
68	SHAFT	-	
69	SHAFT SLEEVE	-	
70	CASING RING	-	
71	IMPELLER RING	-	
72	BASE PLATE	-	
73	SOLE PLATE	-	
74	COMPANION FLANGES	-	
75	FASTENERS		
ACCESSORIES			
76	COMPANION FLANGES WITH NUTS, BOLTS, GASKETS	-	YES / NO
77	COMMON BASE PLATE	-	YES / NO
78	FOUNDATION BOLTS	-	YES / NO
79	COUPLING	-	YES / NO
80	COUPLING GUARD WITH BOLTS	-	YES / NO
81	DRIP TRAY	-	YES / NO
82	LATERN RING	-	YES / NO
83	NON SPARK GUARD	-	YES / NO
84	BASE PLATE DRAIN RIM	-	YES / NO
85	STRAINER	-	YES / NO
86	PRIMING TANK WITH ACCESSORIES	-	YES / NO
87	FOOT VALVE	-	YES / NO
88	BEARING TEMPERATURE GAUGE	-	YES / NO
89	SUCTION PRESSURE GAUGE	-	YES / NO
90	DISCHARGE PRESSURE GAUGE	-	YES / NO

91	VIBRATION MONITORING SYSTEM	-	YES / NO
92	MOTOR STARTER	-	YES / NO
93	CANOPY FOR MOTOR	-	YES / NO
94	ACOUSTIC ENCLOSURE	-	YES / NO
95	RECOMMENDED SPARES	-	YES / NO
96	PAINTING: EPOXY/ SYNTHETIC ENAMEL	-	YES / NO

B.7.1.2. SLUICE VALVE

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	MANUFACTURER	-	
2	TYPE	-	
3	MODEL	-	
4	SERVICE	-	
5	NUMBER	NOS	
6	SIZE	MM	
7	RATING	KG/CM ²	
8	TEST PRESSURE	KG/CM ²	
MATERIAL OF CONSTRUCTION			
9	BODY MATERIAL	-	
10	GATE MATERIAL	-	
11	SEALING FACE MATERIAL	-	
12	SHAFT MATERIAL / SHAFT SEAL	-	
13	HANDWHEEL MATERIAL	-	
14	FLANGE DRILLING STANDARD	-	

B.7.1.3. ACTUATOR

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	MANUFACTURER	-	
2	TYPE	-	
3	MODEL	-	
4	SERVICE	-	
5	QUANTITY	NOS.	
TECHNICAL PARTICULARS			
6	MOTOR RATING	KW	
7	DESIGN TORQUE	N-M	
8	TIME FOR FULL OPEN TO FULL CLOSE	SECS	

B.7.1.4. NON RETURN VALVE

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	MAKE	-	
2	TYPE	-	
3	SIZE	-	

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
4	RATING	BAR	
5	STANDARD TO WHICH MANUFACTURED	-	
TECHNICAL PARTICULARS			
6	NON-SLAM CHARACTERISTICS	-	
7	METHOD OF ACHIEVING NON-SLAM CHARACTERISTICS	-	
MATERIALS OF CONSTRUCTION			
8	BODY	-	
9	DOOR/PLATE	-	
10	DIAPHRAGM	-	
11	SEAT	-	
12	BODY	-	
13	DOOR	-	
14	BODY RING	-	
15	HINGE PIN	-	
16	SPRING	-	
17	SEAT/FACE RINGS	-	
18	BY-PASS WITH ISOLATING SLUICE VALVE	-	
19	BEARINGS BUSH	-	
20	INTERNAL FASTENERS	-	
21	EXTERNAL FASTENERS	-	
TESTING AND INSPECTION			
22	BODY TEST PRESSURE	BAR	
23	SEAT TEST PRESSURE	BAR	
24	MAKERS MAXIMUM RECOMMENDED FLOW VELOCITY	M/S	
25	MAX. PERMISSIBLE VELOCITY ON SITE	M/S	
26	PRESSURE DROP ACROSS NRV AT RATED CAPACITY	MWC	
27	WHETHER RESTING FEET PROVIDED	-	YES / NO
28	WEIGHT	KG	
29	SHIPPING DIMENSIONS	MM	
30	ARRANGEMENT DRAWING NO.	-	
31	CHARACTERISTIC CURVE NO.	-	
32	PRESSURE LOSS	MWC	
22	CLOSING FEATURES	-	

B.7.1.5. BUTTERFLY VALVES

SL. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	MAKE	-	
2	TYPE	-	
3	MODEL	-	
4	QUANTITY	NOS	
5	SIZE	MM	

SL. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
6	RATING	BAR	
7	TEST PRESSURE	BAR	
8	FLANGE DRILLING STANDARD	-	
MATERIALS OF CONSTRUCTION			
9	BODY MATERIAL	-	
10	DISC MATERIAL	-	
11	SEALING FACE MATERIAL	-	
12	SHAFT MATERIAL	-	
14	GEAR REDUCERS	-	
TESTING AND INSPECTION			
15	HYDRAULIC TEST PRESSURE	BAR	

B.7.1.6. DISMANTLING JOINT

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	MAKE	-	
2	QUANTITY	NOS	
3	DESIGN & FABRICATION CODE	-	
4	DESIGN PRESSURE	BAR	
5	DESIGN TEMPERATURE	DEG C	
6	CORROSION ALLOWANCE	MM	
7	FLANGE		
7.1	STANDARD	-	
7.2	RATING	BAR	
8	DRUM THICKNESS	MM	
9	FLANGE THICKNESS FOR FLANGES TRANSMITTING STRESS (TIED FLANGES)	MM	
10	FLANGE THICKNESS FOR FOLLOWER FLANGE (SEAL FLANGE)	MM	
11	DISMANTLING ALLOWANCE	MM	
MATERIALS OF CONSTRUCTION			
12	BODY	-	
13	NUT	-	
14	ALL OTHERS AS PER TENDER SPECIFICATION	-	(YES/ NO)
TESTING AND INSPECTION			
15	HYDRAULIC TEST PRESSURE	BAR	

B.7.1.7. EOT CRANES

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	DESIGNATION	-	
2	NUMBER OFFERED	NOS	
3	TAG NUMBERS	-	
4	DESIGN CODE/STD	-	

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
5	SAFE WORKING CAPACITY/HOIST	T	
HOIST			
6	TYPE	-	
7	MANUFACTURER	-	
8	MAKE	-	
9	MODEL NUMBER	-	
10	BRAKE MANUFACTURER / MAKE	-	
TROLLEY			
11	MANUFACTURER	-	
12	MAKE	-	
13	MODEL NUMBER	-	
14	BRAKE MANUFACTURER / MAKE	-	
ELECTRICAL REQUIREMENTS			
15	HOIST MOTOR	-	
16	MAKE	-	
17	TYPE	-	
18	RATING	KW	
19	SPEED	RPM	
20	TROLLEY MOTOR	-	
21	MAKE	-	
22	TYPE	-	
23	RATING	KW	
24	SPEED	RPM	
25	LIMIT SWITCHES FOR	-	
25.1	HOISTING : MAKE, TYPE AND NUMBERS PROVIDED	-	
25.2	TRAVELLING : MAKE, TYPE AND NUMBERS PROVIDED	-	
26	TYPE OF DOWN SHOP LEAD	-	
26.1	MAKE	-	
26.2	SIZE	-	
26.3	LENGTH	M	
27	SUPPORTING ARRANGEMENT	-	
28	METHOD OF OPERATION	-	
DIMENSIONS			
29	MONORAIL IF PROVIDED BY VENDOR: MONORAIL BEAM SIZE MINIMUM / MAXIMUM SUITABLE FOR TROLLEY MOVEMENT.	MM	ISMB /ISMB
30	DISTANCE BETWEEN HIGHEST HOOK POSITION TO BOTTOM OF MONORAIL	M	
TECHNICAL PARTICULARS			
31	WIRE ROPE DIAMETER / CLASSIFICATION	MM	
32	WIRE ROPE BREAKING LOAD	KN	
33	LINK CHAIN DIAMETER	MM	
34	LINK CHAIN BREAKING LOAD	KN	

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
35	WEIGHT OF COMPLETE HOSIT AND TROLLEY ASSEMBLY	KG	
36	WEIGHT OF HOIST	KG	
37	WHEEL LOAD WITH IMPACT AND WITHOU IMPACT	KG	
38	PRELIMINARY DIMENSIONAL GENERAL ARRANGEMENT DRAWING OF HOSIT ALONG WITH WHEEL STOP DETAILS AND WIRING DIAGRAM TO BE FURNISHED	-	
39	SLING / SHACKLE CAPACIITES	T	
40	SLING LOAD ANGLE FACTOR	DEGREES	
41	LONG TRAVEL DISTANCE	MM	
42	CROSS TRAVEL DISTANCE	MM	
43	HOISTING DISTANCE	MM	
PERFORMANCE GURANTEES			
44	CAPACITY	T	
45	LIFT	M	
46	SPEED FOR ALL MOTIONS	MPM	
MATERIAL OF CONSTRUCTION			
47	CABLE DRUM	-	
48	WIRE ROPE	-	
49	HOOK	-	

B.7.1.8. SLUICE GATES

SL. NO.	DESCRIPTION	UNITS	BIDDER TO INDICATE
GENERAL			
1	MANUFACTURER	-	
2	MODEL	-	
3	QUANTITY	NOS	
4	SERVICE	-	
5	TYPE	-	
6	SPINDLE TYPE	-	
7	SIZE	MM X MM	
8	WEIGHT	KG	
9	SEATING HEAD	M	
10	UNSEATING HEAD	M	
MATERIAL OF CONSTRUCTION			
11	WALL THIMBLE	-	
12	GATE	-	
13	FRAME	-	
14	SPINDLE	-	
15	STEM COUPLING	-	
16	SEATING FACE	-	
17	WEDGE	-	
18	HEADSTOCK	-	

SL. NO.	DESCRIPTION	UNITS	BIDDER TO INDICATE
19	GEAR HOUSE COVER & STEM GUIDE	-	
20	LIFT NUT	-	
21	FASTENERS & ANCHORS	-	
22	LIFTING MECHANISM, GEAR HOUSE & STEM GUIDE	-	
SLUICE GATE ACTUATORS			
23	MANUFACTURER	-	
24	TYPE	-	
25	MODEL	-	
26	SERVICE	--	
27	NUMBER	NOS	
28	MOTOR RATING	KW	
29	MOTOR SPEED	RPM	
30	PROTECTION	-	
31	GEAR REDUCER MAKE	-	
32	TYPE	-	
33	MANUFACTURER	-	
34	MODEL	-	
35	QUANTITY	-	
36	SERVICE	-	
37	TYPE	-	
38	SPINDLE TYPE	-	
39	SIZE	MM X MM	
40	WEIGHT	KG	
41	SEATING HEAD	M	
42	UNSEATING HEAD	M	

B.7.1.9. SUMP PUMPS

SR. NO.	DESCRIPTION	UNIT	BIDDER TO INDICATE
GENERAL			
1	MAKE	-	
2	MODEL	-	
3	TYPE	-	
4	SERVICE/LOCATION	-	
5	QUANTITY	-	
TECHNICAL PARTICULARS			
6	CAPACITY	M ³ /HR	
7	HEAD	M	
8	EFFICIENCY	%	
9	POWER ABSORBED	KW	
10	SPEED	RPM	
MOTOR			
11	MOTOR TYPE	-	
12	MOTOR RATING	KW	

B.7.2. PERFORMANCE CRITERIA

B.7.2.1. PERFORMANCE CRITERIA FOR PUMPING STATION

B.7.2.1.1. GUARANTEES

The Contractor's guarantee given in the Schedule of Guarantees as mentioned below when bidding both in respect of output and efficiency shall be binding under the Contract.

The fulfillment of these guarantees shall be verified at the Tests on Contractor's Premises which shall be in accordance with Class B in the latest edition of BS 5316: Part 2 or equivalent ISO 3555. However, the pump and motor efficiency shall be guaranteed without any negative tolerance whatsoever.

SCHEDULE FOR GUARANTEED POWER REQUIREMENTS

The Tenderer shall furnish below the total estimated Power requirements.

Sr. No.	Description of load	KW	No. of Units	Installed load (KW)	Continuous Running load (KW)
1.	Horizontal split case Pumps				
2.	Motorized sluice valves				
3.	Dewatering Pumps for dewatering reservoir				
4.	Sump Pumps				
5.	Ventilation system				
6.	EOT Cranes				
7.	Lighting				
8.	Miscellaneous				
	TOTAL LOAD				
	Monthly Guaranteed Power Consumption: - _____ Kw Hr Units				

Note: Contractor should quote monthly guaranteed power consumption. Excess Power consumption above guaranteed consumption will be recovered from Contractor on monthly basis based on current power charges.

B.7.2.1.2. NOISE LEVEL IN THE PUMPING STATION

If, on Site testing, the noise level in the pumping station with all working pumps provided with acoustic enclosure running simultaneously exceeds the guaranteed noise level, the pump set shall be rejected.

B.7.2.1.3. TRAINING AND ADVISORY REQUIREMENTS

TRAINING REQUIREMENTS

General

The Contractor shall provide comprehensive training for the different categories of the Employers operation and maintenance staff. Training shall fall into two main types which are 'off the job' and 'on the job'. Off the job training shall take place in the classroom, on the job training shall be carried out on the site for the entire infrastructure component.

Off The Job Training

The Contractor shall prepare formal training documentation for distribution to the trainees. Visual aids shall be used where possible to illustrate the points being made and to make the training programme as interesting and enjoyable as possible for the participants.

The off the job training shall comprise the following:

a) Off the Job Training Programme for all Trainees

To provide training:

- (i) health and safety;
- (ii) System safety procedures;
- (iii) on the use of the local and central HMI s.

b) Off the Job Process Training Programme for Operators

To provide training:

- (i) on operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
- (ii) on day to day operation of the Works and procedures;
- (iii) on a comprehensive list of 'what if' scenarios dealing with the actions to be taken in the event of potential process problems, alarms, system failures overflows, power failures etc.;
- (iv) on first line mechanical maintenance;
- (v) safe methods of work general;
- (vi) on safety procedures to be followed in operating, maintaining and cleaning the system;
- (vii) Special precautions to be followed in the event of Hazards.

c) Off the Job Training Programme for Electrical Maintenance Staff

To provide training:

- (i) on configuration, construction and operation of the electrical Plant;
- (ii) on electrical maintenance requirements of the Works;

- (iii) on switching and safety procedures to be followed;
- (iv) safe methods of working;
- (v) On fault finding and repair procedures.
- d) Off the Job Training Programme for Control and Instrumentation Maintenance Staff

To provide training:

- (i) on configuration, construction and operation of the Plant;
- (ii) on control and instrumentation maintenance requirements of the Works;
- (iii) on fault finding and repair procedures;
- (iv) safe methods of working;
- (v) special training on the use of the PC and associated programming software for fault finding on PLC based control systems;
- (vi) special training on the use and performance of the central HMI SCADA hardware and software and other specialist hardware and software systems used on the plant;
- e) Off the Job Training Programme for Mechanical Maintenance Staff

To provide training:

- (i) on routine mechanical maintenance requirements of the Works;
- (ii) on lubrication requirements of the Works;
- (iii) on fault finding, repair and overhaul procedures;
- (iv) Safe methods of working.

On The Job Training

The Contractor shall utilize the Operations and Maintenance Manuals as the primary training aid in carrying out the on-the-job training. Short comings, omissions and errors identified in the O & M Manuals during the training shall be rectified prior to final acceptance of the O & M Manuals.

- a) On the Job Training Programme for all Trainees

To provide training:

- (i) plant familiarization tour;
 - on use of the local and central HMI s;
 - health and safety;
 - Identify areas where special safety precautions are necessary.
- b) On the Job Process Training Programme for Operators

To provide training:

- Under operational conditions on the operation of individual items of plant and sections of the Works including automatic operation and manual operation in the event of say automatic control failure;
- illustrate by example day to day operation of the Works and procedures;
- illustrate by example the actions to be taken in the event of potential process problems, alarms, plant failures overflows, power failures etc.(as identified in the 'what if' scenario off the job training);
- illustrate by example the first line mechanical maintenance;
- illustrate by example safety procedures to be followed in operation, maintenance and cleaning of the Works.

c) On the Job Training Programme for Electrical Maintenance Staff

To provide training:

- carry out detail tour of the electrical plant;
- illustrate by example the operation of the electrical Plant;
- illustrate by example the electrical isolation and maintenance procedures;
- illustrate by example fault finding and repair procedures;
- illustrate by example switching and safety procedures to be followed;
- illustrate by example safe systems of work.

d) On the Job Training Programme for Control and Instrumentation Maintenance Staff

To provide training:

- illustrate by example the operation of the Works;
- illustrate by example the control and instrumentation maintenance requirements of the Works;
- illustrate by example fault finding and repair procedures
- illustrate by example fault finding on PLC based control systems, the central HMI SCADA hardware and software and other specialist hardware and software systems used on the plant;;
- illustrate by example safe systems of work.

e) On the Job Training Programme for Mechanical Maintenance Staff

To provide training:

- illustrate by example the routine mechanical maintenance requirements of the Works;
- illustrate by example lubrication procedures;
- illustrate by example fault finding, repair and overhaul procedures.
- Illustrate by example safe systems of work.

Training Programme

Off the job training shall be carried out prior to Taking Over of the Works or any section of the Works. On the job training shall be carried out primarily after Taking Over of the Works or any section of the Works. However, where it is possible to do so without reducing the effectiveness of the training and with the permission of the Engineer and the Employer on the job training may be carried out prior to Taking Over. On the job training shall be completed as a condition for acceptance of the Works following completion of the Tests after Completion.

The Contractor shall provide a training plan for each category of staff. The training plan shall detail the content and duration of each course. The training plan shall be submitted for the approval of the Engineer at least 120 days prior to the commencement of the Tests on Completion. The duration of training offered for each category of staff shall not be less than that detailed in the following table.

Category of Staff	Off the Job (Minimum days duration for each course)	On the Job (Minimum days duration for each course)
All staff	1	1
Operator	3	5
Electrical technician/electrician	2	2
Control/instrument technician	10	5
Mechanical technician/fitter	2	2

The training day shall be assumed to be not less than 6 hours split into two sessions. The off the job training rooms shall be provided by the Employer at the Site in the existing buildings. The Contractor shall provide facilities for training which shall include inter alia tables and chairs, projectors, white/black boards, training aids etc.

Where trainees of a given category can all be released from their Works operational duties simultaneously, they may be trained together. Where this is not possible the Contractor shall repeat the complete course for those who could not attend.

Training Personnel

The Contractor shall provide suitably qualified trainers to carry out the off the job and on the job training. The trainers are to be experienced in infrastructure management, operation and maintenance in their relevant discipline and in the training of skilled and

unskilled staff. The Contractor shall submit the curriculum vitae of the nominee's to the Engineer for approval. The training expert shall be fluent in both English and Hindi or the Contractor shall provide the services of an interpreter during the training periods.

Operation and Maintenance Manual

This Operation & Maintenance manual shall be provided by the contractor to establish guideline for system operator to understand and operate the system efficiently and successfully. The guideline shall be provided to the training personnel, on how to operate the system so that they shall be able to manage; with less consumption of energy; with less cost of maintenance expenses; providing a long life of equipment; protection against accident, safe working methods and protecting systems from damages.

The system operation and unit operation of each component needs to be adjusted and modified depending on situational requirements and the required data are collected during the training program as well as operation and maintenance period.

The contractor shall train the SPV personnel about system operation knowledge, abilities and skill as follows:

a) Capacity Building

(i) Knowledge;

- System flow and unit operation, maintenance, pumps, other plant equipment and machinery;
- Basic maintenance period and work sheet;
- Avoiding any chance of accident, and
- Basic safety and health;

(ii) Abilities;

- Make repairs and/or adjustments to system and to keep records and prepare reports;
- Make repairs and/or adjustments to each equipment and keep records and prepare reports;
- Handling safety valves and its pipeline;
- Read and interpret gauges and recording devices;
- Usage of safety Equipment in case of Emergency.

b) Tasks of Maintenance works shall include:

- (i) Makes minor repairs and adjustments to machinery, equipment, pipes and other materials pertinent to the operation of the system;
- (ii) Work on troubleshooting including bulk flow control as well;
- (iii) Maintain maintenance records;

- (iv) Cleaning of machinery, equipment and civil structure, building, loading and unloading of materials properly;
- (v) Does general maintenance of the plant, including, but not limited to, painting, general custodial work, maintenance of equipment, etc;
- (vi) Assist in repairing flow meters and pipeline including valves in inactive time and /or operation time;
- (vii) Assist in the inspection of all necessary equipment.
- (viii) Information to be covered in the Operation and Maintenance Manual
- (ix) The operation and maintenance manual shall include but not necessarily be limited to the following;
 - (x) Background of project;
 - (xi) Plan and design condition;
 - (xii) System operation indices and unit operation indices;
 - (xiii) Outline of system operation (Civil, Mechanical & Electrical);
 - Summary
 - Table of facilities
 - (Tag number, Type, Number, Nominal bore, capacity, motor rating, and weight)
 - c) Outline of component and its aim (Civil & Mechanical);
 - (i) Normal operation
 - (ii) Emergency operation
 - (iii) Selection of facility
 - (iv) Selection of Auto/Manual mode
 - (v) Notice of danger/peril/hazard
 - d) Verification items of system operation mode (Civil & Mechanical);
 - (i) Before start of system operation
 - (ii) Start of system operation
 - (iii) During regular operation
 - (iv) Set value of level sensors and safety pressure on safety devices
 - (v) Position of plant/equipment on the selected mode
 - (vi) Remove potential danger/peril/hazard
 - e) Detail of facility/equipment component (Civil & Mechanical);
 - (i) Summary
 - (ii) Specification
 - (iii) Outside dimension
 - (iv) Weight, quality of material
 - (v) Outside drawing

- (vi) Graph, charts, performance curve, table
- (vii) Photo after installation
- f) Verification items of component operation (Civil & Mechanical);
 - (i) Preparation before the operation
 - (ii) Starting operation flow
 - (iii) Normal operation
 - (iv) Set value of level sensors and safety valves
 - (v) Emergency maintenance
 - (vi) Notice of danger, peril, hazard
- g) Outline of component and its aim (Electrical);
 - (i) Verify income power Hz, Kwh
 - (ii) Verify output from cogeneration Hz, Kwh
 - (iii) Ordinary line or Emergency line operation
 - (iv) Detail and full operation procedure
 - (v) Select standby generator
 - (vi) Emergency operation
 - (vii) Selection of facility
- h) Verification items of system operation mode (Electrical);
 - (i) Before start of system operation
 - (ii) Start of system operation
 - (iii) Set value of level sensors and protection
 - (iv) Select Auto/Manual mode on central control panel
 - (v) Remove potential danger/peril/hazard
 - i) Detail of facility component (Electrical);
 - (i) Summary
 - (ii) Specification
 - (iii) Single line diagram
 - (iv) Panel dimension
 - (v) Weight, quality of material
 - (vi) Outside drawing
 - (vii) Graph, charts, performance curve, table
 - j) Facility verification items (Electrical);
 - (i) Preparation before the operation
 - (ii) Select Normal operation or Emergency operation
 - (iii) Select equipment operation mode/switch by Auto /manual
 - (iv) Before start of system operation

- (v) Start of system operation
- (vi) Set value of level sensors and protection
- (vii) Remove potential danger/peril/hazard
- (viii) Notice of danger/peril/hazard
- k) Standard;
 - (i) Emission control
 - (ii) Noise and vibration
 - l) Fire/explosion protection
- m) Frequency of sampling, analysis and evaluation;
 - (i) Regulated pollutants
 - (ii) Operation index
 - (iii) Water temperature
 - (iv) Water pressure
 - (v) Water quality
- n) Maintenance schedule (Mechanical & Electrical);
 - (i) Routine work
 - (ii) Regular work
 - (iii) Manufacturer recommendation
- o) Maintenance schedule (Civil);
 - (i) Routine work
 - (ii) Regular work
 - (iii) Manufacturer recommendation
- p) Troubleshooting guide (Phenomenon/action/comments);
 - (i) Mechanical equipment
 - (ii) Electrical equipment
 - (iii) Case study or/and previous experiences (Normal troubleshooting)
- q) Operation / test data
 - (i) Operation index
 - (ii) Mechanical site inspection data
 - (iii) Electrical site inspection data
 - (iv) Noise and vibration
 - (v) Water temperature
 - (vi) Power consumption
 - (vii) Operation cost during training period
 - (viii) Consumables, spare parts and its list
 - (ix) Photo of inspection (evidence)

- r) List
- (i) Equipment control
- (ii) Operation record formats
- (iii) Maintenance record formats
- (iv) Material control
- (v) Inventory
- (vi) Spare parts
- (vii) Safety and Health

B.7.3. INSPECTION AND TESTING DURING MANUFACTURE

B.7.3.1. GENERAL

All inspection and testing shall be carried out in accordance with the Specification and in absence of Specification relevant Indian Standard or internationally approved equivalent standard shall be referred to. After award of contract, Tender shall furnish QA plan which will be mutually discussed with the Employer and finalized. QA plan shall include test, on incoming supply of raw materials and bought out items, stage inspections and tests on finished products at manufacturer's works / appropriate testing station. QA plan shall clearly indicate tests which are intended to be witnessed by the Tender alone and those by both Tender and Employee.

The Contractor shall carry out at the place of manufacture tests of the Plant / Equipment at any part of the Works. The Employer shall be entitled to attend the aforesaid inspection and / or tests by his own duly authorized and designated representatives.

The Employer and his duly authorized representative shall have access to the Contractor's premises at all suitable times to inspect and examine the material and workmanship of the mechanical and electrical plant and equipment during its manufacture there. If part of the plant and equipment is being manufactured on other premises, the Contractor shall obtain permission for the Employer or his duly authorized representative, to inspect as if the plant and equipment was manufactured on the Contractor's own premises. Testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Employer's Representative who will have the right to witness or inspect the above-mentioned inspection / testing at any stage desired by him. Where inspection or testing is to be carried out at a subcontractor's works, a representative of the Contractor shall be present.

The procedure for the testing and inspection to be carried out during or following the manufacture of the materials to ensure the quality and workmanship of the materials and

to further ensure that they conform to the Contract in whatever place they are specified shall be as described below. The Contractor shall give the Employer at least 21 clear days notice in writing of the date and the place at which any plant or equipment will be ready for inspection / testing as provided in the Contract. The Employer or his duly authorized representative shall thereupon at his discretion notify the Contractor of his intention either to release such part of the plant and equipment upon receipt of works tests certificates or of his intention to inspect. The employer shall then give notice in writing to the Contractor and attend at the place so named the said plant and equipment which will be ready for inspection and / or testing. As and when any plant shall have passed the tests referred to in this section, the Employer's Representative shall issue to the Contractor a notification to that effect.

- a) The Contractor shall forward to the Employer 6 duly certified copies of the test certificates and characteristics performance curves for all equipment.
- b) If the Employer's Representative(s) fails to attend the inspection and/or test, or if it is agreed between the parties that the Employer's Representative(s) shall not do so, then the Contractor may proceed with the inspection and / or test in the absence of the Employer's Representative and provide the Employer with a certified report of the results thereof as per (ii) above.
- c) If any materials or any part of the works fails to pass any inspection / test, the Contractor shall rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice as per (i) above. Any fault or shortcoming found during any inspection or test shall be rectified to the satisfaction of the Engineer before proceeding with further inspection of that item. Any circuit previously tested, which may have been affected by the rectification work, shall be re-tested.
- d) Where the plant and equipment is a composite unit of several individual pieces manufactured in different places, it shall be assembled and tested as one complete working unit, at the maker's works.
- e) Neither the execution of an inspection test of materials or any part of the works, nor the attendance by neither the Employer's Representative(s), nor the issue of any test certificate pursuant to (iii) above shall relieve the Contractor from his responsibilities under the Contract.
- f) The test equipment, meters, instruments etc., used for testing shall be calibrated at recognised test laboratories at regular intervals and valid certificates shall be made available to the Employer's Representatives at the time of testing. The calibrating instrument used as standards shall be traceable to National / International standards. Calibration certificates or test instruments shall be produced from a recognised /

Laboratory for the Engineer's consent in advance of testing and if necessary, instruments shall be recalibrated or substituted before the commencement of the test.

- g) Items of plant or control systems not covered by standards shall be tested in accordance with the details and program agreed between the Employer's Representative and Contractor's Representative. If such materials or works are found to be defective or not conforming to the Contract requirements, due to the fault of the Contractor or his sub-contractors the Contractor shall defray all the expenses of such inspection and/or test and of satisfactory reconstruction.
- h) Tests shall also be carried out such that due consideration is given to the Site conditions under which the equipment is required to function. The test certificates shall give all details of such tests.
- i) The Contractor shall establish and submit a detailed procedure for the inspection of materials or any part of the works to the Employer for approval within the date indicated in the Programme Details. The detailed procedure shall indicate or specify, without limitation, the following:
 - (i) Applicable code, standard, and regulations.
 - (ii) Fabrication sequence flow chart indicating tests and inspection points.
 - (iii) Detailed tests and inspection method, indicating the measuring apparatus to be used, items to be measured, calculation formula, etc.
 - (iv) Acceptance criteria.
 - (v) Test report forms and required code certificates and data records.
 - (vi) Method of sampling if any sampling test to be conducted.
 - (vii) Contractor's or Employer's witness points.

The Contractor shall not pack for shipment any part of the Plant until he has obtained from the Employer or his authorized representative his written approval to the release of such part for shipment after any tests required by the Contract have been completed to the Employer's satisfaction.

- j) The following Inspection and Testing procedures shall be carried out for the equipment as applicable.
 - (i) Visual Inspection.
 - (ii) Dimension Checking
 - (iii) Dynamic balancing for all rotating parts
 - (iv) Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
 - (v) Operation check

- (vi) Liquid pen-entrant tests or magnetic particle tests for all machined surfaces of pressure parts.

The Contractor shall maintain proper identification of all materials used, along with reports for all internal / stage inspection work carried out, based on the specific job requirement and or based on the datasheets / drawings / specifications.

- (i) The expenses incurred during inspection shall include, but not be limited to all travelling, boarding, lodging and out of pocket expenses.
- (ii) For inspections within India, the Contractor shall incur all the expenses of Employer and Employer's Representative.
- (iii) For inspection outside India, the Contractor shall incur the expenses of Employer, Employer's Representative and delegates of Employer's Representative.
- (iv) However, cost of inspection when material or any part of the facilities is not ready at the time specified by the Contractor for inspection or when re-inspection is necessitated by prior rejection shall be borne by the Contractor and will not be reimbursed.

Inspection and testing witnessed by the Engineer (termed witnessed testing) shall be carried out at the manufacturer's works in accordance with the relevant clauses of the Conditions of Contract. Witnessed testing will normally be waived on standard types of equipment such as small motors made by approved manufacturers, individual standardized instruments, small mass produced components used in the manufacture of Plant items, small bore pipe work and fittings, minor installation materials and low voltage cable. In order to remove doubt this shall not relieve the Contractor of his obligation under the Contract to ensure that all Plant is tested at the manufacturer's works prior to delivery to Site.

As a guide to the Contractor the Engineer will require witnessing test the following, but not limited to the Plant items listed below:

- k) Electrical:
 - 33kV & 11kV Outdoor CT & PT Transformers;
 - PCC s, MCC s and switchboards;
 - capacitor banks with APFCR;
 - Motors
 - Control and Instrumentation:
 - plant control and HMI software systems;

control panels;

MIMIC

HMI s;

UPS s.

l) Mechanical:

All types of pumps;

Air vessels;

Compressors;

Valve and valve actuators;

Valves and non return valves greater than 300 mm diameter;

SS screens

Piping & specials

Water meters,

The Engineer reserves the right to be present during the testing of all items.

All apparatus, instruments and connections required for the tests shall have been tested for accuracy and safety and certified as such within the preceding six months.

Any equipment used in the testing of the Plant shall in all respects comply with the appropriate safety regulations and / or requirements regarding electrical apparatus for the safety of the Plant and the personnel working thereon.

B.7.3.2. FACTORY ACCEPTANCE TEST DOCUMENT

Fifty-six (56) days prior to commencement of inspection of each Plant item the Contractor shall supply a Factory Acceptance Test (FAT) Document for approval. This shall comprise four copies of the following:

- (a) Un-priced copy of the Contractors order for the Plant item concerned:
- (b) Details of the inspection and test procedures to be carried out.

The FAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The FAT shall provide space within the documentation for results of the tests to be added and for each test and for the FAT as a whole to be signed off by the Contractor and the Engineer.

On completion of the tests the Contractor shall provide four copies of all test certificates, curves etc. for the inspected Plant item. To remove doubt test certificates shall be

provided for the system item as a whole plus certificates for the relevant component parts such as:

- (a) motors;
- (b) pumps;
- (c) instruments;
- (d) gear boxes;
- (e) electrical switchgear rated in excess of 250 A;
- (f) integral control and switchgear panels;
- (g) valve gear;
- (h) Castings.
- (i) Pipe
- (j) All types of water meters
- (k) Manhole chambers with covers

Where witness tests are not required the test certificates and curves etc. shall be forwarded to the Engineer within two weeks of the tests being completed.

INSPECTION AND TESTING PROGRAMME

The Contractor shall not deliver Plant to Site without the Engineer's approval in writing. This permission will not be given unless amongst other things a valid Contractors test certificate and completed FAT document for the item of Plant concerned is in the possession of the Engineer.

The Contractor shall submit to the Engineer not later than 56 days prior to the commencement of the first inspection and test during manufacture a programme detailing the inspection dates for all Plant. Those items of Plant that the Engineer has specifically identified for witness testing test shall be highlighted in the programme.

The Contractor shall keep the Engineer informed of any changes to the programme.

The Engineer shall not be requested to inspect an item of Plant until the Contractor has satisfied himself that the equipment meets all requirements of the Employer's Requirements.

The Contractor shall inform the Engineer in writing at least 21 days in advance regarding readiness for carrying out inspection of equipment/material etc. at manufacturer's works or at places of inspection. The programme for inspection shall be finalised by the Engineer after the receipt of the above. In case inspection cannot be carried out due to non-readiness of equipment/material etc. a subsequent date shall be finalised for carrying out

the inspection in which event all expenses incurred by the Employer for such visits shall be recovered from the Contractor. In case equipment/material etc. is found not to comply with the specification, dates for re-inspection shall be finalised and expenses incurred by the Employer for such visits shall also be recovered from the Contractor. Contractor's Representatives shall essentially be present during all inspections. The following information shall be given in the inspection call letter mentioned above:

- (a) Name of manufacturer/supplier;
- (b) Address of place where inspection is to be carried out;
- (c) Proposed date/s and equipment to be inspected;
- (d) Name/s of contact personnel at manufacturer's/ supplier/s works with their telephone and fax numbers.
- (e) Name of Contractor's Representative who will be present during the inspection.
- (f) Confirmation that internal testing has been completed.
- (g) Testing Procedure with relevant codes and standards.

The Contractor shall provide all the necessary instruments, labour, chemicals, and all other materials to carry out the tests after assembly. All instruments used for such tests shall be calibrated and certified by and approved by an independent testing authority not more than six months prior to the tests in which they are used. Calibration certificates for instruments used for such tests shall be produced for the approval of the Engineer and if necessary, instruments shall be recalibrated before the commencement of the tests. No material shall be delivered to the Site without inspection having been carried out or waived in writing by the Engineer. If during or after testing, any item of plant fails to achieve its intended duty or otherwise proves defective, it shall be modified or altered as necessary and retested and re-inspected as required by the Engineer.

B.7.3.3. MANUFACTURER'S WORKS ACCEPTANCE TESTS ON MECHANICAL EQUIPMENT

The Contractor shall carry out further specified tests (but not limited to) as follows in addition to any tests stated or implied by the foregoing sections of this clause.

Pumps

Manufacturers standards test certificates will be acceptable for small centrifugal pumps rated for powers of 25 kW or less. All other pumps shall be tested individually in accordance with the relevant international standard. Site conditions shall be simulated as near as possible including the NPSH condition. Pumps shall be tested with their own prime movers. Where it is impractical to include the full length of the connecting shaft, the

Contractor shall state the allowances to be made for the losses incurred by its omission and shall demonstrate the accuracy of the allowances to the satisfaction of the Engineer. Each centrifugal pump shall be tested on the manufacturer's premises individually, in accordance with the provisions of BS EN ISO 9906:2000 with clean, cold water. Each and every rotating part / assembly / sub-assembly shall be dynamically balanced as per grade G6.3 of ISO 1940/1 - 1986.

Each pump shall be tested at its guaranteed duty point and over its full working range from its closed valve condition to 20% in excess of the specified quantity at minimum head. Tests shall provide information for performance curves to be drawn for: head / quantity, efficiency / quantity, power absorbed/quantity and net positive suction head/quantity.

Pump casings shall be subject to a pressure test at 2.0 times the pressure obtained with the delivery valve closed. The positive suction head shall be taken into account in determining this pressure. Performance characteristics of motors used during testing shall be furnished prior to commencement of tests. In addition to confirming the hydraulic performance of the pump set as specified, the test shall demonstrate that vibration is within the specified limits and that the mechanical performance is satisfactory. However, for the purpose of the Performance Guarantee, noise and vibration levels shall be demonstrated at site to be within acceptable limits.

Valves

Type test certificates will be acceptable for valves sized 300 mm diameter or less. All valve bodies shall be hydraulically tested closed ended to (minimum) 1.5 times the rated pressure in accordance with the appropriate standards. Satisfactory operation of manual / motorized and pneumatic actuators with valves shall be demonstrated.

Butterfly valves with rubber seats shall be tested to the maximum differential pressure, at which pressure they shall be drop-tight. Filter outlet control valve type testing shall be witnessed.

During testing there shall be no visible evidence of structural damage to any of the valve component.

Motorized valves shall be tested with their actuators, with a differential head equivalent to their maximum working pressure, to prove that the actuators are capable of opening and closing the valves under maximum unbalanced head condition within the specified opening or closing period.

The following test shall be carried out for sluice valves:

- (a) Seat leakage test at rated pressure
- (b) Body hydrostatic test at 1.5 times the rated pressure
- (c) Valve operation

The following test shall be carried out for non-return valves:

- (d) Seat leakage test at rated pressure
- (e) Body hydrostatic test at 1.5 times rated pressure
- (f) Operation

Plant Items

All plant items shall be tested to ensure they meet the Employer's Requirements for quality of workmanship, construction and performance.

Ventilation system

The ventilation fans shall be tested at manufacturer's works to verify the design flow and pressure. Internal test certificates shall be furnished.

Other equipment

For all other equipment other than those specified above, functional test shall be carried out at site prior to commissioning.

Cranes & Hoists

Cranes shall be completely assembled and tested for all operations in accordance the relevant international standard. Internal Test certificates shall be furnished. Hoists and lifting equipment shall be assembled and tested at the place of manufacture in accordance with IS 3938. Each and every rotating part/assembly/sub-assembly shall be dynamically balanced as per grade G16 of ISO 1940/1 - 1986.

Motors

Condition of winding insulation be tested, and insulation values shall be restored to required level by suitable heating arrangements locally.

Cranes

The crane and lifting tackle shall be tested to 125 % of the safe working load. The Contractor shall arrange the test load.

PIPE WORK

The inspection and testing of all pipe work shall be carried out in accordance with the appropriate standards approved by the Engineer.

Ductile iron pipes

a) Mechanical Tests

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in relevant IS codes. The results so obtained shall be considered to represent all the pipes and fittings of different sizes manufactured during that period and the same shall be submitted to the Employer's Representative. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per relevant IS codes.

b) Brinell Hardness Test

For checking the Brinell hardness, the test shall be carried out on the test ring or bars cut from the pipes used for the ring test and tensile test in accordance with IS 1500.

c) Retests

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

d) Hydrostatic test

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in relevant IS codes for 15 seconds, they may be struck moderately with a 700 g hammer. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before coating the pipes and fittings.

Pumps, piping and valves

- a) The erected pipe work shall be subjected to a hydraulic test at 1.5 times the maximum pressure or twice the working pressure whichever is higher to test the soundness of the joints. Provision of the necessary pumps, gauges, blank flanges, tappings etc. for carrying out these tests shall be included in the Contract. All gas piping shall be air tested to twice normal working pressure.
- b) Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.
- c) Operating tests shall be conducted on valves.
- d) The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within the specified limits.

B.7.3.4. MANUFACTURER'S WORKS ACCEPTANCE TESTS ON ELECTRICAL EQUIPMENT

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause.

Switchgear and Motor Control gear Assemblies

Switchgear and control gear shall be witness tested as complete assemblies. Factory built assemblies of LV switchgear and control gear shall be tested in accordance with relevant Indian Standards. Additionally, switchgears and control gear assemblies shall be tested for the following.

- a) Interchange ability
- b) All components of the same rating and construction designated as draw out or plug-in shall be demonstrated as being interchangeable.
- c) Protection and control circuits

For all forms of current transformer protection, the following information, as applicable shall be made available to the Engineer before the time of inspection:

- a) Current transformer magnetising curve.
- b) Recommended relay setting.
- c) Calculated primary operating current at this setting
- d) Calculated through-fault stability values where applicable.
- e) Values of any stabilising and setting resistors employed in the system. As far as possible, based on the completeness of the circuits, in the final manufactured form within manufacturer's premises, the satisfactory operation of associated control and protection circuits shall be proved by the following tests as applicable.
- f) To ensure the correct operation of all relays and coils at the recommended setting by current injection.
- g) To ensure the correct polarity between current and voltage elements of power relays, meters and instruments.

The following tests shall be carried out:

- a) Dielectric tests at an approved voltage/s.
- b) Primary injection tests to ensure correct ratings and polarity of current and voltage transformers and of the current operated protection relays and direct acting coils, over their full range of settings.
- c) Tests on auxiliary relays at normal operating voltages by operation of associated remote relays.
- d) Correct operation of sequencing and control circuits at normal operating voltages by operation of local control switches, and simulation of operation from remote control

positions.

- e) Correct functionality of the equipment in all modes of control.

Cables

All cables and armoured cables shall be subject to routine and acceptance tests in accordance with the relevant Indian Standards. Test certificates shall be provided against each drum and / or cable length.

The tests carried out on every cable length and / or drum at manufacturer's premises shall include:

- a) High voltage dc insulation pressure test, between cores, each core to earth, metallic sheath or armour as applicable;
- b) Insulation resistance test;
- c) Core continuity and identification;
- d) Conductor resistance test.

Motors

The manufacturer's type test certificate will be accepted for motors rated at less than 55 kW. A type test certificate and an individual motor test certificate shall be provided for all other motors. All type test certificates shall be not later than 3 years. Electric motors shall be subjected to routine and acceptance tests in accordance with relevant Indian Standards.

It will be responsibility of the Contractor to select sizes, and types of motors to suit the starting and running characteristics of driven equipment with due consideration for specified margin over the requirement of the driven equipment at duty point. Motors not complying with the above shall be replaced by the Contractor at his own cost by appropriate motors. Replacement motors shall undergo testing and inspection as per the provisions in the contract. Cost of such testing and inspection shall be to Contractor's account. The motor rotor assembly shall be dynamically balanced as per grade 6.3 of ISO 1940/1-1986.

Manufacturer's Works Acceptance Tests on PLC s and Associated Equipment

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause. The tests shall be carried out on the fully assembled control panel containing the PLC and associated equipment in order to demonstrate correct functional operation of the hardware and software systems. The Contractor shall prepare for the approval of the Engineer a detailed Factory Acceptance Test (FAT) document that shall fully detail the scope of the tests to be carried

out and the tests themselves. The tests shall encompass the normal modes of operation and failure modes and shall demonstrate correct functionality of the system or systems in accordance with the Functional Design Specification (FDS).

The PLC program or programs shall be tested by means of a test rig designed to input and receive digital and analogue signals. Using this test rig it shall be possible to fully simulate the operation of the controlled equipment in order to demonstrate correct functional operation of the hardware and software systems. The analogue to digital conversion shall be tested by means of a calibrated current source, digital to analogue outputs shall be tested by means of ramping the output channel and measuring the current by means of a calibrated current meter.

All inputs and outputs to the PLC and associated equipment shall be made through the field terminal connections of the control panel containing the PLC and associated equipment.

Manufacturer's Works Acceptance Tests on Uninterruptible Power Supplies

The Contractor shall carry out further specified tests as follows in addition to any tests stated or implied by the foregoing sections of this clause. The tests shall be carried out on the fully assembled unit utilizing the batteries that are to be supplied with the unit. The Contractor shall demonstrate the following:

- (a) Change-over from full load with mains present to full load on battery supply;
- (b) Carry out a discharge test on the system at full load and for the specified duty bridging time period;
- (c) Carry out recharge test after operation for the specified duty bridging time at full load.

The UPS shall supply the full load during the recharge cycle.

Inspection at Site

In addition to the progressive supervision and inspection by Employer the Contractor shall offer for inspection to Engineer, the completely erected system / part of system on which tests are to be carried out. After such inspection by Engineer, each equipment/sub-system shall be tested by the Contractor in accordance with the applicable standards in the presence of Engineer. Such tests shall include but not be limited to the tests specified in following clause.

The Contractor shall possess during the entire working period the Electrical Contractor's license of appropriate class from the concerned statutory authorities governing the area of workplace. The Contractor shall fully comply with the relevant statutory rules and regulations. On completion of the installation or at intermediate stages, if required by the statutory authorities, the Contractor shall arrange for inspection and obtain the approval

from the concerned statutory authorities. If any fees are to be paid to statutory authorities for testing, inspection, and calibration these shall be paid by the Contractor and shall be included in his erection and commissioning charges.

Plant Protection on Site

Factory finished plant shall be adequately protected both before and during installation against damage to finished surfaces, fitted components, and the ingress of dust. It may be necessary for structural finishing operations to be carried out in the vicinity of installed plant before it is taken over and the Contractor shall take this into consideration in complying with the requirement of this clause.

Erection Staff

The Contractor shall provide at least two approved senior English speaking working erectors to supervise the erection of all system in the Contract. The Contractor shall also provide sufficient erectors skilled in electrical, mechanical and instrument engineering, with such skilled, semi-skilled and unskilled labour as are necessary to ensure completion of the various sections of the Contract in the time required. The Contractor shall not remove any supervisory staff or labour from the site without the prior approval of the Engineer.

The Contractor shall make all the necessary arrangements to ensure that sufficient plant has been or is about to be delivered to site, so that there shall be no delay to the start of erection. It shall be the responsibility of the CONTRACTOR to obtain necessary Licence / Authorization / Permit for work from the Licensing Boards of the Locality / State where the work is to be carried out. The persons deputed by the CONTRACTOR's firm should also hold valid permits issued or recognized by the Licensing Board of the Locality / State where the work is to be carried out.

B.7.3.5. ERECTION AND BUILDING

a. General

The installation work shall comply with the latest applicable Standards, Regulations, Electricity Rules and Safety Codes of the locality where the installation is to be carried out. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

It will be the CONTRACTOR's responsibility to obtain approval / clearance from local statutory authorities including Electrical Inspector, wherever applicable for conducting of any work or for installation carried out which comes under the purview of such authorities. The Contractor shall carry out the complete erection of all system, including the provision

of all necessary skilled and unskilled labour, material, transportation, supplies, power and fuel, Contractor's Equipment and appurtenances necessary, for the complete and satisfactory implementation of the system.

The CONTRACTOR shall have a separate cleaning gang to clean all equipment under erection and as well as the work area and the project site at regular intervals to the satisfaction of the Engineer. In case the cleaning is not up to the Engineer's satisfaction, he will have the right to carry out the cleaning operations and any expenditure incurred by the Engineer in this regard will be to the CONTRACTOR's account.

b. Erectors

The Contractor's employees shall include skilled erection staff in sufficient number, who shall arrive on the site on or before the respective dates set out in the approved work programme and prior to delivery of any item of Plant to the Site. The Engineer will not entertain any claim by the Contractor in respect of delayed erection due to a delay in the delivery of any items of Plant to the site.

Contractor's Equipment, materials, and appurtenances

The Contractor shall have available on the Site sufficient suitable equipment and machinery, as well as all other materials and appurtenances required by him, of ample capacity to ensure the proper erection of system and to handle any emergencies such as may normally be expected in work of this character. The CONTRACTOR shall be responsible if any installation materials are lost or damaged during installation. All damages and thefts of equipment/component parts, after takeover by the CONTRACTOR, till the installation is taken over by Engineer shall be made good by the CONTRACTOR.

c. Workmanship

System shall be erected in a neat and workmanlike manner at the locations and elevations shown on the approved drawings and other engineering documents. Unless otherwise directed by the Engineer the Contractor shall adhere strictly to the drawings and no departures there from will be permitted. All system shall be correctly aligned, levelled and adjusted for satisfactory operation and shall be installed so that the proper and satisfactory connection can be made readily between the various units and pipe work and equipment installed under the Contract.

d. Building-in

Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of system are to be installed, and shall bring any deviations from the required positions, lined or dimensions to the notice of the Engineer and shall take such measures as are necessary for their correction.

The Contractor shall take particular care for the correct positioning and alignment of all pipes which are required through concrete structures prior to, and during the pouring of concrete. The Contractor shall pin and plug in the holes prepared, all small clips, plugs, screws, nails, sleeves, inserts, etc., required for fixing electric wires and conduits, pipe work and all other apparatus.

The Contractor shall align all equipment and holding down bolts and shall inform the Engineer before proceeding with grouting-in the item or item concerned. The Contractor shall ensure that all equipment is securely held and remain in correct alignment before, during and after grouting-in.

The Contractor shall properly bed in cement grout each item of plant or its supporting base resting on foundations and shall grout-in where required holding down bolts placed in the holes prepared in the foundations. The materials and workmanship used in grouting shall be such as will result in a solid anchoring of foundation bolts and complete filling of the gaps between the Plant or its base and the foundations, without shrinkage or cracking.

e. Precautions

The approval by the Engineer of the Contractor's proposals for rigging and hoisting of any item of system into its final position shall not relieve the Contractor from his responsibility for avoiding damage to completed structures, parts or members thereof or other installed equipment. He shall at his own cost make good, repair or replace any damaged or injured items whether structural, mechanical, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Engineer.

Inspection after Erection

After the erection of any item of system and its associated equipment has been completed, it shall be offered to the Engineer for inspection in its static state prior to commissioning the item. Completion of erection and procedure prior to setting to work.

The mechanical completion of plant under erection shall be deemed to occur if all the units/systems of the Works are structurally and mechanically complete as noted below:

- All rotary, static, structural equipment, piping, electrical / instrumentation and other equipment under the scope of the Contract have been erected, installed and grouted and are as per the specifications.

- All systems have been washed/flushed/drained/boxed up where necessary.
- All system testing including pressure, vacuum and non-destructive tests, no load tests and such other tests are completed with safety valves / relief valves set to operating conditions installed in position.
- All panels, local control desks erected with power / control cable terminations with all continuity checks, insulation checks and other installation checks are carried out.

Prior to pre-commissioning checks, the Contractor shall erect the entire system and ensure readiness of civil works to the satisfaction of Engineer, so that the Works are physically ready to undergo pre-commissioning checks. Pre-commissioning checks will include checks like no-load running of machinery, checks on instruments and electrical including calibration and loop checks, functional checks, inter-lock checks etc.

At the stage of mechanical completion of erection, the Contractor shall ensure that all the physical, aesthetic and workmanship aspects are totally complete, and the Plant is fit and sound to undergo pre-commissioning checks.

The following documentation shall be completed before the Contractor notifies Mechanical Completion of Erection to the Engineer:

- (a) All shop inspection records updated, As-built drawings compiled and bound in 4 (four) copies.
- (b) All erection and commissioning procedures duly approved.
- (c) All instruction manuals in draft form - with each sheet bearing a stamp to indicate "DRAFT FOR REVIEW ONLY" submitted in 4 (four) copies.

Upon achieving mechanical completion, the Contractor shall notify the Engineer of such completion of section / units / systems and readiness for inspection for acceptance of mechanical completion of erection. The Engineer shall proceed with inspection of such sections/units/systems within 10 days of such notice.

Consequent to inspection, the Engineer will inform the Contractor a list of deficiencies for rectification and the Contractor shall complete the rectification work within a jointly agreed period prior to start of pre- commissioning tests. The erection period allowed by the Contractor shall include all activities of mechanical completion as noted above.

B.7.4. GENERAL PAINTING AND PROTECTION REQUIREMENTS

B.7.4.1. GENERAL

The preparation, application and conditions for work shall comply with the recommendations of BS 5493 and BS 6150 or if the protection is of a special nature, in accordance with the manufacturer's directions. Paints, primers and undercoats shall be

obtained from the same manufacturer and except where a definite time is specified between mixing and application, shall be ready mixed for use. They shall be compatible with one another.

Paints shall be delivered in sealed containers bearing the manufacturer's name, batch number, etc. and shall carry a label giving details of quality and instructions for use. No site painting shall be carried out unless the surface to be painted is dry, the air temperature above 4°C and the relative humidity less than 85%. The Engineer shall approve the methods for removing all dirt, oil, grease, etc, before Site painting commences. Test plates carrying finishes from the actual coating used may be required by the Engineer for inspection and test purposes. To facilitate inspection, no consecutive coats of paint shall be of the same shade except in the case of white. Priming to two mating surfaces shall be applied prior to assembly.

All items of system shall be delivered to Site with the shop paint finish applied unless specified otherwise. A further coat of final finish paint shall be applied at Site, of sufficient thickness to produce a uniform colour and appearance. Such painting shall be carried out within one month of successful acceptance trials for the system components. All paint thicknesses shall be checked using an alkometer or equivalent instrument, supplied by the Contractor, for each layer of paint, to the reasonable satisfaction of the Engineer.

B.7.4.2. COLOUR CODING AND LABELLING OF PIPES AND EQUIPMENT

All pipes and equipment shall be colour coded to a schedule to be agreed with the Engineer before any site painting starts, or earlier if necessary to suit manufacturing procedures. Valves and fittings shall be painted in the same colour as the pipe of which they form a part. Where a pipe enters or leaves a piece of equipment the pipe colour shall extend up to but not including the flange attached to the equipment. All pipelines shall be identified by stick-on 90-micron thick vinyl film labels showing the name of the material to be carried by the pipeline and an arrow indicating the direction of flow. Letters of titles shall be pre-spaced on carrier tape and the complete title protected by one-piece removable liners. Titles shall be at intervals not less than 8 m but shall in any case be provided in every space through which the pipe passes. Locations of labels shall be subject to prior approval by the Engineer. Lettering sizes shall be between 16 mm and 75 mm in height depending on the size of the pipe.

Pipes smaller than 22 mm outside diameter shall be labelled by use of tags instead of labels. Tags shall be made of brass no smaller than 65 mm x 16 mm by 1.5 mm thick,

with lettering etched and filled with black enamel. Titles shall also be provided on all equipment in locations and in sizes to be approved by the Engineer.

B.7.4.3. CLEANING AND PREPARING AT PLACE OF MANUFACTURE

The Contractor shall be responsible for cleaning and preparation for painting, priming or otherwise protecting as specified of all parts of the Plant at the place of manufacture prior to packing.

a) Cleaning

Parts shall be cleaned prior to testing at the manufacturer's works. Parts subject to hydraulic test shall be tested before any surface treatment. After test all surfaces shall be thoroughly cleaned and dried out if necessary, by washing with an approved dewatering fluid prior to surface treatment.

b) Preparation

- (i) Bright parts: Bright parts and bearing surfaces shall be thoroughly polished and protected from corrosion by the application of rust preventive lacquer or high melting-point grease, as approved by the Engineer, before the parts are packed. A sufficient quantity of the correct solvent for removal of the protective compounds shall be supplied and packed with each particular part.
- (ii) Embedded parts: Embedded parts or those parts of an assembly which will be embedded in concrete shall be thoroughly descaled and cleaned to the satisfaction of the Engineer and before being packed shall be protected by a cement wash or other approved method. No cast iron or steel work shall be bitumen or tar coated where it is to be cast into the concrete and provision shall be made for cleaning off any portions so coated.
- (iii) Grit or shot blasted parts: Grit or shot blasting shall be carried out in accordance with B.S. 7079 to a standard between 'First Quality' and 'Second Quality' given in Table 1 after which the maximum amplitude of the surface shall not exceed 0.1 mm.

Cast Iron and Steel pipe work: All un-galvanized steel pipe work including pump suspension mains, bearing spiders and tunnel tubes shall be prepared internally and externally by grit or shot blasting as specified above and the surfaces primed as specified within four hours of blasting.

B.7.4.4. PAINTING AND FINISHING AT PLACE OF MANUFACTURE

This Clause governs the methods for the protective coatings to be applied to structural steel, metal work and ironwork as corrosion protection systems. The systems designed as specified here shall be applied as specified under Protective Coatings. Protective coating specified elsewhere for particular works such as pipes and cladding shall firstly be designed in accordance with particular requirements specified elsewhere and secondly in accordance with any requirements herein which are not overridden elsewhere.

This specification makes reference to the following standard:

B.S.5493 "code of practice for the protective coating of iron and steel against corrosion"

The Contractor shall design each protective coating system and shall submit details of each system to the Engineer for approval. Submissions shall where possible be in the format of which examples are given at the end of this section with such additional information and samples as the Contractor may provide or the Engineer may require to enable the system to be assessed.

Protective coating shall be designed in accordance with B.S. 5493 to have a long life, generally of at least 10 years to first maintenance. Protection systems shall be chosen to be easily maintained in the future and to allow non-specialist on-site re-coating where necessary using single part paints.

For the purposes of system design the general environment shall be as specified in B.S. 5493 Table 3 Part 2 'Exterior exposed polluted inland'. Bulkhead gates and stop logs shall be assumed to be exposed to a Table 3 Part 8 'Non-saline water' environment unless otherwise approved by the Engineer.

Interior spaces shall be considered to be dry in administration areas open to continuous access and damp or immersed in other spaces. The protective coating of components or structures which are continuously or infrequently immersed shall be designed for the more onerous of these two conditions relevant to the protection system used.

All exterior exposed items to be coated shall have a final coat of good appearance of a colour and type as approved by the Engineer.

Protective coating systems shall generally fall into one of the following basic systems;

- a) galvanizing;
- b) galvanizing plus painting;

- c) multi-coat painting;
- d) bitumen enamel;
- e) others as proposed by the Contractor and approved by the Engineer.

The Contractor shall submit to the Engineer details of his proposals for the corrosion protection of each of the items requiring such protection, which will generally fall into the above categories as follows:

- a) trash screens, flooring, ladders, access covers and frames, step irons and other components which are inaccessible but subject to abrasion / damage.
- b) structural steelwork (including crane beams, monorails, crane structures and chassis), bulkhead gates, stop logs, grappling beams, steel tanks and other large items readily accessible for maintenance;
- c) valves and other corrosion-susceptible items which may be buried and are not covered by the provisions of other specifications ;
- d) other components not covered by the above for which the contractor may propose a system which he considers to be more suitable for the duty;
- e) Electrical switchgear, transformers, control panels etc.
- f) All painting material shall be applied in strict accordance with the paint manufacturer's instructions.

Plant supplied to site with final coating applied:

Before any steel work is painted the steel must be thoroughly cleaned and an approved anti-rusting priming coat applied so that the possibility of rusting or corrosion taking place is negligible. All surfaces should have not less than two stoved undercoats and two topcoats or air-drying paint. The undercoats shall be easily distinguishable in shade or colour from the priming and finishing coats. The two final coats shall be in a colour and finish to be advised by the Engineer. The inside surfaces of any cubicles, cabinets etc. where condensation is liable to occur, shall be coated with an approved anti-condensation composition. The Contractor shall ensure that all component sections of a switch board wherever manufactured shall have a finish of uniform texture and an exact colour match.

- a) Chromium plated parts:

Where chromium plating is specified or offered by the manufacturer it shall comply with the requirements of B.S. 1224 including the following provisions. No blistering of any surfaces will be tolerated. The finished appearance shall be brought. Where the base metal is steel, plating shall be applied in accordance with Table 2. Other base metals shall be plated in accordance with Tables 3, 4, 5 as appropriate. For all base metals the service

condition number 2 shall be used. Small bore pipes, valves and fittings etc., which are sited in architecturally finished areas of the station and selected by the Engineer shall be chromium plated. Damage to chromium plating shall be made good before taking over.

b) Galvanized parts:

All materials to be galvanized shall be of the full dimensions shown on the approved drawings or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanizing process begins. Parts to be galvanized shall be shot blasted as specified above. Such parts shall be galvanized not more than four hours after commencement of shot blasting.

All galvanizing shall be done by the hot dip-process. No alternative process may be used without the approval of the Engineer. No components shall be galvanized which are likely to come into subsequent contact with oil. The zinc coating shall be uniform, clean smooth and as free from spangle as possible. In the case of component parts, the zinc coating shall weigh not less than 610 g/sq.m of area covered and shall not be less than 0.090 mm in thickness.

Bolts and nuts shall be sherardized. The Engineer may select for test as many components to be weighed after pickling, and before and after galvanizing as he may think fit. All galvanized parts shall be protected from injury to the zinc coating due to differential serration and abrasion during the periods of transit, storage, and erection. Damaged areas of the coating shall be touched up with an approved zinc-dust paint or other approved flake metallic compound.

c) Cast iron and steel pipe work: (Internal surfaces):

The internal surfaces shall have an approved coating. Where a bitumen-based coating is used, it shall be in accordance with Type 2 of B.S. 4147.

Prior to lining, the pipe shall be grit blasted and primed with an approved primer. The lining shall be in accordance with B.S. 534. After installation, the internal lining shall be made good and satisfactorily tested with a Holiday detector to 8 KV.

The coating shall be suitable for use in contact with drinking water. The type of coating shall be entered in Schedule L provided and the Engineer reserves the right to call for test plates of the paint. The manufacturer shall at the time of ordering carry out the 'Taste and smell test' (Appendix E of B.S.4147) and 'Effects on water test' (Appendix C of B.S. 3416) and forward 3 copies of the test results to the Engineer for approval.

Where pipe are to be welded after the protective coatings have been applied the pipe surfaces shall be primed and all other coating stopped 250 mm short of the weld

preparation. Collars and fillings shall be primed but no other coating applied. The manufacturer shall supply a sufficient quantity of suitable materials to repair damage occurring during delivery to site and to provide a flush finished internal lining at welded joints. He shall supply sufficient coating to fill in the recesses at internal welds over the previously primed areas. The coating shall be applied in accordance with the manufacturer's instructions and with Appendices J and K of B.S. 3416.

Machinery- (Internal surfaces) e.g., pumps, valves, strainers, rising and suspension mains of wet well pumps:

As for cast iron and steel pipe work (Internal surfaces).

Cast iron and steel parts (External surfaces) immersed in Water:

All un-galvanized metal parts which will be immersed in water shall be cleaned by grit blasting and within four hours of blasting given an approved coating.

Cast iron and steel (External surfaces) in manholes and areas of high humidity.

Ungalvanized metal parts exposed in manholes or areas of high humidity shall be cleaned by grit blasting and given two coats of a black bituminous solution.

d) Plant forwarded to site for final finishing.

Cast iron and steel parts (External surfaces) outside buildings:

All un-galvanized metal parts which will be exposed to the outside atmosphere shall be cleaned by grit blasting and provided with two coats of an approved primer.

Cast iron and steel parts inside buildings:

All exposed metal surfaces which will not be immersed in water or exposed in areas described above shall be rubbed down, cleaned by grit blasting and within four hours of blasting given one coat of an approved primer before packing.

B.7.4.5. PAINTING AT SITE

Immediately on arrival at the site, all items of plant shall be examined for damage to the paint coat applied at the manufacturer's works, and any damaged portions shall be cleaned down to the bare metal, all rust removed, and the paint coat made good with similar paint.

Steel and cast-iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating or Polyurethane coating as specified & approved, to a total dry film thickness of minimum 275 microns including the primer coats. All sharp edges, nuts, bolts and other items difficult to be painted shall receive a brush coat of specified paint before application of each coat of epoxy-based coal tar paint giving

a total dry film thickness of at least 275 microns. In the case of fabricated steelwork this work shall be done after assembly.

Before painting is commenced the Contractor shall submit for the approval of the Engineer, full details of the paints he proposes to use together with colour charts for the gloss finishes. After erection, such items which are not finish painted shall be finish painted, items finish painted at the Manufacturer's works shall be touched up for any damaged paint work. The painting work shall conform to the following requirements:

- a) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005
- b) The surface preparation shall be carried out generally in accordance with IS: 1477 Part I and IS: 6005
- c) After surface preparation, two coats of primer-red oxide zinc chromate with modified phenolic alkyd base conforming to IS: 2074 shall be applied. Dry film thickness of each coat shall be 25 microns.
- d) For finish painting, after application of primer as in (b) above, two coats of synthetic enamel conforming to IS: 2932 shall be applied. Dry film thickness of each coat shall be 25 microns.
- e) Colours shall be selected as per IS: 5

No painting shall be carried out unless the item has been inspected and accepted by Engineer at the Manufacturer's works. The dry paint film thickness shall be measured by Electrometer or other instruments approved by the Employer. In order to obtain the dry film thickness DFT specified, the Contractor shall ensure that the coverage rate given by the paint manufacturer will enable this thickness to be obtained. Strength of adhesion shall be measured with an adhesion tester and this value shall not be less than 10 kg/cm². Painted fabricated steel Work which is to be stored prior to erection shall be kept clear of the ground and shall be laid out or stacked in an orderly manner that will ensure that no. poles of water or dirt can accumulate on the surface. Suitable packings shall be laid between the stacked Materials. Where cover is provided, it shall be ventilated.

- f) The painting procedure shall be submitted in the following format for approval:
 - Surface Preparation
 - Reference Standard
 - Conditions of Work

- Type of Materials
- Tests and inspection methods and sequence, thickness (DFT)
- Colour in final coat
- Total thickness of coats (DFT)
- Other necessary data and information
- The following items in the plant are required to be painted;
- Outer surfaces of pumps, valves, pipes, fittings, motors etc., not exposed to treated water.
- Steelwork exposed to weather, such as outer surface of surge vessel, valves, pipes etc.
- Internal Plant and pipe work, cranes, exhaust fans, fire extinguishers and miscellaneous steelwork not exposed to weather.
- Steelwork exposed to weather, such as platforms, ladders, hand railing, etc.
- Steelwork exposed to humid weather and requiring hard maintenance and repairs.
- Buried steelwork.
- Buried pipes and fittings prior to application of wrapping.
- Other equipment, as per requirement of employer.

All buried steel pipes and fittings shall be coated and unwrapped with hot or cold applied, self-adhesive, polyethylene in accordance with AWWA C214 or equivalent Standard.

Cast iron or mild steel parts to be built into concrete shall remain unpainted. Immediately before it is cast in-situ, it shall be made perfectly free from dirt, scale, loose rust, paint, oil limewash or any other coating. No blast cleaning or painting shall be applied to corrosion resistant Materials such as stainless steels. Ni-resist cast iron, bronze and other metals used for seals, bearings, lighting fitting etc.

Machined surfaces such as gear teeth shall be coated with a thick layer of grease. Other mechanical surfaces such as shaft ends, or other bright parts shall be coated with two coats of an anti-rust solution which can be removed easily when required. Permanently bolted mechanical interfaces such as flanges shall be coated with a thin coat of anti-rust compound before assembly. All primers, under coats and finishes shall be applied by brush or airless spray, except where otherwise specified.

Consecutive coats shall be in distinct but appropriate shades. All paints shall be supplied from the store to the painters, ready for application, and addition of thinners or any other Material shall be prohibited. Any instruction given by the paint manufacturer shall be strictly followed.

All painting shall be carried out by the painters under supervision. Paint shall be applied to the dry surface which has been prepared in compliance with the approved procedure. Paint shall not be supplied when the ambient temperature falls below 4°C or relative humidity rises above 90%. The Plant and equipment shall be inspected and reviewed at the various stages of the coating application both at the manufacturer's Works and at the Site of the Works. Samples may be taken from the paints as delivered and submitted to such tests as are deemed necessary. The completed paint systems shall be tested by instruments to ensure that the protection is of adequate thickness and is free from pinholes and the direct measurement of adhesion shall be checked by the removal of a small section of the coating. The Contractor shall supply all instruments and apparatus required for carrying out such tests required by the Employer.

B.7.4.6. WATERWORKS FINISH

A high standard of finish, defined as "Waterworks finish" is required for all Plant as detailed below.

B.7.4.6.1. WELDING AND FLAME CUTTING

A smooth neat finish, by careful grinding if necessary is required on all exterior welding and flame cutting. All plates and bars used in fabrication shall have smooth surfaces with no pitting or deep slag inclusions.

B.7.4.6.2. CASTINGS

Casting surfaces shall be smooth and free from surface blowholes. Stock castings shall be specially selected with this in mind. All castings shall be shot blasted before machining.

B.7.4.6.3. COVERS

All covers shall be firmly fixed. Weld mesh shall sit square in its frame. Where panels are placed next to each other the patterns shall line up.

B.7.4.6.4. FLANGES AND BEADINGS

All bolt holes shall be spot faced parallel with the mating face for good seating of nuts and bolt heads. Surplus jointing shall be removed from mating faces and peripheries.

B.7.4.6.5. ITEMS TO BE CHROMIUM PLATED

Name plates, instruction plates, rotation arrows, indicators and pointers, small bore pipe work, tundish oil level gauges and fittings, small valves (including air valves), plugs and grease nipples, which are sited in architecturally finished areas of the station and as selected by the Engineer, shall be chromium plated. Damage to chromium plating shall be made good. All pipes and fittings etc., shall be fitted in a straight, neat symmetrical manner so as to present a pleasing appearance.

B.7.4.6.6. EXTERNAL SCREWS, BOLT HEADS, NUTS AND WASHERS

These shall be chromium plated, sherardised or made in stainless steel.

B.7.4.6.7. GAUGES

All indicating gauges fitted to any machine assembly shall be of similar appearance and grouped together to present a pleasing aspect. They shall all have chromium plated cases, bezels, cocks and fittings.

B.7.5. GENERAL WORKMANSHIP, MATERIAL AND DESIGN REQUIREMENTS FOR SYSTEM

B.7.5.1. INTRODUCTION

This part of the Employer's Requirements sets out the standards of materials, workmanship and design to be used by the Contractor for the entire infrastructure system. Reference to any specific material or equipment does not necessarily imply that such material or equipment is to be included in the Works.

All Plant used for the Works shall, unless otherwise specified, comply with the provisions of this part. The names of the manufacturers of materials and equipment proposed for incorporation in the Works together with performance, capacities, certified test reports and other significant information pertaining to the same, shall be furnished when requested for consideration by the Engineer, who shall have power to reject any parts which in his opinion are unsatisfactory or not in compliance with the Specifications and such parts shall be replaced by the Contractor at no extra cost to the Employer.

B.7.5.2. COMPLIANCE WITH STANDARDS

The British Standard specifications shall refer to the latest issue or revision of those standards as issued by the British Standards Institution of 2 Park Street, London W1 and the Indian Standard Specifications as issued by the Bureau of Indian Standards. Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 001, Central Public Health Engineering and Environmental Organizations, New Delhi and ASTM standards as issued by the American Society for Testing and Materials, 1916, Race Street, Philadelphia, PA, 19103, U.S.A. and ANSI standards as issued by the American National Institute, 1430, Broadway, New York, NY 10018, U.S.A. Equipment conforming to other national or international standards shall be at least equivalent to those specified and shall be subject to approval by the Engineer. Full details of the difference shall be supplied by the Contractor.

Where the design or choice of materials of plants is affected by the Factory Acts, then the materials and plant supplied shall comply with all relevant sections of those Acts even though no particular reference may be made in this Specification.

B.7.5.3. MATERIALS GENERAL

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of first-class commercial quality, free from imperfections and selected for long life and minimum maintenance.

All submerged moving parts of the Plant, or the pins and spindles, etc., of the submerged moving parts or the faces etc. in contact with them (water, sludge, wastewater) shall be of corrosion resistant metals. All parts in direct contact with various chemicals, shall be completely resistant to corrosion, or abrasion by these chemicals, and shall also maintain their properties without aging due to the passage of time, exposure to light or any other cause. Where Mild steel is specified for submerged parts, the metal shall be protected by polyurethane coating.

Where "stainless steel" is specified or used it shall have resistance to atmospheric corrosion not less than that provided by B.S.970, Grade 410 S21 for forgings and B.S. 3100, Grade 410-C-21 for castings. Particular attention shall be made to the prevention of seizure by fretting where two corrosion resistant metals are in contact, by the selection of materials of suitable relative hardness and surface finish and the application of lubricants. Where bronze is specified or used it shall be zinc free, to B.S. 1400, Group B-PB1.

Particular attention shall be paid to the prevention of corrosion due to the close proximity of dissimilar metals. Where it is necessary to use dissimilar metals in contact, these shall be selected so that the bimetallic corrosion is as low as possible. The publication by H. M. Stationery Office (in the U.K.) entitled "Corrosion and its Prevention at bimetallic Contacts" shall be used as a guide.

B.7.5.4. WORKMANSHIP GENERAL

Workmanship and general finish shall be of first-class commercial quality and in accordance with best workshop practice and shall provide what is generally recognized as waterworks finish as defined elsewhere. All similar items of system and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit all similar items of plant. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to manufacturer's drawings may be readily installed.

All equipment shall operate without excessive vibration and with minimum of noise. All revolving parts shall be dynamically balanced so that when running at all operating speeds and any load up to the maximum there shall be no vibration due to lack of balance.

All parts which can be worn or damaged by dust shall be totally enclosed in dust proof housings.

All materials incorporated in the Works shall be the most suitable for the duty concerned, free from imperfections and selected for long life and minimum maintenance. All necessary accessories required for satisfactory and safe operation of the Plant shall be supplied by the Contractor unless it is specifically excluded from his scope. Suitable provision by means of eyebolts or other means are to be provided to facilitate handling of all items that are too heavy or bulky for lifting and carrying by two men.

If, after installation, the operation or use of the materials or equipment furnished by the Contractor proves to be unsatisfactory, then the Employer shall have the right to operate or use such materials or equipment until correction of defects, errors or omissions, by repair or by partial or complete replacement, can be made without interfering with the system operations. Except for any warranty provided for elsewhere in this Contract or unless otherwise agreed upon in advance, the period of such operation or use, pending correction of defects, will not exceed 1 year.

Dynamic balancing of rotary components shall be to the relevant standards. All bearings shall have L-10 rating life of minimum 16,000 hours. All instruments used for the works whether for permanent installation or for checks / inspection at the Manufacturer's works or for checks / inspection at site shall be calibrated using standard reference instruments from institutions recognized by the Government such as "Institute for Design of Electrical Measuring Instruments (IDEMI), Mumbai. All outdoor instruments shall be provided with locked, galvanized metallic enclosures of 2 mm thickness, suitably painted.

B.7.5.5. DESIGN LIFE

All materials, system and equipment shall be designed for long reliable operating life and shall be suitable for continuous 24 hour per days operation for prolonged periods in climatic and working conditions prevailing at the Site, and with minimum maintenance and the Contractor may be called upon to demonstrate this for any component either by the service record of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall as far as possible, not require the services of highly skilled personnel.

Except for consumable items such as rubber bushings, gland packings, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continuous normal operation and where major dismantling is required to replace a part, such life shall be not less than ten years. Design features shall include the protection of Plant against damage caused by vermin, dirt, dust and dampness and to reduce risk of fire. Plant shall operate without undue vibration, and parts shall be designed to withstand the maximum stresses under the most severe condition of normal service. Materials shall have a high resistance to change in their properties due to the passage of time, exposure to light, temperature and any other cause which may have a detrimental effect upon the performance or life of the Works. Plant located outside lockable areas/buildings shall have additional features to prevent unauthorized operation. All water, sewage and other storm water related components including civil works shall be designed as per the CPHEEO recommendations.

B.7.5.6. WELDING

In all cases where welds are liable to be highly stressed the Contractor shall supply to the Engineer before fabrication commences detailed drawings of all welds and weld preparations proposed. No such welding shall be carried out before the Engineer has

signified his approval of the details proposed. No alteration shall be made to any previously approved detail of weld preparation without prior approval of the Engineer.

Welding shall comply with the latest revision of the B.S 5135. Approval of welding procedures shall be as per B.S. EN 288-3:1992. Welders shall be qualified to B.S. EN 287-1:1992. All aspects of fabrication and examination procedures including pre / post heating treatment, electrodes, non-destructive Tests (NDT) shall be subject to approval of the Engineer.

The Engineer shall have the right to call for further qualification from time to time from any welder who, in the opinion of the Engineer, does not produce weld in accordance with the qualification. Each welder shall be assigned a number and letter. Each weld-ments shall clearly be identified as to its welder marking the welder's Code adjacent to the welds. A record chart shall be maintained for each welder showing the procedures, for which he has qualified, the date of such qualification, the type of defects produced and their frequency. The Engineer shall disqualify the welder whose Work requires a disproportionate amount of repairs. Inspection and quality of surveillance shall not be limited to the examination of finished welds. The techniques employed shall be based on methods which are known to produce good results, and which have been verified at Site by actual demonstration.

Haphazard striking of the electrodes for establishing an arc shall not be permitted. The arc shall be struck either on the joint or on a starting tag. The starting tag shall be of the same material or a material compatible with the base metal being welded. In case of any inadvertent strike on place other than the welding, the area affected shall be ground flushed and examined by liquid penetration method. Generally, a stringer bead technique shall be used with a slight oscillation if necessary to avoid slag and to minimize the number of beads needed to fill exceed 3 times the wire diameter. Vertical welds shall be made in upward direction. For all pipes above 300 mm dia., welding shall be done whenever possible, by 2 welders working simultaneously along both sides of the pipe.

The root pass shall have less than 1.5 mm internal reinforcement. Defects like icicles, burn through and excessive "such back", etc. shall be cause for rejection of welds. Final welds shall be suitable for appropriate fabrication of the non-destructive examination of the weld. If grinding is necessary, the weld shall be blended into the parent metal without gouging or thinning of the parent metal in any way. Uneven and excessive grinding may be a cause for rejection. Fillet weld shall preferably be convex and free from undercutting

and overlap at the toe of weld. Convexity and concavity shall not exceed 1.5 mm. The leg lengths shall not exceed the specified size by more than 1.5 mm.

All attachments such as lugs, brackets and other non-pressure parts shall also be done by qualified welders in accordance with the design details and materials specifications. Temporary attachments shall be removed in a manner that will not damage the parent metal. Areas of temporary attachments shall be dressed smooth and examined by ultrasonic or liquid penetration methods. All tack welds shall be made using qualified procedure and welders, the number and size of tack welds shall be kept as small as possible consistent with to consist of adequate strength and joint alignments. All tack welds shall be examined visually for defects and if found defective shall be completely removed. As welding proceeds, tack welds shall be either removed completely or shall be properly prepared by grinding or filling their starting ends so that they may be satisfactorily incorporated in the welds. Unacceptable defects shall be removed by grinding machine or chipping or gouging. Flame gouging may be permitted provided gouged surfaces are ground at least by 1.0 mm below the deepest indentation. All weld repairs shall be carried out using the approved welding procedures and welders. Re-welded areas shall be re-examined by the methods specified for the original welds and repair procedures shall be duly qualified by the Engineer's Representative.

Following codes shall apply for the NDTs:

- (a) B.S. 2600: Radiography;
- (b) B.S. 3923: Ultrasonic Test;
- (c) B.S. 6072: Magnetic Particle Test;
- (d) B.S. 6443: Penetrant Test.

B.7.5.7. CASTINGS

All cast iron shall be of standard grey close-grained quality to B.S.1452: 1977 Grade 220 or better. The structure of the castings shall be homogeneous and free from non-metallic inclusions and other injurious defects. All surfaces of castings which are not machined shall be smooth and shall be carefully fettled to remove all foundry irregularities.

Minor defects not exceeding 12.5 per cent of total metal thickness and which will not ultimately affect the strength and serviceability of the casting may be repaired by approved welding techniques. The Engineer shall be notified of larger defects and no repair welding of such defects shall be carried out without prior approval.

If the removal of metal for repair should reduce the stress resisting cross-section of the casting by more than 25 per cent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 per cent, then that casting may be rejected. Castings repaired by welding for major defects shall be stress relieved after such welding.

Test coupons cast simultaneously with the main castings shall be identified to check physical, chemical analysis of casting. Major defects on casting are not acceptable. Non-destructive tests will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine that repair welds have been properly made.

B.7.5.8. INSTRUMENT COMPONENTS

Iron and steel parts shall in general be painted or galvanized as appropriate in accordance with the Specification. Indoor parts may alternatively have chromium or copper-nickel plating or other approved protective finish.

Small iron and steel parts (other than stainless steel) of all instruments and electrical equipment, the poles of electro-magnets and the metal parts of relays and mechanisms shall be chromium or copper-nickel plated or have some other approved finish to prevent rust. Cores, etc., which are built up of laminations or cannot for any other reason be antirust treated, shall have all exposed parts thoroughly cleaned and heavily enameled, lacquered or compounded.

B.7.5.9. SAFEGUARDING OF MACHINERY

The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this requirement shall remove the Contractor's obligation from drawing the attention of the Engineer to any feature of the Works, which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the Plant.

The installation layout and system design shall not allow any item of system to be so positioned that danger to operating personnel could arise during normal operation and maintenance. Particular attention shall be paid to the position of pipes, air vents and rotating machinery, Electrical Equipment etc.

All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease

points, thermometer sockets and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of the structure.

B.7.5.10. RATING PLATES, NAME PLATES & LABELS

All equipment, apparatus and Plant shall be clearly labelled or fitted with nameplates and rating plates generally as follows:

B.7.5.10.1. INDOOR TYPE LABELS

(a) Labels for the outside of equipment shall be of a rigid type laminated and engraved plastic material, with black block capitals on a white background. The labels shall be fixed by non-rusting screws or similar approved.

(b) Labelling inside equipment shall be as above except that a flexible self-adhesive type labelling may be used if suitable for the ambient temperatures and if not less than 12 mm in width.

B.7.5.10.2. WEATHERPROOF LABELS

These labels may be vitreous enameled or brass. Plastic labels will not be accepted unless proof can be given that the labels can withstand the environmental conditions found at Site. Vitreous enameled labels shall be secured by brass or non-rusting roundhead screws, with brass and fiber washers in contact with the enamel front and back to prevent damage.

B.7.5.10.3. NAME AND RATING PLATES

Each main and auxiliary item of sytem shall have permanently attached to it in a conspicuous position a nameplate and a rating plate. Upon these shall be engraved the manufacturer's name, type and serial number of Plant, details of the loading and duty at which the item of Plant has been designed to operate, and such diagrams as may be required by the Engineer. All indicating and operating devices shall have securely attached to them or marked upon them designation as to their function and proper manner of use. Provision shall be made to incorporate descriptive numbering codes as indicated on the Record Drawings. Details of proposed plates, labels and inscriptions shall be submitted to the Engineer for approval before manufacture.

B.7.5.10.4. LUBRICATION

A complete schedule of recommended oils and other lubricants shall be furnished by the contractor. The number of different types of lubricants shall be kept to a minimum. The

schedule and the name of the supplier of the lubricants shall be submitted to the Engineer for approval before incorporation in the instruction manuals. In the case of grease lubricated roller type bearing for electric motors lithium base grease is preferred. Contractor shall indicate indigenously available equivalent lubricants, with complete specification, to enable the Employer to arrange for regular supply.

Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment of recharging. Frequent, for this purpose means more than once a week and grease systems having shorter periods between greasing should be avoided. Where necessary for accessibility grease nipples shall be placed at the end of the extension piping, and, when a number of such points can be grouped conveniently, the nipples shall be brought to a common place mounted in a convenient position. Button head type nipples shall be used for normal grease and all grease nipples shall be of the same size and type for every part of the Plant. Arrangements shall be provided to prevent bearings being overfilled with either grease or oil. Where more than one special grease is required a grease gun for each special type shall be supplied and permanently labelled. Oil lubricated bearings shall be provided with an oil reservoir capable of automatically maintaining the correct oil level within the bearings. It must not be necessary to shut down the pump in order to see the oil level or to add oil to the bearings.

Oil sumps shall be fitted with oil level indicators of the sight glass type, or where this is not practicable, with dipsticks. The indicators shall show the level at all temperatures likely to be experienced in service. The normal, maximum and minimum levels at 20°C shall be clearly visible in the sight glass type from the normal access floor to the particular item of plant, and they shall be easily dismantled for cleaning.

All sight glasses shall be firmly held and enclosed in metal protection in such manner that they cannot be accidentally dislodged. All lubrication systems shall be designed so as not to present a fire hazard and particular care shall be taken to prevent leakage of lubricants and to avoid leaking lubricants coming into contact with any electrical equipment, heated surfaces or another potential source of fire. The Contractor shall supply flushing oil for each lubrication system when an item of plant is ready for preliminary running and a sufficient quantity of the approved lubricants for setting to work and for the commercial operation of the Plant for two years after the Taking over Certificate has been issued.

INITIAL CHARGES OF OIL AND GREASE, ETC.

The initial charges of oil, grease, and similar materials necessary for the correct setting to work and operation of the system shall be included in the appropriate system item.

B.7.5.10.5. NON-METALLIC MATERIALS

Fabrics, cork, paper and similar materials which are not subsequently to be protected by impregnation shall be treated, with an approved fungicide. Sleaving and fabrics treated with linseed oil varnish will not be permitted. The use of organic materials shall be avoided as far as possible but where these have to be used, they shall be treated to make them fire resistant and non-flame propagating.

The use of wood shall be avoided as far as possible. If used, woodwork shall be thoroughly seasoned teak or other approved hardwood which is resistant to fungal decay and other blemishes. All woodwork shall be treated to protect it against damage by fire, moisture, fungus, vermin, insect, bacteria or chemical attack, unless it is naturally resistant to all these. All joints in woodwork shall be dovetailed or tongued and pinned. Metal fittings on wood shall be of non-ferrous material. Adhesives shall be specially selected to ensure the use of types which are impervious to moisture and fungus growth. Synthetic resin cement shall be used for joining wood.

B.7.5.10.6. ENGINEERING HARDWARE

Nuts, bolts, studs and washers for incorporation in the Works shall conform to the requirements of the appropriate British or other approved standard. Nuts and bolts for pressure fittings shall be of the best quality steel machined on the shank and under the head and nut.

Bolts shall be of such a length that one thread shall show through the nut when in the fully tightened condition. Fitted bolts shall be a light driving fit in the reamed holes they occupy, shall have the screwed portion of such a diameter that it will not be damaged in driving and shall be marked in a conspicuous position to ensure correct assembly at site.

Washers, locking devices and anti-vibration fittings shall be provided where necessary to ensure that no bending stress is caused in the bolt. Where there is a risk of corrosion, bolts and studs shall be designed so that the maximum stress in the bolt does not exceed half the yield stress of the material under all conditions. All submerged hardware Nuts, bolts, studs, washers, Fasteners shall be SS316 material.

All bolts, nuts and screws which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel. The Contractor shall supply all holding down, alignment and leveling bolts complete with anchorages, nuts, washers and packings required to attach the Plant to its foundation, and all bedplates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.

Unless otherwise necessary to meet special requirements, all thread shall be of preferred metric sizes with standard coarse threads. ISO metric black hexagon bolts, nuts and screws shall comply with SII 0589-81, or ISO 885, ISO 888, ISO 898-1 and -2. ISO metric precision hexagon bolts, nuts and screws shall comply with ISO 272, ISO 4759-1, ISO 885, ISO 888, ISO 898-1 and -2 or ASTM F-593, ASTM F-468 M, strength grade 8.8.

The dimensions of ISO metric countersunk head bolts screws and hexagon nuts shall comply with ISO 225, or ISO 888, ISO 898-1. Plain steel washers for use with ISO metric bolts shall comply with ISO 887 or ASTM F-844. Taper steel washers shall comply with ASTM F-844 and ASTM F-436.

B.7.5.11. INSTRUMENTS

Unless otherwise specified, any indicating and recording instruments supplied under the Contract shall be approved by the Engineer. They shall be flush-mounted pattern with dust- and moisture-proof covers and shall be suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks. Indicating instruments shall be of the dial type and shall be provided with a readily accessible zero adjustment.

Dials in general shall be white with black markings and not subject to fading. Scales shall be of such material that no peeling or discoloration will take place with age under humid conditions. Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale. Steel screws, when used, shall be zinc, cadmium or chromium-plated, or where plating is not possible due to tolerance limitations, shall be of stainless steel. Instrument screws (except those forming part of a magnetic circuit) shall be of brass or bronze. Springs shall be non-rusting materials, e.g. phosphor-bronze or nickel-silver, as far as possible. Pivots and other parts for which non-ferrous material is unsuitable shall be of stainless steel.

Pressure gauges shall be not less than 150 mm diameter unless otherwise approved. The internal components shall be of stainless steel, bronze or some other corrosion resistant

material other than aluminum. The gauges may be mounted directly on the pipe work or side by side on a board or panel. Each pressure gauge shall be fitted with a stop cock immediately adjacent to the gauge, and all pressure gauge piping shall be fitted with an isolating valve at each point of connection to the main system. Where pressure gauges are mounted on panels, the isolating valve shall be suitable for the connection of a test gauge. Stop cocks of gauges shall be clearly identified by means of separate labels of approved type and lettering.

All fixed pipes below 25 mm nominal bore shall be compression jointed heavy gauge copper where this material is suitable. In other cases pipe materials are to be approved by the Engineer. All pressure gauges shall be fitted with an air release cock and hydraulic pressure snubbers to protect them against shock pressures.

B.7.5.12. NOISE AND VIBRATION

The Contractor shall provide a quiet installation. All items of system, Plant and equipment shall be carefully chosen with a view to minimizing sound levels.

The Contractor shall provide and fix all material for the prevention of transmission of noise and vibration through the system. Where appropriate all fans, compressors, and other motive Plant shall be mounted on resilient mountings in such a manner that the Plant foundations are isolated from the floor or structure. In addition, all rotating Plant shall be statically and dynamically balanced. Mechanical vibration shall be eliminated by the use of anti-vibration mountings and flexible connections to ensure an isolation efficiency of 95% from the building structure.

The noise level produced by any equipment like pump sets, and compressor sets etc shall not exceed 85 dBA measured at a distance of 1.86 m from the outline of the equipment. At the time of operation, the mechanical vibration shall not exceed the limits given below, at recommended points of measurement as per ISO 10816:1995.

Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor KW less than or equal to 15 KW	
All rotating equipment not having reciprocating parts with motor KW more than 15 KW and less than or equal to 75 KW	
All rotating equipment not having reciprocating parts with motor KW greater than 75 KW	

B.7.5.13. PIPING AND EQUIPMENT LAYOUT

In general, all pipes and fittings shall be steel or ductile iron with flanges to BS EN 1092-1 & 2. Where steel and cast flanges are mated together the steel flange shall be machined over its full face, after welding to its respective pipe is completed. The pipe work shall be laid out and designed such as to facilitate its erection, painting in situ, dismantling of any section for maintenance and to give a constant and uniform flow of working fluid with a minimum loss in head. Where steel pipe work is used the number of flanges is to be kept to a minimum with the size of each unit of pipe work determined by the ease of handling, installation and general appearance of the completed pipe system. Positions of flanges shall take into account any necessary concrete pipe supports or thrust blocks.

Facilities shall be provided for proper draining the pipe system. Where a pipe passes through a wall, retaining wall or is subject to thrust it shall incorporate a puddle flange which shall conform to the dimensions stated in BS EN 1092-1 but remain undrilled. Unless otherwise specified, nuts, bolts and washers for pipe work shall conform to the requirements of BS EN 1092-1. Bolts shall be of sufficient length that one thread shall show through the nut when in the fully tightened condition.

B.7.5.14. GASKETS AND JOINT RINGS

Joint rings shall be manufactured to conform with BS 2494 and shall be of chloroprene rubber or other approved synthetic material suitable for temperatures up to 80oC.

Joints shall be made in accordance with manufacturer's instructions or as specified herein.

Until immediately required for incorporation in a joint, each rubber ring or gasket shall be stored in the dark free from the deleterious effects of heat or cold, and kept flat so as to

prevent any part of the rubber being in tension. Only lubricants recommended by the manufacturer shall be used in connection with rubber rings and these lubricants shall not contain any constituent soluble in water of the quality stated in the Requirements, shall be suitable for the climatic conditions at the Site and shall contain an approved bactericide.

After cleaning the flanges, the gaskets shall be fitted smoothly to the flange and the joint made by tightening the nuts to finger pressure first. Thereafter the final tightening of the nuts shall be made by gradually and evenly tightening bolts in diametrically opposite positions using standard spanners. Graphite grease shall be applied to the threads of bolts before joints are made.

B.7.5.15. STEELWORK

Any small areas of chequer plating or similar covering that are necessary to cover gaps between items of Plant and the surrounding structure, and any access ladders, platforms and handrails that must be attached to items of Plant to facilitate operation, inspection or maintenance, shall be supplied and erected by the Contractor.

The Contractor shall include in his Contract for providing adequate means of access to all hand wheels, sight glasses, gauges, lubrication points and any other items to which access is necessary for routine maintenance. Handrails shall be of SS304 construction as per Para No.5.14 of Part-5 and shall be made of 32NB pipes / tubes with top and intermediate rows of pipes running parallel to each other and the height of railing not less than 1100mm. The distance between 2 vertical posts shall not be more than 1.8 metres. Chequer plating shall be of 'Durbar' or other non-slip pattern, not less than 4.5 mm thick (exclusive of pattern) and hot dipped galvanised after fabrication in accordance with BS 729. Aluminium alloy flooring may be offered as an alternative, manufactured in accordance with BS 1470, material H30 TB.

B.7.5.16. SPARE PARTS

The Contractor shall supply the details of Recommended spare parts and quantity required for continuous operation of works. The spare parts required shall be decided by the Employer prior to Award of contract or during the execution of the contract, which shall be binding on the contractor. The cost of spare parts shall be borne by the Contractor. It shall not be binding on the

Employer to select the spare parts recommended by the contractor.

All spare parts shall be new, unused and strictly interchangeable with the parts for which they are intended to be replacements and shall be treated and packed for long storage under the climatic conditions prevailing at the site. Each spare part shall be clearly marked or labelled on the outside of its packing with its description and purpose, and when more than one spare is packed in a single case or other container, a general description of its contents shall be shown on the outside of such case or container and a detailed list enclosed. All cases, containers and other packages shall be marked and numbered in an approved manner for purposes of identification. All cases, containers or other packages are liable to be opened for such examination as the Engineer may require and packings shall be designed to facilitate opening and thereafter repacking.

"Spares, accompanied by technical details/leaflets etc., shall be delivered to site before the start of commissioning tests. Spare parts shall be indicated in the assembly drawings of respective plant items with clear details of part numbers. Contractor shall also furnish the manufacturers recommendations on spares for respective plant items."

B.7.5.17. TOOLS AND TEST EQUIPMENTS

The contractor shall supply the details of recommended special tools and test equipment required to enable any erection, dismantling or testing to be carried out on any part of the Plant, whether of an electrical, mechanical or any other nature during the life of the Plant and shall be listed in Schedule for Recommended Spare Parts, Accessories and Tools. The cost of Tools and Test equipment shall not be taken for evaluation. It shall not be binding on the Employer to buy any/part of the tools and test equipment recommended by the contractor. The tools and testing equipment required shall be decided prior to award of contract or during the execution of the contract, which shall be binding on the contractor.

The tools and test equipment shall not be used for the erection of the Plant and except that the Engineer may call upon the Contractor to demonstrate their use or effectiveness, they must be handed over to the Employer in a completely new and unused condition. Should the Contractor require any such tools and test equipment at the site during erection, he shall provide his own.

The tools for each different type of equipment shall be contained in a suitable box clearly marked or labelled with its description. Each tool shall be identified and a list of tools shall be affixed to the inside of the box lid. Each set of tools shall be supplied with the equipment with which it is associated. The test equipment shall include only special purpose items

essential to the testing or recalibration of related items of Plant. The tools provided shall include clamps, wrenches, lifting lugs, grease guns; gauges test rigs, jigs or extractors which may be required for the life of Plant. All tools and test equipment shall be clearly detailed with size/capacity etc.

B.7.5.18. PROTECTION AND PACKAGING FOR TRANSPORTATION

Before any Plant is dispatched from a manufacturer's works it shall be properly prepared and packed. Prior to dispatch all Plant shall be adequately protected by painting or by other approved means for the whole period of, transit storages and erection, against corrosion and incidental damage, including the effects of vermin, sunlight, rain, high temperatures and humid atmospheres. The Contractor shall be held responsible for the Plant being so packed and / or protected as to ensure that it reaches the site intact and undamaged. The Plant shall be packed to withstand rough handling in transit and all packages shall be suitable for storage including possible delays in transit.

The Contractor shall be deemed to have included in the Schedule of Prices for all materials and packing cases necessary for the safe package, conveyance and delivery of the Plant.

The flanges of pipes, valves and fittings shall be protected by wooden discs attached by means of service bolts (which shall not be used at Site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500 kg gross. No one package or bundle shall contain items of Plant intended for incorporation in more than one section of the Works. All items of Plant shall be clearly marked for identification against the packing list. Every crate or package shall contain a packing list in a waterproof envelope. A duplicate copy of the packing list shall be sent by post to the Engineer at Site.

All crates, packages, etc., shall be clearly marked with a waterproof material to show the weight, and where the slings should be attached, and shall also have an indelible identification mark relating them to the packing lists.

B.7.5.19. CHECK LIST FOR HAND-OVER AT THE END OF CONSTRUCTION PERIOD

B.7.5.19.1. GENERAL

This section applies to procedure(s) on how to transfer the works after the completion of Construction period (after necessary testing and commissioning of the system up to the satisfaction of the Employer) by the Contractor.

- a) Internal road network including bridges and culverts,
- b) Water supply Transmission and Distribution system including Elevated service reservoirs for both potable and Recycled water system (thro direct pumping),
- c) Waste water collection system including Intermediate sewage pumping stations
- d) Storm water drainage and rain water harvesting systems
- e) Power supply transmission and distribution system including 33kv/433kv substations
- f) All Mechanical, Electrical and SCADA systems required for the infrastructure works.
- g) All ancillary buildings in campus area.
- h) Complete instrumentation and communication system.

The procedure for Handover shall be verified through the final examination by the Engineer. A completion approval Certificate shall be issued after the successful final examination and submission of the completion documents before the contract deadline.

B.7.5.19.2. DUTIES AND RESPONSIBILITIES

- a) All the Responsibility lies with Contractor:
- b) All cost for the examination / test / training, and preparation of any document of the activities shall be the Contractor's responsibility.
- c) Official certificate
- d) All test certificates shall be issued by authorized organization with qualified personnel with his signature.
- e) Receiving inspection

All of equipment and construction material installed in site shall be inspected by the Engineer to verify whether damaged or not. Rejected items shall be replaced by the Contractor at his own cost.

The typical examination shall consist of as follows:

- (i) Appearance test / Visual examination
- (ii) Check attached invoice
- f) Conduct first training:

The Contractor shall provide the first training program to client's staff member for one months before acceptance inspection. The typical training program is as follows:

- (i) Study of Operation and maintenance manual
- (ii) Operation skill / technology (Mechanical and Electrical) including normal and emergency operation.
- (iii) Maintenance, repair skill / technology (Mechanical and Electrical)

(iv) Recordkeeping and maintenance of records

(v) SCADA systems

(vi) Safety & Health

(vii) Evaluation of the program (examination)

g) Conduct joint completion inspection:

To verify the plant condition and its performance before operation, joint inspection will be carried out using up-dated Operation and, maintenance manual. The typical inspection items shown in Table 17.1.

(i) Submission of the report of completion documents:

The contractor shall submit the completion document after passing the final examination before the deadline on the contract time.

The typical report consists of relevant documents as shown in Table 17.2.

These data shall be provided in soft and hard copies in proper professional format.

Table B-25 Typical Items to be examined at the End of Construction Period

Items	Description
Appearance test / Visual examination (Damage/crack, differential settlement, soil settlement, peel off painting, missing / lost, leakage of water /solution /gas, corrosion, decolonization, condition of maintenance, others)	All Road network, Civil structures, Water and waste water pipelines, Storm water drainage, building including interior/exterior, fence/gate, stairs, others All Mechanical & Electrical equipment /accessories, others All Pipe line valves and others All SCADA system, Instrumentation and control equipment, others
Performance examination (Selection of operation mode, selection of facilities, flow / water level, overflow, leakage of water, heating, vibration / noise level, speed of rotation,	Check Sequence, or Manual operation including water level sensors / protections, others Check specification of all Mechanical equipment including pressure gauges, valves, others Operational characteristics of all Electro-Mechanical Equipments in Pump stations etc Check specification of all Electrical equipment, others Check specification of all pipe line including valves, others

smoothness, accuracy, setting value, condition, others)	Check specification of all accrual condition after troubleshooting, others Check for the actual losses in the water transmission and water distribution system. Check for the actual residual pressures in the water distribution system. Working condition of the Wastewater collection system including septicity conditions if any. Strom water drainage working conditions, condition of storm inlet arrangements and water stagnations conditions during rainy season. Performance of Culverts / bridges during a storm event and also during heavy vehicular movement. Performance of fire station building during an event of fire. Operational characteristics of the Fire station building.
Verification of rectified works (System, leakage, crack, damage, soil settlement, corrosion, others)	Check a list of all defect items, tendency, repeating, others Check a list of all miss operation and maintenance items, others Check all factors of defect / miss operation, others Verification of action on the take measures, others Verification of all rectified works with the reports and photo, others Check emergency works and its factor, action plan, others. Check actual condition after rectified works, others
Operation skill (Staff member, others)	- Format for preparation of daily report and summary reports on O/M activities, time and motion of staff member, others - Interview of Experienced operators in the respective fields regarding troubleshooting, others - Paper test (basic knowledge, safety, others)
5. Spare parts and others	- Check inventory list (parts, others) - Check the quantity of inventory, others - Check maintenance tools and equipment, vehicles, others

Table B-26 Typical Completion Documents to be handed over at the end Construction period

Contents	Description
1. Outline	Outline

	- Summary of project, scope of work, location of project, main component with specification, others
2. Completion Photographs (At acceptance complete inspection, completion inspection and final inspection)	Photographs with short description - Road networks including street lighting, Signals, Road furniture's, etc. - Civil (structural, buildings, Reservoirs, Pump stations, Culverts / bridges, others) -Mechanical, Electrical (equipment, facility, others) - SCADA, Instrumentation and Control systems - Piping works
3. Inspection summary (At acceptance complete inspection, completion inspection and final inspection)	Appearance test / Visual / performance examination Table of Summary of test activity based on daily and monthly. - List/ of type of test, date, inspector, evaluation, comments - Road (name, Length, Road furniture etc. drawing No., drawings, design dimension, previous dimension, actual dimension, photograph with short description others) - Civil (name of structure, drawing No., drawings, design dimension, previous dimension, actual dimension, photograph with short description others) - Mechanical (name of facility and equipment, Tag. No., Q'Ty, others). - Electrical (name of facility and equipment, Tag. No., Q'Ty, others).
4. Main inspection data during construction	Summary of data with graphic / chart Civil (plate load bearing test, compressive strength test, water retaining test, compaction field test, road restoration works, road construction works, hydrostatic test, others) Mechanical, Electrical (earthing resistance test, others)
5. Inspection record (At acceptance complete inspection, completion inspection and final inspection)	Appearance test / Visual / performance examination Performance examination Verification of rectified works

Training and commissioning record (At first and second training program)	- Summary (Schedule of training and commissioning, attendance rate, impression on training program) -Training attendance list (participants, trainings date, others) -Commissioning daily record (designed and actual, tested, name of operated facility, list of measurement and its time and reading value, value of V/Am/kw of each equipment, others) -Photographs with short description
Operation/maintenance manual (Civil, Mechanical, Electrical)	Update
Spare parts list	- Mechanical (name of parts, Tag.No., Q'Ty., location of stock, others) - Electrical (name of parts, Tag. No., Q'Ty., location of stock others) -Pipe & fittings (name of parts, Tag. No., Q'Ty., location of stock others) -Valve & accessories (name of parts, Tag. No., Q'Ty., location of stock others) -Others (name of parts, Tag. No., Q'Ty., location of stock others)
Key list with boxes	-Name of key, location, Tag. No., Q'Ty.
Manufacture produced catalogue. (Civil, Mechanical, Electrical)	Civil (all related material: bar, round bar, cement, cement paste, asphalt, chemical admixture, water reducing agent, pozzolan, vibrator, water-tightness sheet, construction equipment, manhole, fence-gate, pipe, water-resistant coating, paint, coating agent, windows, door, lock & key, others). Mechanical (all related equipment; pumps, dewatering pumps, tanks, pipe, valve, pressure gauge, safety valves, flow meter, coating, painting, Water meters etc. others). Electrical (all related equipment: electric wire, electric conduit, manhole, motor, control panel, relay, transformer, heater, generator and silencer, timer, breaker, light / lamp, switch, streetlight, earthing measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) SCADA and instrumentation system

	Safety equipment Others
Instruction manual (Civil, Mechanical, Electrical)	See above
Factory inspection record or quality assurance (Civil, Mechanical, Electrical)	Civil (all related material: bar, round bar, cement, asphalt, chemical admixture, water reducing agent, pozzolan, vibrator, water-tightness sheet, construction equipment, manhole, fence-gate, pipe, water-resistant coating, paint, coating agent, windows, door, lock & key, others) Mechanical (all related equipment; pumps, compressors dewatering pumps, tanks, pipe, valve, pressure gauge, safety valves, flow meter, coating painting, others) Electrical (all related equipment: electric wire, electric conduit, manhole, motor, control panel, relay, transformer, heater, timer, breaker, light/lamp, switch, streetlight, earthing measurement equipment, air condition, communication equipment, electric pole, coating painting, ventilation fan, air duct, others) Safety equipment Others
Photograph (during Construction, at joint completion inspection, at defect liability) (Civil, Mechanical, Electrical)	History of construction Replacement of defect liability Road: construction site before starting construction, earthwork, Base course, subbase coarse formation, tack coat and final coat, Road furniture's, street lighting, all field inspection and lab test, others Civil construction site before starting construction, earthwork, arrangement of bar, rust, cleaning before placing, formwork, concrete mixing work, placing, vibrator, curing, remove of formwork, backfill, compaction, all field inspection and lab test, Reservoirs, Bridges / Culverts others. Water and Wastewater pipelines etc., including Storm water and Rainwater harvesting etc. Mechanical: inspection at factory, receiving inspection, completion inspection, all field inspection, others

	Electrical: inspection at factory, receiving inspection, completion inspection, all field inspection, others SCADA and instrumentation and control system.
production samples (civil, mechanical, electrical)	All samples for technical approval Attach Tag.No, and its name, approved sign of the Engineer.
Report	Monthly and annual report Others

SPECIFICATIONS

The specification of materials suggested for repairs shall be the same as used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to HANDOVER. Without being limited by this clause, the Contractor shall suggest appropriate material for repairs even if material required for such repairs has not been approved earlier, However, subsequent to suggestion of use of such material the Contractor shall submit proposals for the approval of specifications of such material.

CHECK LIST

General

Within the framework of the Contractor's responsibilities given above, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities which otherwise are required as per terms and conditions of the Contract or to fulfill the Contractor's responsibilities or are essential as per good industrial practices. The Contractor shall hand over the components of works in good working condition for the following, but not limited to:

- a) All required consumables required for functioning of infrastructure works with inventory of material.
- b) All Electrical Equipments such as 33kV/433V Transformers, LT Switchgears / MCCs, Control Stations, Cables, Earthing, etc., pumping station, administrative buildings, fire station unit etc.(all works constructed in this Contract) in neat and clean condition
- c) All required consumables required for functioning of infrastructure works with inventory of material.

- d) All required consumables required for functioning of infrastructure works with inventory of material.
- e) All required consumables required for functioning of infrastructure works with inventory of material.
- f) All Electrical Equipments such as 33kV/433V Transformers, LT Switchgears / MCCs, Control Stations, Cables, Earthing, etc., pumping station, administrative buildings, fire station unit etc.(all works constructed in this Contract) in neat and clean condition
- g) AMC contracts with system / equipment suppliers, as necessary for PLC and SCADA system supplier or the authorized system integrator who executed the work for this project.
- h) Lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures.
- i) Records for:
 - (i) Repair history of all mechanical, electrical and instrumentation control equipment, and communication instruments;
 - (ii) Logbooks through PLC system;
 - (iii) Daily log of operations of all the important equipment such as electrically actuated valves, etc., with time tag;
 - (iv) Daily list of alarms with time tag;
 - (v) Logbook format and the data to be included in the logbook;
 - (vi) Last periodic maintenance done for all equipment / buildings of the system;
- j) Required spares, special tools and test equipment and adequate inventory of required accessories or equipment itself for repair of Pipe line system (including water and sewage system), electrical, mechanical, instrumentation and control system, pipe and the communication system. However at the end of the Contract the Contractor shall hand over the full spares, tools and tackles as supplied with the Contract by replacing the used items with fresh supplies of the same specifications.
- k) Repair of the roads, buildings and campus area utilities.
- l) Potable water supply and recycled water facilities, Waste water collection facilities and all its units.

- m) Record of stores for the electrical, mechanical and instrumentation and control equipment. The records will include but shall not be limited to:
 - (i) Loading / unloading of materials received and issued for works;
 - (ii) Proper arrangement of material in stores to ensure its safety and easy availability;
 - (iii) Maintaining store areas in a neat and tidy condition;
 - (iv) Keeping records and accounting for the incoming materials,
 - (v) Keeping records and accounting for the consumed materials.
- n) Structures / buildings of the project areas and others built in the Contract must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be in acceptable condition and adequate plantation; horticultural activities must be well maintained to give pleasant environment of the project area.
- o) Updated operation and maintenance manual as defined in specifications for O&M works.

Infrastructure system

The Contractor shall hand over all components of the works in good working condition for the following, but not limited to:

- a) Manpower requirement chart along with organizational chart with responsibility matrix for and maintenance of the entire Infrastructure components in the project area.
- b) All required spares for daily maintenance of the road system including road furniture works like bitumen, paints, signals and requisite O&M manual on the traffic management plans, road safety measures, etc.
- c) All required spares for daily maintenance of the water supply system including feeder systems works like pipe line operations and maintenance, UFW reduction programs and requisite O&M manuals, etc. Tools and Equipments required for the routine operation and maintenance of the system
- d) All required spares for daily maintenance of the Waste water collection system including pumping station works operations and maintenance and requisite O&M manuals, Tools and Equipments required for the routine operation and maintenance of the system.
- e) All required spares for daily maintenance of the Storm water collection system including storm inlet works operations and maintenance and requisite O&M manuals, etc

- f) All Pump house facilities including pipes, valves pumps, sluice valves, dismantling joints, non return valves, pressure gauges, flow meters, dewatering pumps, HV/LV switchgear room, PLC control, MCC's, Cables ,Earthing , all motors and valves in the system.
- g) PLC, including the hardware, software and all instruments, in good working condition.
- h) Entire control system and instruments as per the manufacturer's recommendations.
- i) Communication cables and power supply cables.
- j) All instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, and laboratory instruments along with all other equipment.
- k) Calibration of all measuring /metering equipment or as recommended by the manufacturer. The calibration at manufacturer's works shall be done only in case of major failure/ repairs of the instruments.
- l) Preparation and Submission of daily and monthly customized report formats produced by the local SCADA system
- m) Provision of all required consumables for printing.
- n) Details of all moving parts, steel structures and the RCC structures.
- o) Lubrication of all gears of reduction motors, motorized valves, and other parts of the system.
- p) Check all valves for their manual and electric operation. Operation of valves must be checked from local control console, switchgear and through PLC system.
- q) Make good all circuits and buildings all electrical, mechanical and instrumentation equipment, substation equipment, lighting, and earthing system associated works
- r) Painting of the exposed mild steel components of pipeline, ladders, railings etc.
- s) Make good surrounding areas of the works free from shrubs, weeds, grass and other unwanted vegetation.
- t) Ensure safety accessories, e.g. gloves, shoes, first aid box, etc.
- u) Ensuring fire and safety equipment.

Lubrication for pump stations

The Contractor, in the operation and maintenance manuals, shall furnish a complete schedule of recommended oils and other lubricants. The number of types of lubricants shall be kept to a minimum. In case of grease lubricated bearings for electric motors, lithium base grease is preferred. The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the O&M manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in O&M manual.

Where lubrication is affected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be used. All lubricant systems shall be designed so as not to cause a fire or pollution hazard. The Contractor shall supply flushing oil for such lubrication system when an item of plant is ready for preliminary running.

Spare Parts

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

Electrical System

The Contractor shall hand over the following at the end of the Period

- a) As built drawings based on all modifications suggested. All Electrical Drawings like Single Line Diagrams, Control Circuits Equipment Layout, Cable Layout, and Cable Schedules, earthing Layouts

- b) Details of Protective Relay Settings and time relay settings including any changes, Details of Oil Changes / Filtration of Transformers, Records of any changes made in the System suggested etc should be maintained.
- c) Equipment wise maintenance record for O&M Period. Motor wise Power consumption Details and over all power consumption detail of plant, equipments etc.
- d) Details of IR Test of all Equipments like HT/LT Panels, HT/LT Motors, Transformers, Switchgears, and Cables etc.
- e) Log book showing details Electrical faults that have occurred in the plant and record of corrective actions taken.
- f) Equipment wise technical data given by equipment supplier, Documents showing Bill of Materials and Operation & Maintenance Manual (hard copy or soft copy).
- g) List of mandatory spares that are to be maintained at stores and their actual availability in plant, if it is below same has to be replenished.
- h) Details of Measurement of Earth resistance, Earth Pit wise and Overall Values during the O&M Period.
- i) Details of Illumination Levels required during the O&M Period along with details of changes, required if any.

Electrical Checks to Be Done During Handover

- a) Contractor to provide a test schedule & format to be approved by engineer before commencing any test.
- b) Checking of all electrical equipment, items etc as per bill of materials. Visual checking and tracing out the circuit based on revised as built drawings.
- c) Visual Operational checks of all Equipment & Protections have to be done.
- d) Transformer oil samples testing have to be done during taking over.

Instrumentation, Control and Automation System

The Contractor shall hand over the following documents/drawings/manuals/programs at the end of Construction Period

- a) As built drawings approved by the employer's representative based on all modifications. All ICA Drawings like P&ID, System configuration diagram (PLC & SCADA architecture), Instrument installation drawings, Instrument cable schedule, and cable layouts should be maintained and should be handed over.
- b) Handing over document / manuals shall include on a minimum 3 sets of softcopies and 3 sets of hard copies. The hard copies shall be spiral bounded clearly indicating the

version/revision submitted. All the contents shall be indexed .The contents of handing over document/manual shall be clearly legible and shall include original manufacturer's literature minimum, and in-corporate any changes as per site conditions.

- c) Detailed drawing and manual of the PLC installed. Manual shall include the PLC series installed along with complete details on I/O modules, Ethernet switch, Relay modules, and converters (if any).
- d) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the PLC and accessories installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- e) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the SCADA and accessories installed, illustrated with examples .This shall be provided along with the standard manufacturer's literature.
- f) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the ODMS installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- g) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the interface control panel to Central Monitoring unit, illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- h) Interoperability testing tool / software shall be provided along with relevant manuals and operating instruction with examples.
- i) Latest PLC program back-up, SCADA software back-up with license, SCADA database backup, reports and alarm back-up, Historical archived data containing reports and alarms and ODMS data and configuration set-up shall be provided.
- j) All software's used under ICA shall be handed over along with their original licenses.
- k) Complete list of database /addresses shall be provided clearly indicating the spare tags for PLC, SCADA and ODMS software's.
- l) List of mandatory spares that are to be maintained at stores for complete ICA package and their actual availability in plant, has to be provided.
- m) Any password's set to access the internal PLC program; interface control panel shall be provided and demonstrated.
- n) All passwords (PLC, Interface control panel & SCADA and other software / hardware) shall be provided in a sealed envelope and addressed to the Engineer In Charge.
- o) PLC, SCADA and ODMS package shall be updated with the latest software version / patch before handing over. The same has to be demonstrated to the Engineer in Charge.

- p) Latest licensed version of windows operating system along with MS –Office or equivalent software which is prevailing at that point of time shall be installed on SCADA machines and other machines installed and integrated with the SCADA and ODMS package. The same shall be demonstrated to the engineer.
- q) Contractor shall conduct a training session for the client's staff which shall include PLC configuration, troubleshooting techniques, SCADA configuration and troubleshooting techniques, ODMS configuration and troubleshooting techniques, diagnostic techniques and troubleshooting techniques for wireless technology employed for communication.
- r) The training session shall be of duration of minimum Five (5) working days at a stretch.
- s) Manufacturer's literature / Manuals for flow meters, level transmitters, switches, pressure transmitters etc and analytical instruments installed.
- t) Instrument wise, PLC and SCADA wise and ODMS maintenance record during complete O&M Period shall be provided.
- u) A complete and updated list of all manufacturers/system integrators/contractors of ICA with contact numbers shall be provided. The same shall also be made available on site for ready reference.
- v) The latest versions of all drawings of ICA, which will include cable termination details, I/O mapping, database details etc shall be provided in PDF format and editable format and loaded in the operator machine available on site. The same shall be demonstrated to the engineer.

ICA Checks to Be Done During Handover

- a) Contractor to provide a test schedule and format to be approved by the engineer before commencing any of the tests.
- b) Functional Checking of all ICA equipment including flow meters, pressure and level instruments, vibration monitoring instruments, and wireless equipment being used for communication.
- c) Loop checks shall be conducted.
- d) All instrument cabling shall be inspected for continuity. If found faulty, the same shall be replaced and demonstrated.
- e) All instrumentation cable conduits shall be checked for damage. If found faulty, they should be rectified or replaced and sealed to the satisfaction of the engineer
- f) Visual operational checks of PLC panel, SCADA system and interface control panel.
- g) Licensing feature of PLC, SCADA software and hardware, ODMS software and other hardware shall be demonstrated.
- h) Functional check of set points change at HMI and it's downloading to PLC's concerned.

- i) Hot-standby feature of PLC and hot swappable feature of I/O modules shall be demonstrated. If found to be faulty / non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client.
- j) Dual-redundant server feature of SCADA shall be demonstrated. If found to be faulty / non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client.
- k) Functional check of ODMS software in conjunction with SCADA shall be conducted.
- l) Functional check of data received / transmitted from remote stations shall be conducted in conjunction with SCADA.
- m) Functional check of interface control panel to Centralised Monitoring station in conjunction with other units shall be conducted.
- n) Historical archiving of all data shall be demonstrated.
- o) Availability of memory for smooth operation of PLC, SCADA and ODMS machines shall be demonstrated. If found to be in-adequate, the same shall be rectified / archived and demonstrated.
- p) If any instruments and automation equipment are found to be faulty during the above tests, the same shall be rectified or replaced as necessary.

Ancillary Works

- a) Make gardeners and plantation in the campus area green, neat and tidy with removal of shrubs, weeds, grass and unwanted vegetation and make pruning, trimming and cutting of old big trees from the Area along with including pumping station locations, office building locations etc as directed by the Engineer.
- b) Make good and in working condition for lighting fixtures and lighting circuits, water supply facilities in project area, offices and other residential buildings.
- c) The Contractor shall carry out ordinary repairs to buildings / pump stations. The repairs may include but not limited to the following items:
 - (i) Easing of doors and windows, monsoon repairs to roofs, attention to drains, rainwater spouts, attention to plinth protection.
 - (ii) External white or color wash, external or internal painting, internal distempering, renewal of approach roads within the campus.
 - (iii) Repairs to other administrative buildings.

Wireless Communication System

- a) Make good a wireless communication system to ensure reliable and easy communication to and from all infrastructure components.

- b) Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble free communication if required.

Operations and Maintenance Manual

The comprehensive manual (six sets) shall be submitted at the end of the construction period, as specified. It shall be updated based on the principals broadly listed in O&M section. These manuals shall be made available during both the first and second training module conducted by the contractor.

Payments

The Contractor, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfill the entire responsibilities as described above. His bid price, as quoted in the Schedule of Prices, shall include all costs for hand-over.

Format

For proper maintenance and recording of all the infrastructure works, the formats are given in O & M section. All the O & M record should be submitted in soft editable form.

Completion Certificate

A joint inspection shall be arranged by the contractor to assess the condition of civil structure, electrical & mechanical equipment and instrumentation equipment. Based on this inspection, a list of remedial, repair and replacement for the components shall be prepared by employer. The contractor shall carryout such remedial works at his own cost. Again joint inspection shall be arranged by the contractor for certification completeness of remedial work as well as restoring the condition of all civil work to its original appearance.

The contractor shall submit the entire required document to employer for review and comments. The contractor shall resubmit the document incorporating the comment. The employer shall issue a completion certificate to the contractor on his request within 30 days after the take back of the works by the employer subject to the above documents and obligation are met by the contractor before 90 days prior to hand over of the project area.

B.8. SEWERAGE SYSTEM

B.8.1. BACKGROUND

The Wastewater network system shall be designed for the expected domestic sewage flows from residential as well as other sectors such as commercial & institutional. Sewage flow from a plot shall be primarily based on the estimated population for the plot and per capita sewage generation rate as per the CPHEEO manual/ National Building Code norms / as per Development Plan. Industrial effluent generation from the industrial shall be collected into separate sewer line and will be treated into a CETP.

Wastewater collection network is divided into 2 zones. Zone one for collecting the sewer generation from residential as well as other sectors such as commercial & institutional and zone two is for collecting the effluent generation from industries. Both networks are to be laid separately and collected wastewater will be treated into STP and CETP respectively.

B.8.2. DESCRIPTION OF THE WORKS

Hydraulic design of wastewater collection system including house service connections.

Design. Construction of Sewage collection system for zone 1 area having a total length of 1.8 KM along with other appurtenances.

Design. Construction of effluent collection system for zone 2 area having a total length of 26 KM along with other appurtenances.

B.8.3. POPULATION AND WASTEWATER GENERATION

S.No	Land use	Sewage Generation (MLD)		
		Zone-1 (STP)	Zone-2 (CETP)	Total
1	Residential	1.51		1.51
2	Industrial work force		1.75	1.75
3a	Commercial-Workers	0.295		0.295
3b	Commercial-Floating	0.148		0.148
4	Administrative office+ ICC building		0.052	0.052
5a	Hospital	0.04		0.04
5b	Institution		0.34	0.33
6	Public utilities	0	0.018	0.008
7	Industrial effluent		11.85	11.85
8	Hotels	0.143	0.048	0.191

9	Office Block	0.54		0.54
10	Parking	0.037	0.143	0.19
A3	Sewage generation	2.71	14.20	16.92
A4	Infiltration@ 2%	0.05	0.28	0.34
A5	Total sewage generation	2.76	14.48	17.25
A6	Recycled water available (95%)	2.62	13.77	16.39

B.8.4. DESIGN CRITERIA

Sewage Collection Network

- Peak factors shall be considered based on contributory population to arrive at the peak flows as per CPHEEO manual.
- Design formula: Manning's formula
- System design: Gravity system
- Coefficient of Roughness: as prescribed in CPHEEO manual, 1993 / 2013.
- Pipe Material: RCC of NP3 Class as per IS 458.
- Bedding for Sewers: as per the relevant standards.
- Minimum size of sewers: 200mm
- Design capacity of sewers: 80 % at ultimate peak flow
- Self-cleansing velocities:

Minimum velocity : 0.6 m/s (present peak flows)

: 0.8m/s (design peak flows)

Maximum velocity: 2.5m/s

As per relevant CPHEEO guidelines

- Depth of cover: The minimum depth of cover at sewers start is 1.0 meters
- Per capita sewage generation shall be 80% of total water supply. Sewage generation from industrial area shall be 80% water supply per area basis.
- In the hydraulic design of sewers, an allowance for infiltration for the project area shall be considered as per Part A of CPHEEO Manual, Nov 2013
- Peak factor for sewerage system shall be based on contributing population for domestic sewage as per CPHEEO sewerage manual, 2013.

- Manning's formula shall be adopted for design of gravity sewers with coefficient of roughness as specified in CPHEEO manual.

Sr. No.	Design Parameters	Value										
1.	Ground water infiltration	500 ltr/day/manhole										
2.	Peak Factor	2.25										
3.	Capacity of conduits	80% full at peak flow										
4.	Minimum velocity	0.6 m/s – minimum velocity at initial peak flow 0.8 m/sec –peak flow										
5.	Depth of cover	1.2 m Minimum depth of cover will be provided over top of pipe at the start of the sewers.										
6.	Bedding for Sewers	<table><tr><td>Bedding Factor</td><td>Type of Bedding</td></tr><tr><td>Up to 1.9</td><td>Granular</td></tr><tr><td>1.9 -2.8</td><td>Concrete Cradle Bedding with Carefully compacted backfill (PCCB)</td></tr><tr><td>2.8-3.4</td><td>Reinforced concrete cradle (RCCB)</td></tr><tr><td>> 3.4</td><td>Reinforced concrete encasement (RCE)</td></tr></table>	Bedding Factor	Type of Bedding	Up to 1.9	Granular	1.9 -2.8	Concrete Cradle Bedding with Carefully compacted backfill (PCCB)	2.8-3.4	Reinforced concrete cradle (RCCB)	> 3.4	Reinforced concrete encasement (RCE)
Bedding Factor	Type of Bedding											
Up to 1.9	Granular											
1.9 -2.8	Concrete Cradle Bedding with Carefully compacted backfill (PCCB)											
2.8-3.4	Reinforced concrete cradle (RCCB)											
> 3.4	Reinforced concrete encasement (RCE)											
7.	Manholes	@ 30 m c/c distance and at junctions										
8.	Pipe Material	RCC- NP3 class										

- Manhole

Brick masonry Sewer manholes have been proposed for the Wastewater network. The manhole frame and cover proposed is of Steel Fibre Reinforced Concrete (SFRC) capable of withstanding heavy-duty loads, conforming to the IS: 12592-2002. Sizes of Manhole is as per relevant IS codes.

B.8.5. GENERAL REQUIREMENTS

- Design, construction and maintenance of Sewer collection network including manholes, vent shafts etc.
- Interconnection with existing sewer networks

B.8.5.1. SEWERAGE APPURTENANCES

a) **Manholes:** Manholes shall be constructed at the locations as per the relevant codes. The manholes shall be circular and shall be constructed in brick masonry. The manhole spacing in general shall be 30m or more and at every junction, change in direction or change in diameter of pipe or as per the directions of Engineer in Charge. The manhole cover and frame shall be heavy duty Steel Fibre Reinforced Concrete (SFRC) /CI / DI/

RCC material and shall be capable of withstanding Class AA loading as per IRC and shall conform to IS: 12592 (Part I & II) for manholes up to 1.2m dia. For manholes greater than 1.2m dia, RCC manhole cover and frames (heavy duty class-HD 20) shall be provided. The inspection and testing of manhole frames and covers shall be done at factory in presence of Engineer and the cost of such inspection shall be made by the contractor and shall be deemed part of the pipeline works. The entire height of the manhole shall be tested for water tightness as per the relevant specifications / Engineer In charge.

- b) **Connection of pipes and bedding:** Suitable pipe material with bedding shall be used. The pipe material used and its laying joining, testing and commissioning shall confirm to relevant IS codes. Granular bedding shall be provided for pipes as per the relevant IS codes.
- c) **Concrete encasements:** shall be provided in those places where the sewer lines cross the road or as per the directions of the engineer in charge. The pipe shall be encased all-around in 15 cm thick cement concrete 1:5:10 (1 cement: 5 fine sand: 10 graded stone aggregate 40 mm nominal size) with compacted sand or gravel. The material and construction shall confirm to relevant IS codes.
- d) **Chamber for property connection** Property connection chambers (at least 1 for each property) shall be constructed at suitable locations. Chamber shall be of rectangular sections made of masonry with suitable manhole covers and frame as per the relevant IS codes. All Masonry works shall be suitably plastered and painted as per the relevant IS codes.

B.9. STORM WATER DRAINAGE

B.9.1. BACK GROUND

Hisar is located at the central area of the west part of Haryana with an area of about 3983 Sq Km. The district area falls in Yamuna sub-basin of Ganga basin. Area is drained by network of canals and the artificial drains. IMC area is measured about 6.38Sq Km (1575.74 Acre) covering around 5.73 km in length and around 1.8 km wide. The general topography of IMC Hisar area is predominately flat with ground slope towards the NH-9. The site elevation varies from RL 212.5 m to maximum RL 215.0 m.

The project is bifurcated by an irrigation canal. From the view it is evident that it serves water to the adjacent agriculture land. A lined canal sections is running through the boundary of the Project site.



Figure B-3 Project Boundary

B.9.2. DESCRIPTION OF THE WORKS

B.9.3. STORM WATER DRAINAGE WATER SYSTEM

Storm water drains adjacent to the proposed roads (under this Contract) shall be sized for a rainfall intensity, allowing for 100% runoff. Drains adjacent to roads shall be in reinforced concrete of M25 grade minimum with minimum cement content of 330 kg/ cum. The storm water drain shall be considered as culvert and shall be designed for applicable vehicle class loading criteria.

The storm water drainage system shall also be designed to cater the run-off from the existing plot areas and structures, if necessary depending upon the site topography.

Following is the description of works for stormwater drain to be carried out by contractor:-

- Construction of storm water drains including works like raft, walls, top slab, PCC and all allied works as per layout, detail engineering drawing, specifications and as per direction of Engineer-in-charge.
- Laying of RCC NP3 pipe for stormwater drainage as per layout, detail engineering drawing, specifications and as per direction of Engineer-in-charge.
- Rcc Box Drain Section sizes ranges from 450X400 mm to 1400 X 1400 mm and Pipe sizes ranges from 1400mm to 2400mm.
- Construction of storm water drains of 8.75 (approx.) KM for zone 1 area
- Construction of storm water drains of 17.00 (approx.) KM for zone 2 area
- Construction of storm water drains of 15.25 (approx.) KM for zone 3 area
- Construction of storm water drains of 18.05 (approx.) KM for zone 4 area
- Construction of Stormwater pumping station at Outfall No. 2, 3 & 4.
- Providing strutting & shoring at specific locations & as per site requirements.
- Providing dry lean concrete and sand filling for compaction at tight spaces.
- Construction of Water Inlet chambers/ Catchbasin at every 15 m interval for the collection of water from the road surface and carrying it to the drainage system with Ductile iron horizontal grating.

- Provision of Ductile iron horizontal grating for the stormwater drain proposed under the carriage way.
- Provision of Heavy duty RCC Manhole cover with frame for the storm water drain proposed under the footpath.
- Construction of RCC Manhole at regular interval for Stormwater RCC NP3 pipe with precast RCC Manhole cover & frame.
- Provision of HDPE PE-100, PN-10 pipe for connecting Stormwater drain to the Plot boundary.
- Dewatering of water to be carried out (if required) from the trenches.
- Provision of MS footrest with 20mm diameter round bar.

B.9.4. CATCHMENTS

Catchment area of the project is divided into 4 zones for the 4 outfalls. 3 out of 4 outfalls of IMC Phase-I will discharge storm run off to a city drain under irrigation department and the outfall no 4 will discharge water to the city drain managed by PhED department.

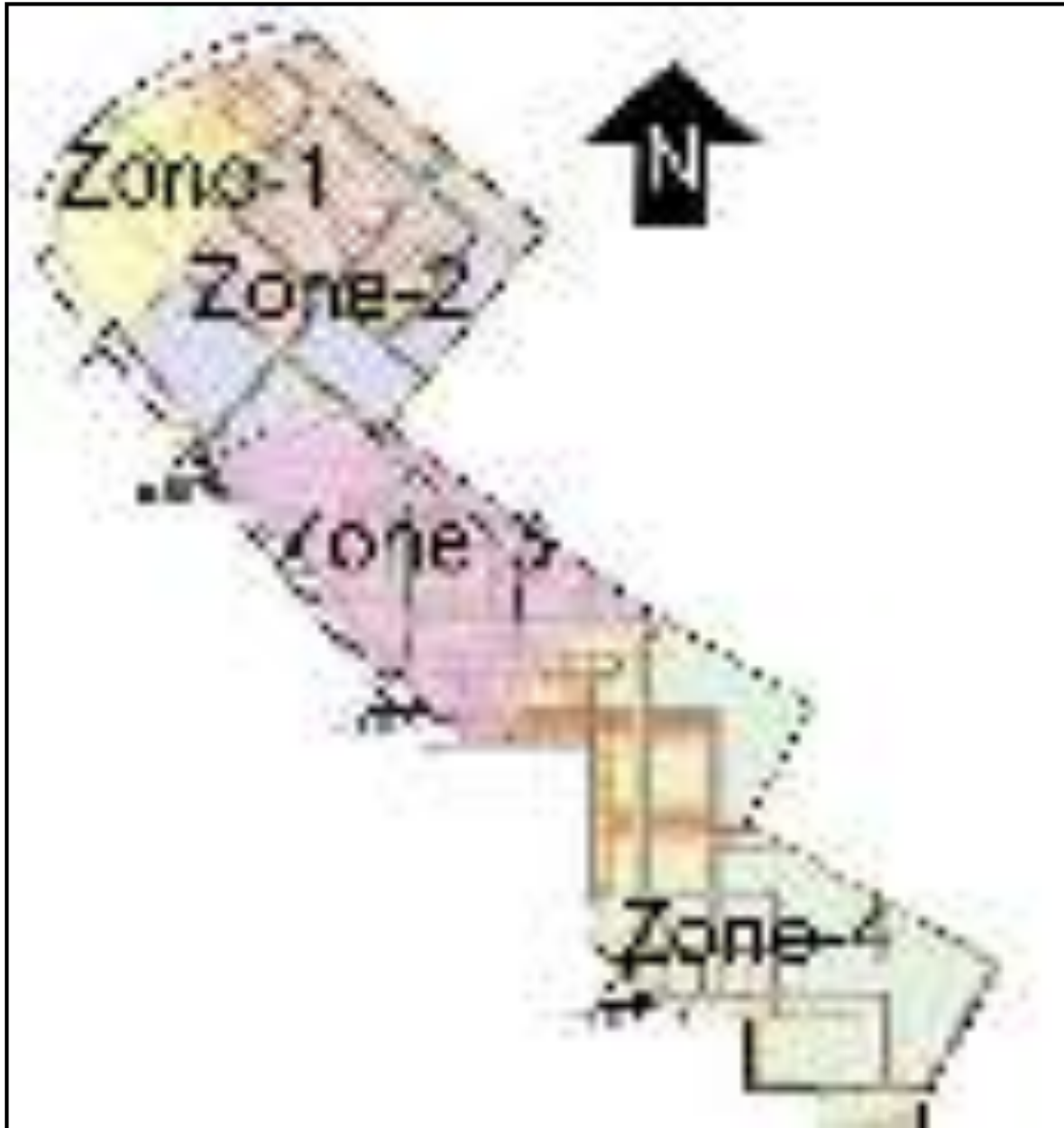


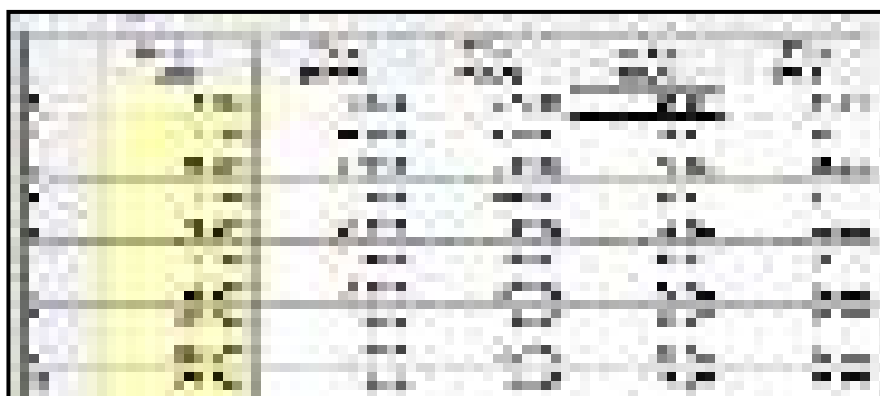
Figure B-4 Zone Demarcation

Figure above shows that there are several areas contributing to the demarcated project site. The external catchment is falling within the extension of Hisar airport area. No storm run-off is expected within project boundary as per the discussion with authorities.

B.9.5. DESIGN CRITERIA

- **Computation of Design Flow:** Rational formula $Q_p = CIA/360$ shall be used
- **Frequency of Storm / Return Period**
 - o **For bridges:** 25year return period
 - o **For road side drains, residential and commercial:** 2 year return period restricting the velocity to 3m/s but analysed for 5 year return period

- **Depth-Duration of Rainfall:** Past 30 year rain fall data collected from the Nearest Rain Gauge Station (From IMD station) shall be used
- **Time of Concentration:** The empirical formula, (Kirpich) shall be used
- **Co-efficient of Runoff :** CPHEEO / as per the Surface drainage design Manual, US department of Transportation)
- **Method of Computing Flow:** Manning's formula.
- **Co-efficient of Roughness:** as per Relevant IS / International standards
- **Rainfall Intensity**
- The daily maximum rainfall data for the region for the past 17 years was collected from IMD Pune for Hisar rain gauge station. This rainfall data has been considered for formulating IDF curve. The average intensity rainfall is calculated using Gumbel's distribution method. IDF curve details are provided in below table.
- **IDF Curve Details**



- **Other Design Parameters**

The design parameters for the drainage system shall be followed as per the following table.

Table B-27 Design Parameters

S. No	Design Parameter	Value	
1	System	Gravity system	
2	Minimum and maximum velocity	As per CPHEEO manual	
3	Time of Concentration	As per CPHEEO manual	
4	Coefficient of Run off	As per CPHEEO manual	
5	Manning's 'n' value	As per CPHEEO manual	
6	Minimum Free Board	Drain Width (m)	Free Board (m)
		< 0.3	0.1
		0.3 to 0.9	0.15
		0.9 to 1.5	0.3
		>1.5	Depends on discharge

B.10. COMMON EFFLUENT TREATMENT PLANT

B.10.1. GENERAL DESCRIPTION OF WORKS

The scope under this contract comprises of Data collection and studies, Design, Engineering, Manufacture, Supply, Transportation to site, Storage, Construction, Installation/Erection, Testing, Commissioning and putting into successful operation of the complete Facility on EPC basis with 4 year O&M basis including all Civil, Structural and Architectural, Mechanical, Electrical, Control & Instrumentation and all Infrastructural work covering lighting, drains, all preparatory & temporary works for the purpose of meeting the entire scope of works for Common Effluent Treatment Plant of capacities 15.00 MLD (100% Recycle and Reuse). The CETP shall be constructed in three phases of Phase 1- 2.5 MLD, Phase 2- 5MLD, Phase 3- 7.5 MLD capacity each.

The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the successful Bidder within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavor to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements. The Contractor shall ensure that his designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which shall facilitate routine and periodic maintenance operations.

Note: CETP of 2.5 MLD is under the scope of this tender.

B.10.2. DETAILED SCOPE OF PROJECT

The scope of works shall include but not be limited to following:

- The Bidder shall be responsible for the Design, Construction, engineering, manufacturing, shop fabrication, assembly, testing and inspection at supplier's works, packing, dispatch, shipping, delivery at Indian port/unloading at Indian port/delivery from Indian port to site

in case of imported equipment and delivery/unloading at site for indigenous equipment, unloading and storing at site, insurance up to time of take -over/hand over by Employer at the need of O&M period, handling at site, complete erection, start-up, commissioning, successful performance testing and handing over of the full Package, warranty, and defect liability period on EPC basis.

- Submission of process design, design calculations, plant layout and hydraulic flow diagram, Process & Instrumentation diagram, electrical & mechanical equipment drawings including equipment installation drawings, supporting calculations & technical information, instrumentation & control system, Erection of all mechanical, electrical items including, testing, commissioning, performance testing of process units & trial run for a period of one months, laboratory with necessary reagents and testing facilities, supply of pumps for transferring the treated effluent from treated water tank.
- Boundary wall with top barbed fencing for the required perimeter of site.
- Landscaping of the Site.
- Construction/installation of Additional Units /equipment's
- Lifting equipment's in Pump house, blower house and wherever applicable for lifting of mechanical equipment's.
- Dyke arrangement for all chemical storage tanks.
- One month performance guaranteed test to perform the guarantees for treated effluent and others (power, chemicals consumption) after successful commissioning and stabilization of Common Effluent Treatment Plants (CETP) of 2.5 MLD.
- Upon completion of the Performance Test and issue of Completion Certificate, Bidder is responsible for 5 years of the operation and maintenance including five Years of defect liability of the complete Facility from the date of issue of Completion Certificate.
- Site clearance
- The Bidder shall include in its scope all the equipment, works and services necessary for complete, safe and reliable operation and maintenance of the facility in accordance with the terms of the Contract, even if certain works are not expressly stated in any part of the Tender Documents. Power meter for energy measurement.
- Throughout these Tender Documents, the terms "Bid" and "Tender" and their derivatives ("Bidder/Tenderer", "Bidding/ Tendering", etc.) are synonymous, and Day means calendar day of twenty-four (24) hours. Singular also means plural. "Bidder" or "Applicant" and "Bid" or "Application" for the purpose of interpretation of Instructions to Bidders shall mean the same. Any other term not defined herein should be interpreted in a manner as defined in the General Condition of Contract.

- All pressure containing equipment and components shall be designed, fabricated, tested, and inspected in accordance with project specification and ASME Section VIII, Div 1. Material certification to BS-EN-10204:2004 shall be supplied for all items.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.
- Training of client Operating and Maintenance personnel.
- The Bidder's proposal shall include details and references of the recorded operational reliability of the key equipment and systems to be provided.

The scope of work shall include but not be limited to the following:

- Construction of Internal Roads, including connecting road to site from existing road to have a separate and independent entry to plant/site.
- Storm water Drainage within battery limits and extension up to nearest drain/point of disposal, drinking water & sanitation water system for operating & maintenance personnel, yard lighting, fencing, etc.
- Construction of permanent boundary walls and/or fence and internal fencing, entry gates and lighting including any temporary fencing required during construction
- Solar Street Lighting.
- Ventilation system for all buildings and units, Fire Fighting System, Tools & Tackles for handling of equipment during maintenance.
- Commissioning spares
- Office, Admin building, Laboratory in complete for efficient operations of the plant.
- Site services as required for the construction and commissioning of the Plant including start-up and handover.
- Lay-down areas, warehouses, workshops for site construction and pre-fabrication purposes, vehicles, mobile equipment etc.
- Inspection and Quality Control of all equipment and civil work, Erection, Commissioning, trial run, along with all consumables and manpower, project management and monitoring for timely submission of design documents and drawings and timely execution of the project with demonstration of performance guarantee parameters including supply of all measuring instruments and manpower.

- Material of Construction: For any proprietary or generic design, the Material of Construction shall be as per the tender document – (e.g. Pipes, Plates, Valves etc)
- The purpose facilities shall require minimum skilled manpower for the operation and maintenance and shall have a complete PLC based operation of all units in proposed plant.
- Model of CETP -The successful bidder shall have to provide a model of CETP depicting the picture of post completion stage of DB base work; using acrylic or any other approved durable material within 3 months from the substantial completion of basic engineering.
- Disposal of CETP residuals like but not limited to screenings, grit, dewatered sludge (primary sludge, secondary sludge) shall be disposed of at the nearest Common Hazardous Waste Treatment Storage & Disposal facility CHWTSD facility, including all cost of transportation and treatment charges.
- All statutory works and compliance during construction and O & M period.
- Automation & Control
- PLC based automation system with application software. Automation to control blowers, VFDs, limit switches and Instrumentations in the plant and other units of sewage treatment plant, including I/Os with 20% spares, power supplies, UPS, etc. complete.
- Stand alone/ or integrated PLC panel having Suitable PLC.
- Ultrasonic level transmitter on all sump/ tank.
- Flow meter in rising main of effluent transfer pumps to equalization tank, treated effluent transfer pumps
- Digital energy meter along with CT's and protective switchgears on each MCC which shall be connected on MODBUS communication with PLC to have all parameters like, Voltage, current, Power Factor, active and reactive power.
- HMI Panel to comprise of up-to-date standard PC with monitor, printer, mouse, RS-view, RS-links (gateway version), entire process and operator software with dynamic flow charts, pictures, screens, alarms, historical trends, reports etc.
- Complete SCADA based operation including but not limited to Pre-Treatment including Screening, Grit Chambers, Raw Effluent Transfer Pumps, Primary Treatment, Secondary Treatment, Tertiary treatment, Sludge Dewatering System, Polyelectrolyte dosing system, Odour Control Unit.
- Flow Diagram & P&ID diagrams
- Any other items of work which have not been specifically mentioned in specifications but are necessary for the plant as per engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within

scope of work of these specifications and shall be provided by the Contractor without any extra cost to the Employer.

- The Contractor shall ensure that all designs and equipment for which he is responsible are safe. Nothing in this requirement shall remove the Contractors obligation from drawing the attention of the Employers Representative to any feature of the Works, which is not consistent with safety, or to prevent him making proposals for incorporating equipment or designs which would increase the safety of the site and plant.
- The installation layout and system design shall not allow any item of plant to be positioned so that danger to operating personnel could arise during normal operation and maintenance.
- Particular attention should be paid to the position of pipes, air vents, electrical cables and rotating machinery.
- All rotating shafts, couplings, gears, flywheels, belt drives or other moving parts shall be fully guarded. Guards shall be designed to provide ready access to bearings, grease points, thermometer sockets/instrument probes and other check points and to allow safe routine observation and servicing to be executed without the need to dismantle any part of their structure.
- However, prior to commencement of the work, the Contractor shall submit the following:
 - Layouts, general arrangements, dimensional elevations and cross-sectional drawing for all the project components, equipment, structures and facilities of the works.
 - Flow diagrams, hydraulic gradient diagram, Process & Instrumentation Diagrams, Piping isometric, composite layout and fabrication drawings, Piping engineering Diagrams, pipe and fittings schedules, valve schedules, pipe support schedules.
 - Technical data sheets and calculations for all bought out and manufactured items
 - Detailed design calculations including sizing calculations for all system and equipment like pump, pumping station equipment's, piping, valves, Electrical systems, Control and Instrumentation systems and civil works.
 - Characteristic Curves/ Performance Correction Curves.
 - Hydraulic & Mechanical design calculations
 - Comprehensive list of all terminal points which interface with Employer's facilities, giving details of location, terminal pressure, temperature, fluid handling & end connection details, forces, moments etc.
 - Power distribution scheme indicating the equipment's rating
 - Protection system diagrams.
 - Cables schedules, termination and interconnection diagrams

- Instrument schedule, measuring point list, I/O list, Interconnection & wiring diagram, functional write-ups, and installation drawings for field mounted instruments, logic diagrams, control schematics, wiring and tubing diagrams of panels and enclosures etc. Drawings for open loop and close loop controls (both hardware and software).
- List, type, data sheets and valve schedule of motors and actuators, Alarm and annunciation/Sequence of Event (SOE) list and alarms & trip set points.
- Sequence and protection interlock schemes
- Type test reports
- Control system configuration diagrams and card circuit diagrams and maintenance details
- Detailed software manuals & source software listing
- Detailed flow chart for digital control system and Mimic diagram layout, Inputs
- Foundation Plan and Loading Data for Civil Design and drawings.
- Model study reports wherever applicable
- Functional & guarantee test procedures and test reports
- Documentation in respect of Quality Assurance System as listed out elsewhere in this Specification
- Single line Diagram, Schematic, control, wiring, duty cycle diagram and relay settings of all electrical panels/cubicles/cabinets

B.10.3. GEOTECH SURVEYS, TOPOGRAPHICAL SURVEY AND SOIL INVESTIGATION AGENCY

- Site-specific geotechnical investigations were carried out for the existing site and are enclosed as Schedule P. This is for reference only and a detailed geotechnical investigation shall be performed at the Site before starting works by the Bidder.
- The Bidder is required to verify the sub-soil strata including the CBR value by performing its own site investigation prior to developing the civil/structural design.
- The geotechnical parameters necessary for the detailed foundation designs would depend on the findings of site-specific ground investigation.
- The Contractor is required to reconfirm the topographical surveys and soil investigations enclosed with the bid. The Employer does not warrant either the sufficiency or accuracy of site data provided in the Bid Documents or elsewhere. Any Site data in Employer's possession that is not included in the Bid Documents shall be available for inspection at the Employer's addresses provided in Conditions of Contract.

- He should be ready with the qualified agencies he intends to use for the purpose and ensure that the work starts within a fortnight of the LOI. He shall conduct investigations as are normally necessary to ensure full and satisfactory designs and safety.

B.10.4. WORKABILITY AND MAINTENANCE

- Facilities and equipment shall be arranged and spaced sufficiently to enable satisfactory operation and maintenance of the Plant. Access around all equipment shall be provided, in accordance with Good Utility Practices, to allow effective inspection, maintenance and removal of equipment.
- Aisleways adjacent to equipment and lay-down areas shall be sufficient to facilitate all aspects of major maintenance and Plant overhaul. General arrangement drawings shall be provided, clearly identifying the outline of all major Plant equipment, their weights and associated floor loading capacity and lay down location.
- Space should be provided at the front and rear of the MBBR and Tube Settler to allow the use of mobile equipment and access to media replacement or repairs.
- Permanent lifting devices should be provided for maintenance of heavy equipment, they should be sized to lift the heaviest equipment in the said process unit.
- The lay down areas for all major facilities should have adequate space for direct heavy transport, as well as trailer access and direct mobile crane access. Platforms shall be provided around equipment as required for maintenance work, testing, inspection and safe operation. Platforms where provided, shall be sized to facilitate safe ergonomic operation of manual valves and equipment between waist and shoulder level of an average height man. Those parts of the facility where maintenance activities shall be performed shall be provided with permanent arrangements for slinging or handling during maintenance and overhaul.
- All automatic valves and major equipment should be at ground level or accessible by permanent platforms. The marking and test specification of safe working load values on lifting equipment shall be in SI units.
- All platforms to be visited on a daily basis shall be provided with stairways, except where a permanent access ladder is the only feasible means of access. All interior and exterior platforms gratings and/or checker plates shall be of GRP. Handrails shall be SS- 304 Schedule 10 made of 32NB pipes/tubes with top and intermediate rows of pipes running parallel to each other and the height of railing not less than 1100mm. The distance between 2 vertical posts shall not be more than 1.5 meters. The post shall also be of 32 NB.

-
- Platforms shall be constructed using a suitable grade of GRP grating, to the relevant ISO, British Standards or ASME Standards and shall cater for the relevant loadings for maintenance. Generally, no frequently accessed platform shall be less than 1m wide and all platforms shall be extended up to the equipment, valves and instrumentation that they serve. All edges of floors, platforms and walkways shall be provided with curbs or kicking strips.
 - Sufficient space should be provided to ensure easy inspections and maintenance of all the equipment.

B.11. WATER TREATMENT PLANT

B.11.1. GENERAL DESCRIPTION OF WORKS

The scope of work under this Single Responsibility Contract includes construction of all works as described in subsequent paras to achieve the objective to treat the raw water as per the stipulated treatment quality / standards as per good and acceptable engineering practices and workmanship manner.

The scope of work will be in general but not limited to Design & Detailed Engineering, Procurement & Construction of Civil, Mechanical, Electrical, Instrumentation, & Interconnecting Pipe works including erection, testing, trial runs, commissioning, guaranteeing and comprehensive operation and maintenance with repairing work (including spares) of Conventional Water Treatment plant of capacity 15 MLD net treated water at WTP outlet in 22 hours as per the detailed technical specifications and data sheet. The WTP shall be constructed in three phases of 5 MLD capacity each. For the purpose of this tender, wherever the capacity of the proposed Water Treatment Plant is stated as 15 MLD in 22 hours, it shall be interpreted as 15 MLD in 22 hours of net treated water output, excluding treatment losses at the plant outlet. Dirty backwash water after settling in Dirty backwash recirculation sump shall be recycled/pumped back to inlet of raw water channel.

The proposed water treatment plant will have to be designed & constructed considering the given hydraulic flow levels for the raw water at first unit of WTP on one side and FSL of clear (treated) water sump (reservoir) on the other side.

The scope also includes geotechnical survey of plot to derive soil bearing capacity, strata classification and details of water table etc. Contractor shall also prepare survey report including Contour plan at site. Bidder to note that FGL (Finished Ground level) selected of site should be at least 500 mm above HFL (High Flood level) at site & FGL should be at least 300 mm above nearby road level to prevent Flooding at site. Further one common FGL should be adopted by Contractor until unless agreed & approved by Engineer in charge based on site conditions.

The scope also includes providing of inlet isolation butterfly valve with chamber on raw water incoming pipe within WTP premises and providing onwards piping up to first receiving unit of WTP / at cascade aerator including its connection with puddle pipe at cascade aerator along with required set of flanges of matching size.

Similarly on outlet side, the scope also includes providing pipe of required size beyond Chlorine contact tank. The treated water of proposed water treatment plant shall be conveyed to UGSR (Clear Water Sump).

The scope also includes complete system for dirty back wash water Collection, settling, recycling/pumping, clarifier sludge & backwash settled sludge collection and disposal system as described in detail in datasheet & specifications.

All M.S. Pipeline within the scope of this work shall be spirally welded and having outer coating with epoxy paint & inner coating with food grade epoxy paint except for raw water inlet pipeline.

All outside surface of civil structures including columns, etc. shall be painted with a minimum of two coats of snowmen paint and all inner surfaces of various pump house and buildings (chemical house, filter house, guard room, HT/PMCC rooms, etc.) shall be painted with a minimum of two coats of Distemper paint as per civil specifications. The paint shall be of Asian / Berger / Shalimar make only. The colour shade shall meet approval of client.

The contractor shall also undertake the operation and maintenance of system for 5 years after completion of works & 3 Months trial runs.

The scope shall also include development of lawns, landscaping, and plantation along the periphery of the site proposed for construction of WTP including maintenance of all during entire O&M period.

Trial run of water treatment plant with allied works for a period of three (3) months and operation and maintenance of water treatment plant (WTP) for a period of 60 calendar months after successful completion of trial run, commissioning and acceptance of the plant by employer. Only raw water, & power shall be supplied free by client during trial run and O&M period (up to the guaranteed levels & anything beyond guarantees shall be charged at double the normal supply rates) and rest all expenses including chemicals, consumables, spares, manpower, etc. shall be borne by the successful bidder.

Wherever reference is made of the employers design, drawings, or concept, it may be understood that these are concepts of the employer and the responsibility for correctness of designs, drawings and safety of equipment/structure shall rest on the contractor. Bidders are advised to inspect the site for further clarifications and to

understand the scope of work. It is the bidder's responsibility to carry out all the works required to complete the scheme under this project whether it has been mentioned or not.

All the material / bought-out items shall be procured as per approved make / vendor list only and in absence of such a list for any item, the same shall be procured with prior approval for such make from client.

Note: WTP of 5 MLD is under the scope of this tender.

B.11.2. TERMINAL POINTS FOR WTP

Supplying & interconnecting the raw water inlet pipe to first receiving unit of WTP / at cascade aerator including its connection with puddle pipe at cascade aerator along with required set of flanges of matching size shall be in Bidders scope. Inlet Isolation butterfly valve with valve chamber shall be provided by bidder on raw water inlet pipe. The treated water of proposed water treatment plant shall be brought to UGSR (Clear Water Sump) from where it shall be pumped for onward distribution.

B.11.3. MAJOR COMPONENT OF WORK

The major treatment units proposed to be provided for water treatment plant shall comprise of the following component as a minimum requirement:

Providing & interconnecting with Raw water main along with provisions of necessary valves & valve chamber at inlet of WTP.

- a) Cascade Aerator
- b) Raw water channel including Parshall Flume for Flow Measurement
- c) Distribution Chamber (as applicable)
- d) Flash Mixer
- e) Clari-Flocculator
- f) Filter House based declining rate rapid gravity sand filters
- g) Chlorine Contact Tank
- h) Overhead Backwash storage tank with Pump House (PH) & Backwash Tank Filling Pumps.
- i) Pre-Chlorination and Post-Chlorination system with 100% standby for chlorinators & tonners
- j) Clear (Treated) Water Sump / Reservoir of 20 minutes of retention time & Pump House with Clear Water Pumps.

- k) Dirty Backwash Water Recirculation sump & Pump house with Backwash water recycling pumps and related piping work
- l) Sludge disposal pumps to pump sludge from Dirty Backwash Water Recirculation sump to Sludge disposal chamber provided at WTP.
- m) Chlorination room (s) including chlorination system (chlorinator & chlorine tonner house)
- n) Chemical House including Chemical Storage Room, Chlorinator & Chlorine Tonner Room, Chemical Dosing Tanks / Area, LT (MCC) Room, Laboratory, Office Room along with necessary office furniture, Control room with necessary furniture, Toilet Block, etc. This Building shall be a two storied building (GF + FF).
- o) Bypass arrangements
- p) Electric HT Substation comprising of HT & LT (PMCC) rooms, switch yard / transformer yard, etc. as applicable.
- q) Guard Room near Main Entry of plant (having min. 10 sq.m. area)
- r) Drinking water & service water piping / network
- s) Service / Drinking Water Tanks of adequate capacity at Chemical House / Administration Building.

Note:

- a) All the interconnecting piping for all the units, bypass and final disposal piping including fittings and valves for treatment plant, water supply & service water lines shall be provided.
- b) All necessary electrical (power & control) and instrumentation (signal, communication, control & power) cabling for HT, LT power distribution, & instrumentation system shall be provided.

B.11.4. THE OTHER UNITS REQUIRED ARE

- a) Approach road to WTP from the main road as required, all Internal Roads including approach and surrounding roads for proposed WTP, Storm Water Drainage (wherever required), Plant Pathways (min 2 m wide concrete pathways), Plinth Protection & Roads. Width of bitumen carpeting shall be 5.00 mtr. having berm as 2 mtr. on both sides. As per cross section, drains on both the sides with kerb stones and interlocking tiles arrangements shall be provided by bidder.
- b) Water distribution network for drinking purpose/service water within the plant premises and sewage disposal.

- c) Bidder shall consider in his scope to provide lawns, plantation and landscaping within the WTP battery limit. Plantation shall be provided along the plant roads, plot periphery, open areas and others at places as directed by engineer in-charge.
- d) The plantation shall be provided with necessary protection (Tree guard) and the species selected shall be suitable for the site environment and must be shade giving trees. Contractor shall consider to provide saplings such that minimum 80-100 surviving trees are available. Bidder shall submit the Landscaping Design for approval of CLIENT during detailed engineering and shall carry out the work as per approval and direction of engineer-in-charge.
- e) Contractor shall commence this work during 3 months period of trial runs and commissioning and complete the same in all respects within 6 months from the date of works completion i.e. during first 6 months of O&M period, to the satisfaction of engineer-in-charge.
- f) The maintenance of these lawns, plantation & landscaping works shall be in the scope of contractor during O&M period.
- g) Earth filling, levelling and dressing around the treatment unit including cutting of trees, removal of debris, shrubs, etc. within the premises of treatment plant & filling, to bring the site up to formation level, landscape, tree plantation, shall be included in the scope of work of this contract.

B.11.5. THE SCOPE OF WORK SHALL ALSO INCLUDE

- a) Pre-commencement surveying and mapping which include Topographical Survey of proposed site with Total Station,
- b) Detailed sub-soil investigations to assess the safe bearing capacity, and the physical and chemical characteristics of the soil.
- c) All interconnecting pipes, channels, valves, fixtures, appurtenances.
- d) Supply, erection, testing, commissioning of various mechanical, piping, electrical & instrumentation equipment required for the smooth working of the water treatment plant, including the 5 years O&M of entire treatment facility.
- e) Construction and equipping of testing laboratory for routine testing of water quality parameters.
- f) Instituting a Quality Control System during construction.
- g) Integration and tuning of the system.
- h) Any other item not indicated above but necessary, essential or incidental to the completion of the above works and making them operational / All other accessories,

- whether specified or not, but required for complete shall form a part of contractor's scope.
- i) Preparation of plant layout; process design/unit sizing calculations; hydraulic calculations and flow diagram including pump head calculations; P&I Diagram; civil, mechanical, piping, electrical & instrumentation design, drawings, data sheets, sizing calculations, etc. as applicable including architectural drawings for construction after review and approval and as built drawings.
 - j) Remedy for any defects during the Contract Period.
 - k) Obtaining Power connection for designed power load for running and operation of treatment plant and other units within the project campus area from the power supply company (as applicable) including all required liasoning, shall be bidder's scope. Only the applicable statutory fees shall be borne by the employer.
 - l) Obtaining statutory approvals for the entire WTP facility including electrical inspector, chlorine tonner storage & filling, etc. Only the applicable statutory fees shall be borne by the employer
 - m) Preparation and submitting of operation and maintenance manual for plant and equipment in six copies.
 - n) Operation and maintenance of all components of project for the defined period of operation and maintenance after successful trial run for defined period and commissioning.
 - o) Providing training services to CLIENT's engineers or related departments engineers as per the direction of engineer-in-charge.
 - p) Providing inspection and testing of all equipments(s) and material(s) required for execution of the work at his own cost.
 - q) Providing spare parts and specialized tools in accordance with the schedules, and at the Owner's option.
 - r) All erection/ construction tools and tackles, cranes, hoisting equipment, etc. as required.
 - s) All instruments and controls as mentioned in data sheets and the description of this specification to make system complete.
 - t) All instruments shall be supplied by the Vendor. It shall be the Vendor's responsibility that proper controls are established to ensure trouble free smooth operation of the plant.
 - u) All Electrical components as per Typical Single Line diagram and as mentioned in data sheets and description of this specification to make system complete.
 - v) All interconnecting piping, valves, supports, plate, grouting & excavation as required.

- w) Final painting at site.
- x) Packing, forwarding, delivery to site, unloading at site.
- y) All chemicals and consumables till the plants are handed over to the Purchaser.
- z) All other equipment/services required to make system complete & those not mentioned specifically in equipment and services by others will form part of scope.
- aa) Sampling points to be provided at all required points to measure the quality of water.
- bb) The lighting system at treatment plant area.
- cc) Lab testing, chemicals and reagents for commissioning / testing of various water samples.
- dd) This work also includes design and construction of Roads, Storm water drains, Wastewater drainage, Street lighting, Compound wall along plot boundary, site grading, area development, landscaping for entire site.

B.11.6. TRIAL RUN PERIOD

Trial run period for water treatment plant shall be Three (3) month after the date of completion of construction works in all respect. The trial run and acceptance of the plant after stipulated guarantee run shall be carried out based on the quantity of raw water made available by employer at the time of trial run and commissioning including guarantee run of the plant.

B.11.7. WATER TREATMENT PLANT STAFFING REQUIREMENTS

- The bidder shall provide all the necessary minimum operating staff and maintenance personnel as noted below to operate the Works for a total period of 60 months.
- The Contractor shall provide a detailed proposed staffing schedule before the anticipated start of the 30-day operation period for each of the sections of the Works. The schedule shall cover all categories of staff from the works superintendent to cleaners, including adequate numbers of maintenance staff.
- The staffing schedule shall be prepared for operating the Plant 24 hour per day basis with three equal shifts of 8 hours during the complete O&M contract period.
- The O&M staff shall have the min. following personnel in Table below.

Position	Min. Number	Desired Qualification
Plant Manager	1	Bachelor's degree in Environmental/Chemical Engineering with minimum experience of 10 years in similar nature of work.
Chemist	1	Bachelor's degree in Chemistry with minimum experience of 7 years in similar nature of work.
Lab Technician	1	Bachelor's degree in Chemistry with minimum experience of 5 years in similar nature of work.
Process Engineer	1	Diploma in Environmental/Chemical Engineering with minimum experience of 7 years in similar nature of work.
Mechanical Engineer	1	Diploma in Mechanical Engineering with minimum experience of 7 years in similar nature of work.
E&I Engineer	1	Diploma in Electrical Engineering with minimum experience of 7 years in similar nature of work.
Mechanical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Electrical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Required Security Staff		

B.11.8. GENERAL PRINCIPLES

The bidder shall carryout all works wholly in accordance with the terms and conditions of the contract to fulfill the requirement of the project. All the material used, and the equipment installed shall be as per the specifications defined in the contract and the work shall be executed with good engineering practices.

Generally, the following activities shall be carried out for each component of this contract but shall not be limited to.

Submission of all documents required according to the Contract (security money/guarantee, insurance policies, if any etc.)

Preparatory Work: The Contractor shall use the land earmarked to accommodate for sitting of all the units of the final capacity of proposed works. The Contractor shall construct approach roads connecting to all treatment units, and ancillary civil structures to be constructed within the campus from the main road up to Plant site. The contractor will have to use the same for transporting the materials to the site. The Contractor shall construct a benchmark at a suitable location within the campus to establish a GTS benchmark at a suitable location within the site and transfer level from the existing benchmark, as approved by the Engineer-in-charge. All levels shall be deemed to refer to that benchmark. The Contractor may establish other secondary benchmarks on the site, where required.

Soil Investigation: The Contractor in co-ordination with the Engineer in Charge has to determine at each location of a building or a water retaining structure the soil characteristics (safe bearing capacity, angle of friction, cohesion etc.) in order to design the dimensions of the foundations. It is also important to assess the potential of changes in water table, erosion and exposure of foundations and the stability of the soil with a view to the lateral resistance to be taken into account. The soil conditions have to be analysed for all important structure of the water treatment plant. The required soil analyses are:

a) Penetration tests

- Standard penetration test to a depth corresponding to at least 1.5 times the width of the building/foundation.

b) Plate load tests:

- To assess soil bearing capacity at the foundation level (Plate test)
- To take samples for laboratory analyses

c) Laboratory analyses for

- Granulometry
- Cohesion
- Angle of friction
- Proctor density

d) If the standard penetration tests give a sufficiently clear picture of the soil bearing capacity the number of test pits can be reduced.

B.11.9. SOIL DATA

- a) Composition and classification of the soil (sand, clay, silt, organic matter etc, soft, medium, hard, decomposed rock, rock etc.) with view to:
- b) Excavation
- c) Need to support walls of trenches
- d) Compacting
- e) Permanent or temporary groundwater (water logging)
- f) Hard pans below the sand (depth, thickness, type of layer)
- g) Clay lenses

The results of the survey, the sampling, the laboratory analyses and the calculations shall be presented in a report in three copies to the Engineer in Charge. The execution of the foundations shall be started only after approval of the Engineer in Charge. The contractor however will be responsible for design of the structures based on the results of these investigations.

Note: Soil investigation report for the proposed water treatment plant site is enclosed with this tender for bidder's guidance only. However, if required, bidders may carry out the additional soil investigation/analysis at their own cost to ascertain the type of foundation before bidding. If required bidders may consider soil stabilization/ or any other type of foundation in their cost while quoting job. The successful contractor shall carry out detailed soil investigation at sufficient number of places as per design requirement at his own cost. If the data of this report differs from the data given in the tender then structural design of all the units shall invariably based upon the most critical conditions of soil investigation. For any increase in foundation depth or type of foundation etc., no extra claim by the contractor shall be made.

Along with the excavation for the buildings and underground sump etc., the Contractor shall assess all the necessary parameters such as type of soil, the strata, the level of groundwater and other indicators important for structure. He has to establish soil profiles and submit these to the Engineer in Charge for approval of the following:

- a) Carrying out necessary Topographical Survey for all the units, pipeline etc. road works and campus development within the limits of the contract in consultation with the Engineer in Charge.
- b) Preparation and submission of the layout plans of entire treatment system with ancillary structures, cross sections and conceptual drawings etc. of all components of the

project. The drawings must be on scales as appropriate subject to the prior approval of the Engineer in Charge.

- c) Additionally, he has to assess the type of soil, the strata, the level of ground water and other indicators if any and establish soil profiles and submit these to the Engineer in Charge.
- d) Submission of the process design, hydraulic calculations for the design of the water treatment plant, interconnecting pipe, channels etc., layout and P&I diagram.
- e) The Contractors will have a choice to make use of the data/information/reports etc. placed in this volume but the department does not stand guarantee to the data / information / reports / designs / drawings included in this volume. The Contractors will be solely responsible for preparing and submitting required drawing after carrying out appropriate field surveys, data collection, designs etc. for approval of Engineer-in-Charge.
- f) Approval of all design and drawings, material to be used, equipment specifications and the samples, shall be obtained from engineer-in-charge prior to commissioning of work on site. Unless mentioned otherwise, if for any specific provision / references have been made in more than one specifications, the provision which is more stringent of the lot shall be applicable and shall be binding upon contractor.
- g) Submission of the design, specifications, catalogues and the technical data sheets of all the equipment, electrical system, design of the electrical components and the switchyard, shall be made taking into account the interfaces to the other project components /packages and the second phase of Project.
- h) Preparation and submission of all detailed working drawings on the basis of conceptual designs and plans approved by the Engineer in Charge.
- i) Providing adequately planned plinth protection works for all structures to be constructed.

B.11.10.DESIGN, DRAWING AND DOCUMENT SUBMISSION ALONG WITH BID FOR EVALUATION PURPOSE

All drawings/documents/design submitted along with the offer shall be for bid purpose only. These shall be subject to modification/approval at the time of detailed Engineering. Such changes will not have any techno-commercial implications.

The documents as specified elsewhere for submission with bid shall be submitted in two sets in hard copy as well as in soft copy along with on-line submission.

B.11.11.DESIGN / DETAILED ENGINEERING / CONSTRUCTION DRAWINGS FOR REVIEW & APPROVAL

All the drawings enclosed with this tender like- layout plan, Hydraulic flow diagram etc. are given for general guidance only.

After award of work and before starting of any construction activities including excavation etc., Flow balance diagram, process / unit size calculations, unit layout plan, hydraulic design calculations & hydraulic flow diagram, P&I diagram, Single line diagram & G.A. drawings of all the units, , Datasheets & drawings for related Mechanical, Electrical & instrumentation works of the plant shall have to be prepared based on the scope of work & datasheet given in this tender and submitted by the contractor for approval of Client (Employer) / Consultant within 1 month of award of contract. Hence, it is to be very clearly understood by the contractor that concept, shape, specifications, minimum volume, size, capacity etc. given for any unit, item, etc. given in this tender shall have to be followed strictly in submission of all drawings by the contractor. After getting the approval for the same from client, the contractor shall submit structural (RCC/steel) drawings with design calculations for approval of Client / Consultant. The piping, electro-mechanical and instrumentation design shall also require to be approved from the Client / Consultant.

Similarly, the successful contractor shall submit data sheets / drawings for all piping, mechanical, electrical, and instrumentation/automation works conforming to tender specifications for approval from Client / Consultants prior to going ahead with manufacturing / procuring these material at site.

All Designs, Drawings and calculations shall be approved by the consultant of Client. Any drawing can be released for construction / manufacturing only after getting final approval in writing from Client / Consultant.

Contractor shall carry out basic design and detail engineering work for WTP and submit various drawings and documents for approval of client / consultant before these are released for construction or manufacturing.

- a) On award of the work the contractor shall hold a design conference with client / consultant to discuss and finalize various parameters before the start of actual basic engineering at no extra cost to owner. As this is a lump sum contract, any changes

suggested due to sound engineering practice shall be incorporated at no extra cost to the client.

- b) Contractor shall initially submit six sets (two set for client, two sets for consultants and two sets (office & site copy) for contractor) of each of the design, detailed engineering drawings & documents in hard copy for review and approval of client / consultants. In addition, contractor shall also submit these drawings & documents in two sets in soft copy to client / consultants in suitable format for review of client / consultants. Client / consultants shall review and approve or else furnish their comments / observations, if any. Only the approved drawings can be released for construction / manufacturing, subject to compliance of comments, if any, furnished with the drawings or documents approved by client / consultants.
- c) In the event of comments or non-approval of drawings or documents submitted by contractor, the contractor shall re-submit the concerned drawing or documents within 10 days from the date of issue of comments by e-mail or letter, as applicable & whichever is earlier, in required number of sets and type as mentioned above for initial submission for review and approval of client / consultants. All revision number of the drawing / documents shall be revised for each re-submission (i.e. initial submission shall be considered as Revision 0 and subsequent submission shall be treated as Revision 1, 2, 3 and so on till the subject drawing or document is approved for construction) and all the revisions shall be marked in the revised drawings.
- d) Contractor shall retain the set of original as well as a copy of all drawings and documents at site duly approved for construction / manufacturing. All construction and manufacturing shall be as per approved drawings only and shall be subject to compliance of comments.
- e) However, reviewing of design / drawings / documents is not obligatory on the part of client / consultants and complete correctness / soundness of the design / drawings and their execution at site shall be the sole responsibility of the contractor irrespective of the fact whether the same has been reviewed / approved by client/consultants or not. Any defect observed during commissioning and / or operating the plant shall be rectified by the contractor by carrying out the necessary modification or rectifications, as applicable.
- f) All hard copies shall be submitted to client along with required covering letter through courier or in person and soft copies may be submitted either in person or through courier (in CD) or through e-mail to client as well as consultants.

B.11.12.AS-BUILT DRAWINGS

- a) Contractor shall submit five sets (two sets for client, two sets for consultants and one set for contractor for records) and two sets in soft copy (one set each for client and consultants) of each of as-built design and detailed engineering drawings & documents in hard copy duly incorporating the changes, if any, during the construction phase and duly approved by client with respect to the approved drawings for records of client / consultants. The contractor shall get the as-built drawings / documents reviewed and certified by client's engineer and project management consultants or Third-Party Inspection Agency (if applicable) representative at site prior to submitting these documents for records.
- b) Contractor shall submit as-built drawings of all civil works (Civil / Mechanical G.A. Drawings), piping layout and piping drawings/isometrics, electrical SLD, electrical and instrument cable layouts, earthing layout in two sets in AutoCAD format (suitable revision to be conveyed later during detailed engineering) for records and future use of client.

B.11.13.O&M MANUAL / COMMISSIONING RELATED DOCUMENTS

Following Documents shall be submitted as a minimum:

- a) **Plant Operating Manual:** It shall include:
 - Plant Units operation philosophy
 - Instrumentation philosophy
 - Operational-Control Logic
 - Initial start-up
 - Abnormal operating conditions
 - Shutdown and emergency procedures
 - Precautions and hazards
 - Routine checks & operations
 - Process Upsets & Recommended corrective action
 - Recommended spare parts list for two years smooth, trouble-free operation after handing over of plant i.e., after 5 years O & M
- b) **Equipment Operation & Maintenance Manuals**

Operation / maintenance manuals supplied by respective vendors for all equipment / units in consolidated form (Preferably in volumes covering each treatment section). Any specific requirement.

c) Suggested PGTR Procedures

Initially two sets of each of the above documents in hard copy shall be submitted for review and approval of client / consultants. Client / consultants shall furnish their comments / observations, if any.

Contractor shall incorporate the comments / observations furnished by client / consultants and shall submit each of the above documents duly approved by client/consultants in five sets in hard copy (Three sets for Client, One set for Consultant and One set for Site) and Two sets in soft copy (on two separate CDs, one each for client and consultant's records).

B.12. SEWAGE TREATMENT PLANT

B.12.1. GENERAL DESCRIPTION OF WORKS

The scope of work under this Single Responsibility Contract includes construction of all works as described in subsequent paras to achieve the objective to treat the wastewater as per the stipulated treatment quality / standards as per good and acceptable engineering practices and workmanship manner.

The scope of work will be in general but not limited to Design & Detailed Engineering, Procurement & Construction of Civil, Mechanical, Electrical, Instrumentation, & Interconnecting Pipe works including erection, testing, trial runs, PGTR, commissioning, guaranteeing and comprehensive operation and maintenance with repairing work (including spares) of Sewage Treatment plant of ultimate capacity of 2.76 MLD. Construction of STP shall be in two phases – 1.5 MLD for phase 1 and 1.26 MLD for phase 2 using MBBR technology.

The scope also includes geotechnical survey of plot to derive soil bearing capacity, strata classification and details of water table etc. Contractor shall also prepare survey report including Contour plan at site. Bidder to note that FGL (Finished Ground level) selected of site should be at least 500 mm above HFL (High Flood level) at site & FGL should be at least 300 mm above nearby road level to prevent Flooding at site. Further one common FGL should be adopted by Contractor until unless agreed & approved by Engineer in charge based on site conditions.

Bidders are strongly advised to conduct a site visit to assess the conditions and verify spatial and design requirements prior to submitting their proposals.

The designated dumping zone for dismantled material and waste is approximately **3 km** from the current plant location. All demolition waste must be transported and disposed of at this designated site.

The contractor shall also undertake the operation and maintenance of system for 5 years after completion of works & 3 Months trial runs.

The scope shall also include development of lawns, landscaping, and plantation along the periphery of the site proposed for construction of STP including maintenance of all during entire O&M period.

Trial run of sewage treatment plant with allied works for a period of three (3) months and operation and maintenance of sewage treatment plant (STP) for a period of 60 calendar months after successful completion of trial run, commissioning and acceptance of the plant by employer. Only raw water, & power shall be supplied free by client during trial run and O&M period (up to the guaranteed levels & anything beyond guarantees shall be charged at double the normal supply rates) and rest all expenses including chemicals, consumables, spares, manpower, etc. shall be borne by the successful bidder.

Wherever reference is made of the employers design, drawings, or concept, it may be understood that these are concepts of the employer and the responsibility for correctness of designs, drawings and safety of equipment/structure shall rest on the contractor. Bidders are advised to inspect the site for further clarifications and to understand the scope of work. It is the bidder's responsibility to carry out all the works required to complete the scheme under this project whether it has been mentioned or not.

All the material / bought-out items shall be procured as per approved make / vendor list only and in absence of such a list for any item, the same shall be procured with prior approval for such make from client.

Note: STP of 1.5 MLD is under the scope of this tender.

B.12.2. SEWAGE TREATMENT AND ITS COMPONENT

In this project, scope of contractor mainly includes design and construction of sewage treatment plant (STP) capacity of 1.5 MLD in two phases.

Table 28: Process requirements for the following STP are included in this contract

Sl. No.	Proposed STP Location	Design Average/Peak Ultimate Capacity (MLD)	Technology Treatment Process
1	STP at Hisar, Haryana	Proposed 1.5 MLD under this contract	Moving Bed Bio-reactor (MBBR) technology

Bidders shall propose Moving Bed Bio-reactor (MBBR) process as listed above which shall meet plant effluent quality. The treatment shall have biological nitrification, denitrification and phosphorous removal facility.

Bidders will offer proposed technology to the requirements of the Bid documents must provide all information necessary for a complete evaluation of the Bidder's proposal by the Employer, including layout, flow diagram, hydraulic flow diagram drawings, concept design calculations, technical specifications, proposed installation methodology and other relevant details.

Bids must satisfy the Employer's performance requirements as set out in the Bid documents. Bidder shall include with their Bid evidence acceptable to the Employer of satisfactory past performance of Bidder's proposed technology designs and the associated equipment and processes offered and full details of similar plant capacities called for to enable proper evaluation of such designs.

The modular approach shall be considered to standardize units of the STPs so as to reduce capital cost and spare parts inventory for motors, pipe work, valves, electrical panels, etc.

B.12.3. O&M OF SEWAGE TREATMENT PLANT

The lack of proper maintenance results in deterioration of sewers with subsequent backups, overflows, cave-ins, hydraulic overloads at treatment plants, and other safety, health, and environmental problems in several cities across the world. As one of the most serious and environmentally threatening problems, sanitary sewer overflows are a frequent cause of water quality degradations and are a threat to public health as well as the environment.

Flooded surroundings and overloaded treatment plants are some symptoms of collection systems with inadequate design capacity and improper management, operation, and maintenance. The poor performance of many sewerage systems results in potential health and environmental risks experienced frequently in developing countries highlight the need to optimize operation and maintenance of these systems.

A comprehensive Sewage treatment Management plan shall be planned and implemented for the safe and reliable performance of the proposed system & to enable the sewerage system to deliver its intended objectives.

The cleaning routine should indicate clearly the work to be done, the frequency for that work, the equipment and labor to be used and most important any safety measure and equipment required. The cleaning is required for all the elements namely, the kerb channel, bell mouth, the pipe, grit chamber/inspection chamber and the sewer.

Success of such an operation shall be ensured through proper inspection by Contractor O&M staff. Outfall structures and cross-sewer structures also require similar treatment.

Comprehensive O&M of sewerage system (for sewers, STP) shall be carried out as per CPHEEO Manual, 2013.

Treated sewage from STP shall be used for flushing and gardening.

Contactors shall provide their own sewer maintenance equipment, machinery and vehicles for effective operation and maintenance of proposed system during O&M period.

B.12.4. SEWAGE TREATMENT PLANT STAFFING REQUIREMENTS

- The bidder shall provide all the necessary minimum operating staff and maintenance personnel as noted below to operate the Works for a total period of 60 months.
- The Contractor shall provide a detailed proposed staffing schedule before the anticipated start of the 30-day operation period for each of the sections of the Works. The schedule shall cover all categories of staff from the works superintendent to cleaners, including adequate numbers of maintenance staff.
- The staffing schedule shall be prepared for operating the Plant 24 hour per day basis with three equal shifts of 8 hours during the complete O&M contract period.
- The O&M staff shall have the min. following personnel in table below:

Table 3: Requirement of O&M Staff for STP

Position	Min. Number	Desired Qualification
Plant cum HSE Manager	1	Bachelor's degree in environmental / Chemical Engineering with minimum experience of 10 years in similar nature of work.
Chemist	1	Bachelor's degree in chemistry with minimum experience of 7 years in similar nature of work.
Lab Technician	1	Bachelor's degree in chemistry with minimum experience of 5 years in similar nature of work.
Process Engineer	1	Diploma in Environmental/Chemical Engineering with minimum experience of 7 years in similar nature of work.

Mechanical Engineer	1	Diploma in Mechanical Engineering with minimum experience of 7 years in similar nature of work.
E&I Engineer	1	Diploma in Electrical Engineering with minimum experience of 7 years in similar nature of work.
Mechanical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Electrical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Required Security Staff		
Required Gardner, housekeeping staff		

B.12.5. WORKING DRAWINGS

- The Drawings prepared by the Employer's representative, are called Engineer's Drawings/Tender drawings. They may be modified or added to as provided by the following clauses.
- The proposals shown on the Engineer's Drawings/tender drawings are based on information available prior to preparation of the Tender Documents. All levels indicated or proposed are based on survey information previously available but will need to be revised subject to the results of survey and site investigation carried out by the Contractor during SIP.
- Working Drawings of the designs carried out by the Contractor shall be submitted by the Contractor to the Employer's representative. Working Drawings shall include, but not be restricted to, pipeline plans and profiles, reinforcement detail drawings and bending schedules, shop drawings for structural steel and miscellaneous metal work, and drawings for other work for which the Employer's representative's approval is required.
- It shall be the Contractor's own responsibility to prepare such Working Drawings as he may require for the proper setting out and construction of all structures and facilities. Work shall not commence on an individual structure or facilities until the relevant Working Drawings have been approved by the Employer's representative.
- All dimensions shall be in metric units and each drawing shall be properly identified by a drawing head and a numbering code in the form prescribed by the Employer's representative upon commencement of the Works.

- The Contractor shall submit 3 (three) hard copies of all drawings for approval. Additionally, the Contractor shall also submit all the drawings in softcopy (either in CD/DVD or Pen drive)
- Any changes or modifications to the Working Drawings that the Employer's representative considers necessary shall be made by the Contractor promptly and the drawings resubmitted for approval.
- Approval of Working Drawings will be given by the Employer's representative in the form of a stamp "RELEASED FOR CONSTRUCTION" together with the date and the authorized signature. Only those Working Drawings carrying the signed and dated stamp shall be used for execution.
- Copies of all such approved Working Drawings together shall be supplied to the Employer's representative by the Contractor immediately after approval. The cost of preparing and providing all Working Drawings shall be included in the Contract Rates.
- Should it be found at any time after approval has been given by the Employer's representative to a Working Drawing submitted by the Contractor that the said Working Drawing does not comply with the terms and conditions of the Contract or that the details do not agree with the Working Drawings previously approved, such alterations and additions as may be deemed necessary by the Employer's representative shall be made therein by the Contractor and the work carried out accordingly without entitling the Contractor to extra payment on account thereof, except where such alternations and additions are to be made in direct consequence of written order by the Employer's representative to vary the Works.
- No examination by the Employer's representative of any document submitted by the Contractor or of the Contractor's Working Drawings, nor the approval expressed by the Employer's representative in regard thereto, either with or without modification, shall absolve the Contractor from any liability imposed upon him by any provision of the Contract. Notwithstanding the Employer's representative's approval of the Working Drawings the Contractor shall be responsible for any dimensional or other errors.

B.12.6. AS-BUILT DRAWINGS AND GIS DATA CREATION

- Such approved Working Drawings as have been selected by the Employer's representative shall be correctly modified for inclusion in the As-Built Drawings incorporating such variations to the Works as have been ordered and executed. Such drawings shall show the actual arrangement of all structures and items of equipment installed under the Contract. The Contractor shall submit 1 (one) soft copy and 3 (three) prints of all As-Built Drawings (in readable form and in scale) clearly named as

such to the Employer's representative for approval before applying for the Taking-Over Certificate for the respective Section of the Works. After approval of the As Built Drawing the Contractor shall supply an electronic copy of the drawing in together with a licensed copy of the drafting software.

- During the course of the Works, the Contractor shall maintain a fully detailed record of all changes from the approval to facilitate easy and accurate preparation of the As-Built Drawing.
- Irrespective of the other contractual prerequisites no Section of the Works will be considered substantially completed until the respective As-Built Drawings have been approved by the Employer's representative.
- In parallel with the preparation of as-built drawings, the Contractor shall produce GIS data of the constructed works. The contractor conducts all necessary survey work and shall ensure that vertical and horizontal measurements shall be captured at an accuracy of +/- 0.1m at a 95% confidence level, using the most suitable and cost-effective field data collection technology and methodology. All horizontal and vertical survey measurements will be referenced to the present Survey of India GIS geo reference.
- The Contractor will survey the three-dimensional position (x,y,z) of all point and line assets constructed under this project, e.g., pipelines, bridge crossings if any, manholes, chambers, valves, plugs, reducers, and tees, STP. Nodes shall be created to clearly delineate different pipe sections in terms of material and/or diameter and to allow for future development of a hydraulic model in the GIS platform. Nodes shall also require a three-dimensional position, and through this, the position of the ends of a pipeline segment shall be defined. Point and line data (i.e., the pipeline) should be consistent with the attributes of the existing Survey of India GIS. However, the Employer's representative and the Employer may require the Contractor, at no additional cost, to create new attributes to include non-survey data, e.g., valve model, name of the manufacturer, images or plans, etc. Prior to the field survey, the Contractor shall submit to the Employer's representative, for approval, the GIS design in terms of themes, feature types and attributes.
- The Contractor shall develop a checklist of QC checks for each type of deliverable and will be responsible for ensuring that these QC checks are performed. The Contractor shall assign a GIS quality officer to manage the quality review process. This officer shall be independent of the capture and production teams.

B.12.7. OPERATION AND MAINTENANCE MANUAL

Maintenance manuals shall be provided by the Contractor for critical STP components including, but not limited to, Bar Screen, Grit Chamber, MBBR, CCT and Filtration Systems (PSF & ACF), to ensure efficient operation, optimal performance, regulatory compliance, and prolonged equipment lifespan. The manuals must comprehensively cover the following aspects:

- 1 **Operational Guidelines:** Clear, step-by-step operational procedures for regular and emergency scenarios, including troubleshooting and restart procedures.
- 2 **Preventive Maintenance Schedule:** Detailed timelines and checklists for preventive maintenance activities, including cleaning, lubrication, calibration, and routine replacements.
- 3 **Corrective Maintenance Procedures:** Clearly outlined protocols for troubleshooting, repairing, or replacing parts, including detailed instructions and specifications.
- 4 **Equipment Specifications:** Comprehensive documentation of equipment models, capacities, performance criteria, and supplier/manufacturer contact information for spare parts.
- 5 **Safety Guidelines:** Specific safety instructions and personal protective equipment (PPE) requirements for maintenance personnel.
- 6 **Environmental Compliance Measures:** Procedures detailing sludge handling, waste disposal, effluent quality monitoring, odor control, and measures to prevent environmental pollution during maintenance activities.
- 7 **Record Keeping:** Maintain detailed logs of all maintenance activities, inspections, performance evaluations, equipment repairs, and component replacements to ensure regulatory compliance and proper documentation for future reference. The documentation should be systematically organized, regularly updated, and made accessible for periodic audits and regulatory reviews.
- 8 **Training Requirements:** Manuals shall include training material for operation and maintenance staff, outlining necessary training frequency, content, and certification standards.
- 9 **Emergency Response Plan:** Clearly defined procedures to follow during emergencies or critical failures, including contact information, escalation paths, and immediate corrective actions.
- 10 **Preventive Maintenance Schedule:** Detailed timelines and checklists for preventive maintenance activities, including cleaning, lubrication, calibration, and routine replacements.

- 11 **Corrective Maintenance Procedures:** Clearly outlined protocols for troubleshooting, repairing, or replacing parts, including detailed instructions and specifications.
- 12 **Equipment Specifications:** Comprehensive documentation of equipment models, capacities, performance criteria, and supplier/manufacturer contact information for spare parts.
- 13 **Safety Guidelines:** Specific safety instructions and personal protective equipment (PPE) requirements for maintenance personnel.
- 14 **Environmental Compliance Measures:** Procedures detailing sludge handling, waste disposal, effluent quality monitoring, odor control, and measures to prevent environmental pollution during maintenance activities.
- 15 **Record Keeping:** Maintain detailed logs of all maintenance activities, inspections, performance evaluations, equipment repairs, and component replacements to ensure regulatory compliance and proper documentation for future reference. The documentation should be systematically organized, regularly updated, and made accessible for periodic audits and regulatory reviews.
- 16 **Training Requirements:** Manuals shall include training material for operation and maintenance staff, outlining necessary training frequency, content, and certification standards.
- 17 **Emergency Response Plan:** Clearly defined procedures to follow during emergencies or critical failures, including contact information, escalation paths, and immediate corrective actions.

B.12.8. QUALITY CONTROL PLAN AND PROCEDURES

- The Contractor shall be responsible for establishing and maintaining procedures for quality control that will ensure that all aspects of the Works comply with the requirements of the Contract.
- As soon as reasonably practicable prior to the commencement of Works the Contractor shall submit for approval a Quality Control Plan giving detailed proposals for control of quality of all aspects of work on the Site and at suppliers' workshops.
- The Quality Control Plan shall include the following: a) a list of the Contractor's staff engaged in quality control b) a list of any outside testing agencies employed by the Contractor for work in connection with quality control c) where a testing laboratory is to be established on Site under the Contract, a list of major items of equipment and a layout of the laboratory, together with details of the tests which will be carried out there d) a list of manufactured items and materials, obtained by the Contractor for the Works, which require inspection at the suppliers' premises, and the proposed procedures for

ensuring quality control e) a list of materials and operations to be inspected by the Contractor at the various stages of construction work on Site, together with inspection procedures, test types and frequencies f) sample of proposed quality control records, testing and reporting forms.

- Unless the Employer's representative permits otherwise, the approved Quality Control Plan shall be followed throughout the construction of the Works. Any approval by the Employer's representative of the Contractor's plan and procedures shall not relieve the Contractor of his obligation to ensure that the Works comply with the requirements of the Contract.
- The Contractor shall appoint a suitably qualified member of his staff to be responsible for all aspects of quality control and to maintain effective liaison with the Employer's representative.

B.12.9. SAMPLING AND TESTING

- The Contractor shall provide for the approval of the Employer's representative, samples of all construction materials and manufactured items required for the Permanent Works. All samples rejected by the Employer's representative shall be removed from Site. All approved samples shall be stored by the Contractor in a sample room, at a location approved by the Employer's representative, for the duration of the Contract, and any materials or manufactured items subsequently delivered to Site for incorporation in the Permanent Works shall be of a quality at least equal to the approved sample. The approved samples may only be disposed of with the Employer's representative's approval.
- Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the Employer's representative. Samples for testing will generally be selected by the Employer's representative from materials to be utilized in the project and all tests will be under the supervision of, and as directed by, and at such points as may be convenient to the Employer's representative.
- Material requiring testing shall be furnished in sufficient time before intended use so as to allow for testing. No materials represented by tests may be used prior to receipt of written approval of said materials.
- The Contractor shall give the Employer's representative 3 to 7 days' notice in writing of the date on which any of the materials will be ready for testing or inspection at the suppliers' premises or at a laboratory approved by the Employer's representative and the Employer's Representative shall attend at the appointed place and time. The

Contractor shall in any case submit to the Employer's representative within 3 days after every test such number of certified copies of the test readings as the Employer's representative may require.

- Approval by the Employer's representative as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Employer's representative's powers under the Contract.
- The provisions of this Clause shall also apply to materials supplied under any nominated subcontract.
- After all construction at each Section is completed and before applying for taking-over, the Contractor shall perform field tests as called for in the Specifications. The Contractor shall demonstrate to the Employer's representative the proper operation of the facilities and the satisfactory performance of the individual components. Any improper operation of the system or any improper, or faulty construction shall be repaired or corrected to the satisfaction of the Employer's representative. The Contractor shall make such changes, adjustments or replacement of equipment as may be required to make the same comply with the Specifications or replace any defective parts or materials.
- In addition to any special provision made herein as to sampling and testing materials by particular methods, samples of materials and workmanship proposed to be employed in the execution of the Works may be called for at any time by the Employer's representative and these shall be furnished without delay by the Contractor at his own cost. Approved samples will be retained. The Employer's representative will be at liberty to reject all materials and workmanship that are not equal or better in quality and character than such approved samples.

The tests required for quality control shall include but not be limited to:

- a) tests conducted at the premises of the Contractor, Subcontractor, manufacturer or supplier which are normally or customarily carried out at such premises for the items or materials being supplied for the Works
- b) tests which are normally or customarily conducted on the items or materials being supplied for the Works by the Contractor, Subcontractor, supplier or manufacturer but which have to be conducted at an approved laboratory because the necessary testing facilities are not available on the premises of the Contractor, Sub-Contractor, supplier and manufacturer
- c) tests on locally obtained materials or items either on the Site or at an approved laboratory for the purpose of obtaining the approval of the Employer's representative to the classification, use and compliance with the Specifications of such items or materials

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- d) routine quality control tests conducted by the Contractor to ensure compliance with the Specifications
 - e) regular testing of concrete and other materials as specified in the relevant Chapters of the Technical Specifications
 - f) standard shop and Site acceptance tests, including trial assemblies, of Plant.

SCHEDULE C. PROJECT FACILITIES

C.1. CAMP AND OFFICE FACILITIES

The Contractor shall construct and maintain to the Employer's satisfaction a camp to provide living accommodation for all contractor's staff and operatives who have no other local accommodation. The Contractor's camp shall be located close to the Site at a location approved of by the Employer

Responsibility for providing all services to the living quarters and compliance with all sanitary laws and other laws and regulations shall be borne by the Contractor. Security and the fencing of these areas shall be the responsibility of the Contractor.

A separate office for the sole use of the Employer's Engineer, his staff and Consultant shall be provided by the Contractor at the plant site to the satisfaction of Employer. The Contractor shall provide, erect, furnish, clean, maintain and subsequently transfer the office and associated furniture / items to the Employer after the completion of works. The carpet area of the office shall not be less than 200 Sq. Meter.

The walls shall be of 200mm thick solid cement concrete block, plastered and with oil bound distemper on the inner face and snowcem on the outer face. Sheet roofing with 6 mm thick hard board false ceiling at 3 metre from floor, painted with oil bound distemper shall be provided. The doors shall be of first quality wood and steel windows of approved quality shall be provided. The flooring for the office building shall be minimum 2.5mm thick Vinyl over PCC base. Before commencing the construction of the office, the Contractor shall submit to the Employer for his approval a drawing of the proposed building with all architectural and finishing details fully shown. The location of the office shall be as directed by the Employer.

The Employer's Engineer office shall be ready in all respects within 60 days after Contractor takes possession of the site. The Office shall be maintained throughout the construction period with office help staff, power, water, sewerage, and housekeeping. Power, water supply, and sewerage shall be arranged by the Contractor either with the available resources or from independent sources (e.g. diesel generator sets, bore wells, etc.) at his own cost.

The Contractor shall furnish the rooms as described below and the equipment, furniture, furnishings, and fittings supplied shall be new items of approved make.

The equipment, furniture, and furnishings shall include

One conference table 10'-0" x 5'-0" with 12 chairs (approved make)
1 Nos. of 5' x 3' table with drawers on both sides (3 on each side)
2 Nos. of 3' x 2' table with single side three drawers
12 chairs (approved make) excluding chairs for Computer and Conference Rooms
1 Nos. of Steel cupboards (Storewel type or similar approved)
1 No. Drawing Cabinet
1 No Split AC
Vertical blinds / Curtains for all windows
Water supply / Plumbing / Electrical complete
Water purifier
Water cooler
Computer Table and Chair – 5 No.
Photocopier (50 to 200% zoom capability) with a paper storage desk – 1 No.
Personal Computer - 5 No. with following features, plus UPS:
Intel® Core™ Core i5 processor
16 GB RAM
1 TB
17 LCD Monitor
USB Optical Mouse
USB Keyboard
Genuine Windows latest OS
Comprehensive Security and Management features such as antivirus, antispyware, and firewall.
Additional software – MS Office and Auto CAD (latest version)
Fire Extinguisher – CO ₂ type (3 Kg) – 1 No.
The fittings shall include:
2 Nos. of LED lamp in each room except in Conference room
2 nos. LED lights in Conference room
2 No. 48" ceiling fan in each room except in Conference room
2 Nos. of 48" ceiling fan in conference room
All rooms with 2 plug points each
Other: one in passage one outside

The amenities mentioned are for guideline. However, a successful contractor shall Construct the same as per instruction and to the satisfaction of the Employer.

C.2. LATRINES AND WASHING FACILITIES

Throughout the period of construction of the Works the Contractor shall provide, maintain and cleanse suitable and sufficient latrines and washing facilities for use by his employees. He shall ensure that his employees do not foul the Site but make proper use of the latrines.

Where practicable the latrines shall be connected to the nearest sewer, or if this is not practicable the Contractor shall provide an adequately sized septic tank and soak away.

The Contractor is also to provide separate latrines to the above requirements for the entire Employer's Engineer staff. After Completion of the works, the latrines and washing facilities shall be removed, all ground disinfected and the surface reinstated to the satisfaction of the Employer

SCHEDULE D. SPECIFICATIONS AND STANDARDS

The Project shall be designed and constructed in conformity with the Specifications and Standards specified in Schedule- D. All designs shall be based on the latest Indian Standard (IS) Specifications, or Code of Practice, MoRTH, and relevant CPHEEO manual.

D 1. ROADS, BRIDGES, CULVERTS, STRUCTURES AND MISCELLANEOUS WORKS

Specifications and Standards of roads, bridges, culverts, structures and miscellaneous works are given in this section.

The Codes, Standards and Technical Specifications applicable for the design and construction are as given under;

- I. Indian Roads Congress (IRC) Specifications, Standards, Design Codes
- II. IRC Special Publications
- III. Ministry of Surface Transport Publications (The terms 'Ministry of Surface Transport', 'Ministry of Shipping, Road Transport & Highways' and 'Ministry of Road Transport and Highways' or any successor or substitute thereof shall be considered as synonymous).
- IV. Any supplement issued with the bid document

Latest version of the Codes, Standards, Specifications, etc., shall be considered applicable.

Where the Contractor intends to use an alternative to these Standards/Guidelines for delivering an equal or better product, he shall be permitted to use such alternative subject to the following conditions:

He shall demonstrate that the proposed alternative conforms to any of the following international Standards, Codes of Practice, Specifications, Guidelines, etc.

- V. American Association of State Highway and Transportation Officials (AASHTO)
- VI. American Society for Testing of Materials (ASTM)
- VII. Euro Codes
- VIII. National Standards of any of the following countries: United States of America (USA), Canada, United Kingdom (UK), France, Germany, Sweden, Denmark, Norway, Netherlands, Spain, Australia, New Zealand, Japan and South Africa

In case the Contractor intends to use any alternative material/technology/method, whether patented or otherwise, that is not specifically covered in the Indian or International

Standards as listed above, but the use of which has been permitted on similar projects (similar in category of road, traffic and climatic conditions) as the Project Road, he would be permitted, its use on certification by the owners of such similar projects regarding the continued successful performance of such materials, technologies, methods, procedures or processes for at-least 5 years of the service life of the project. Such a certification shall be supported with details of critical performance parameters.

Standards and Specifications for Construction

The Contractor shall comply with the Standards and Specifications for Construction as given below;

All materials, works and construction operations shall conform to the "Specifications for Road and Bridge Works (Fifth Revision, April 2013)", issued by the Ministry of Road Transport & Highways (MoRT&H), Government of India and published by the Indian Roads Congress. Where the Standards and Specifications for a work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer.

List of Standards

Table D-1 Roads, Bridges, Culverts, Structures and Miscellaneous Works

S. No.	Description	Code/Document No.
1	Dimensions and weights of Road Design Vehicles	IRC:3-1983
2	Recommended Practice for the Design and Layout of Cycle Tracks	IRC:11-2015
3	Standard for vertical and horizontal clearances of Overhead electric power and telecommunication lines as related to roads	IRC:32-1969
4	Code of Practice for Road Markings (with Paints) (First Revision)	IRC:35-2015
5	Tentative Guidelines for the Design of Flexible Pavements	IRC:37 -2018
6	Guidelines for the design of curves for Highways & Design tables (First Revision)	IRC:38-1988
7	Recommended Practices for Treatment of Embankment and Roadside Slopes for Erosion Control (First Revision)	IRC:56-2011
8	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways (Third Revision)	IRC:58 -2015
9	Guidelines for Planning and Design of Roundabouts	IRC:65-2017
10	Code of Practice for Road Signs (Third Revision)	IRC:67-2022
11	Space Standards for Roads in Urban Areas	IRC:69-1977

S. No.	Description	Code/Document No.
12	Guidelines on Regulation and Control of Mixed Traffic in Urban Areas	IRC:70-2017
13	Guidelines for the Design of High Embankments	IRC:75-2015
14	Type Designs for Pick-up Bus Stops on Rural (i.e., Non-Urban) Highways	IRC:80-1981
15	Geometric Design Standards for Urban Roads in Plains	IRC:86-2018
16	Guidelines for Design and Construction of River Training & Control Works for Road Bridges (First Revision)	IRC:89 - 2019
17	Guidelines for the Design of Interchanges in Urban Areas	IRC:92-2017
18	Guidelines on Design and Installation of Road Traffic Signals	IRC: 93-1985
19	Guidelines on Accommodation of Underground Utility Services Along and Across Roads in Urban Areas (Second Revision)	IRC:98-2011
20	Tentative Guidelines on the Provision of Speed Breakers for Control of Vehicular Speeds on Minor Roads	IRC:99-2018
21	Guidelines for Pedestrian Facilities	IRC:103-2012
22	Guidelines for Capacity of Urban Roads in Plain Areas	IRC:106-1990
23	Code of Practice for Concrete Road Bridges	IRC : 112 -2020
24	Tentative Recommendations on the Provision of Parking Spaces for Urban Areas	IRC:SP:12-2015
25	Guidelines on Landscaping and Tree Plantation	IRC:SP:21-2009
26	Vertical Curves for Highways	IRC:SP:23-1983
27	New Traffic Signs	IRC:SP:31-1992
28	Guidelines on Design of At-Grade Intersections in Rural & Urban Areas	IRC:SP:41-1994
29	Highway Safety Code	IRC:SP:44-1996
30	Guidelines on Urban Drainage	IRC:SP:50-2013
31	Guidelines for the Use of Interlocking Concrete Block Pavement	IRC:SP:63-2018
32	State-of-the-Art-Report: Lime-Soil Stabilization	HRB SR.No.1,2000
33	State-of-the-Art-Report: Compaction of Earthwork and Subgrades	HRB SR No.3,1999
34	State-of-the-Art-Report: High Embankments on Soft Ground, Part B – Ground Improvement	HRB SR No.14,1994
35	Standard Specifications and code of practice for road bridges – General features of design	IRC:5-2015
36	Standard Specifications and code of practice for road bridges- Foundations and substructure	IRC:78-2020
37	Guidelines for design of small bridges and culverts	IRC:SP:13-2022

S. No.	Description	Code/Document No.
38	Standard Specifications and code of practice for road bridges- Loads and Stresses	IRC:6-2017
39	Code of practice for design and construction of pile foundations	IS:2911-2013

*** Any other relevant code required for design/work, the same shall be referred from IRC publications*

For all works under this project shall be referred to the latest IS codes and standards

STANDARD SPECIFICATIONS

The Specifications and Standard comprises "Specifications for Road and Bridge Works (Fifth Revision, April 2013)", issued by the Ministry of Road Transport & Highways (MoRT&H), Government of India and published by the Indian Roads Congress

SECTION 200

SITE CLEARANCE

201 CLEARING AND GRUBBING

200.1 Scope

This work shall consist of cutting, removing and disposing of all materials such as trees, bushes, shrubs, stumps, roots, grass, weeds, rubbish, top organic soil, etc. to an average depth of 150 mm in thickness, which in the opinion of the Engineer are unsuitable for incorporation in the works, from the area of road land containing road embankment, drains, cross-drainage structures and such other areas as may be specified on the drawings or by the Engineer. It shall include necessary excavation, backfilling of pits resulting from uprooting of trees and stumps to required compaction, handling, salvaging, and disposal of cleared materials with all leads and lifts. Clearing and grubbing shall be performed in advance of earthwork operations and in accordance with the requirements of these Specifications.

201.2 Preservation of Property/Amenities

Roadside trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers and all highway facilities within or adjacent to the highway which are not to be disturbed shall be protected from injury or damage. The Contractor shall provide and install at his own cost, suitable safeguards approved by the Engineer for this purpose.

During clearing and grubbing, the Contractor shall take all adequate precautions against soil erosion, water pollution, etc., and where required, undertake additional works to that

effect vide Clause 306. Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan including the procedure to be followed for disposal of waste materials, etc., and the schedules for carrying out temporary and permanent erosion control works as stipulated in Clause 306.3.

201.3 Methods, Tools and Equipment

Only such methods, tools and equipment as are approved by the Engineer and which will not affect any property to be preserved shall be adopted for the Work. If the area has thick vegetation/roots/trees, a crawler or pneumatic tyred dozer of adequate capacity may be used for clearance purposes. The dozer shall have ripper attachments for removal of tree stumps. All trees, stumps, etc., falling within excavation and fill lines shall be cut to such depth below ground level that in no case these fall within 500 mm of the bottom of the subgrade. Also, all vegetation such as roots, under-growth, grass and other deleterious matter unsuitable for incorporation in the embankment/subgrade shall be removed between fill lines to the satisfaction of the Engineer. All branches of trees extending above the roadway shall be trimmed as directed by the Engineer.

All excavations below the general ground level arising out of the removal of trees, stumps, etc., shall be filled with suitable material and compacted thoroughly so as to make the surface at these points conform to the surrounding area.

201.4 Disposal of Materials

All materials arising from clearing and grubbing operations shall be taken over and shall be disposed of by the Contractor at suitable disposal sites with all leads and lifts. The disposal shall be in accordance with local, State and Central regulations. Materials that can be reused, subject to approval by the concerned authority, shall be reused. All other materials shall be disposed of as per the authority's instructions, without any additional cost.

202 DISMANTLING CULVERTS, BRIDGES AND OTHER STRUCTURES/ PAVEMENTS

202.1 Scope

This work shall consist of dismantling and removing existing culverts, bridges, pavements, kerbs and other structures like guard-rails, fences, utility services, manholes, catch basins, inlets, etc., from the right of way which in the opinion of the Engineer interfere with the construction of road or are not suitable to remain in place, disposing of the

surplus/unsuitable materials and backfilling to after the required compaction as directed by the Engineer.

Existing culverts, bridges, pavements and other structures which are within the highway and which are designated for removal, shall be removed upto the limit and extent specified in the drawings or as indicated by the Engineer.

Dismantling and removal operations shall be carried out with such equipment and in such a manner as to leave undisturbed, adjacent pavement, structures and any other work to be left in place.

All operations necessary for the removal of any existing structure which might endanger new construction shall be completed prior to the start of new work.

202.2 Dismantling Culverts and Bridges

The structures shall be dismantled carefully and the resulting materials so removed as not to cause any damage to the part of the structure to be retained and any other properties or structures nearby.

Unless otherwise specified, the superstructure portion of culverts/bridges shall be entirely removed and other parts removed up to at least 600 mm below the sub-grade, slope face or original ground level whichever is the lowest or as necessary depending upon the interference they cause to the new construction. Removal of overlying or adjacent material, if required in connection with the dismantling of the structures, shall be incidental to this item.

Where existing culverts/bridges are to be extended or otherwise incorporated in the new work, only such part or parts of the existing structure shall be removed as are necessary and directed by the Engineer to provide a proper connection with the new work. The connecting edges shall be cut, chipped and trimmed to the required lines and grades without weakening or damaging any part of the structure to be retained. Due care should be taken to ensure that reinforcing bars which are to be left in place so as to project into the new work as dowels or ties are not injured during removal of concrete.

Pipe culverts shall be carefully removed in such a manner as to avoid damage to the pipes.

Steel structures shall, unless otherwise provided, be carefully dismantled in such a manner as to avoid damage to members thereof. If specified in the drawings or directed by the Engineer that the structure is to be removed in a condition suitable for re-erection, all

members shall be match-marked by the Contractor with white lead paint before dismantling; end pins, nuts, loose plates, etc. shall be similarly marked to indicate their proper location; all pins, pin holes and machined surfaces shall be painted with a mixture of white lead and tallow and all loose parts shall be securely wired to adjacent members or packed in boxes.

Timber structures shall be removed in such a manner as to avoid damage to such timber or lumber having salvage value as is designated by the Engineer.

202.3 Dismantling Pavements and Other Structures

In removing pavements, kerbs, gutters, and other structures like guard-rails, fences, manholes, catch basins, inlets, etc., where portions of the existing construction are to be left in the finished work, the same shall be removed to an existing joint or cut and chipped to a true line with a face perpendicular to the surface of the existing structure. Sufficient removal shall be made to provide for proper grades and connections with the new work as directed by the Engineer.

All concrete pavements, base courses in carriageway and shoulders etc., designated for removal shall be broken to pieces whose volume shall not exceed 0.02 cu.m and used with the approval of the Engineer or disposed of.

202.4 Back-filling

Holes and depressions caused by dismantling operations shall be backfilled with excavated or other approved materials and compacted to required density as directed by the Engineer.

202.5 Disposal of Materials

All surplus materials shall be taken over by the Contractor which may either be re-used with the approval of the Engineer or disposed of with all loads and lifts.

301 EXCAVATION FOR ROADWAY AND DRAINS

301.1 Scope

This work shall consist of excavation, removal and disposal of materials necessary for the construction of roadway, side drains and waterways in accordance with requirements of these Specifications and the lines, grades and cross-sections shown in the drawings or as indicated by the Engineer. It shall include the hauling and stacking of or hauling to sites of embankment and subgrade construction suitable cut materials as required, as also the

disposal of unsuitable cut materials in specified manner, with all leads and lifts, reuse of cut materials as may be deemed fit, trimming and finishing of the road to specified dimensions or as directed by the Engineer.

301.2 Classification of Excavated Material

301-2.1 Classification: All materials involved in excavation shall be classified by the Engineer in the following manner:

- a) Soil:
This shall comprise topsoil, turf, sand, silt, loam, clay, mud, peat, black cotton soil, soft shale or loose moorum, a mixture of these and similar material which yields to the ordinary application of pick, spade and/or shovel, rake or other ordinary digging equipment. Removal of gravel or any other modular material having dimension in any one direction not exceeding 75 mm shall be deemed to be covered under this category.
- b) Ordinary Rock (not requiring blasting) This shall include:
 - i) rock types such as laterites, shales and conglomerates, varieties of limestone and sandstone etc., which may be quarried or split with crow bars, also including any rock which in dry state may be hard, requiring blasting but which, when wet, becomes soft and manageable by means other than blasting;
 - ii) macadam surfaces such as water bound and bitumen bound; soling of roads, cement concrete pavement, cobble stone, etc. compacted moorum or stabilized soil requiring use of pick axe or shovel or both.
 - iii) lime concrete, stone masonry and brick work in lime/cement mortar below ground level, reinforced cement concrete which may be broken up with crow bars or picks and stone masonry in cement mortar below ground level; and iv) boulders which do not require blasting found lying loose on the surface or embedded in river bed, soil, talus, slope wash and terrace material of dissimilar origin.
- c) Hard Rock (requiring blasting)
This shall comprise:
 - i) any rock or cement concrete for the excavation of which the use of mechanical plant and/or blasting is required,
 - ii) reinforced cement concrete below ground level and in bridge/ ROB/RUB/flyover piers and abutments,
 - iii) boulders requiring blasting.
- d) Hard Rock (using controlled blasting) :
Hard rock requiring blasting as described under (c) but where controlled blasting is to be carried out in locations where built-up area, huts, and are situated at within 200 m of the blast site.
- e) Hard Rock (blasting prohibited)
Hard rock requiring blasting as described under (d) but where blasting is prohibited for any reason like people living within 20 m of blast sites etc. and excavation has to be carried out by chiselling, wedging or any other agreed method.
- f) Marshy soil

This shall include soils like soft clays and peats excavated below the original ground level of marshes and swamps and soils excavated from other areas requiring continuous pumping or bailing out of water.

301.2.2 Authority for Classification

The classification of excavation shall be decided by the Engineer and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Engineer.

301.3 Construction Operations

301.3.1 Setting Out

After the site has been cleared as per Clause 201, the limits of excavation shall be set out true to lines, curves, slopes, grades and sections as shown on the drawings or as directed by the Engineer. Clause 109 shall be applicable for the setting out operations.

301.3.2 Stripping and Storing Topsoil

When so directed by the Engineer, the topsoil existing over the sites of excavation shall be stripped to specified depths and stockpiled at designated locations for re-use in covering embankment slopes, cut slopes, berms and other disturbed areas where re-vegetation is desired in accordance with Clause 305.3.3. Prior to stripping the topsoil, all trees, shrubs etc. shall be removed along with their roots, with approval of the Engineer.

301.3.3 Excavation—General

All excavations shall be carried out in conformity with the directions laid here-in-under and in a manner approved by the Engineer. The work shall be so done that the suitable materials available from excavation are satisfactorily utilized as deemed fit or as approved by the Engineer.

While planning or executing excavations, the Contractor shall take all adequate precautions against soil erosion, water pollution etc. as per Clause 306, and take appropriate drainage measures to keep the site free of water in accordance with Clause 311.

The excavations shall conform to the lines, grades, side slopes and levels shown on the drawings or as directed by the Engineer. The Contractor shall not excavate outside the limits of excavation. Subject to the permitted tolerances, any excess depth/width

excavated beyond the specified levels/dimensions on the drawings shall be made good at the cost of the Contractor with suitable material of characteristics similar to that removed and compacted to the requirements of Clause 305.

All debris and loose material on the slopes of cuttings shall be removed. No backfilling shall be allowed to obtain required slopes excepting that when boulders or soft materials are encountered in cut slopes, these shall be excavated to approved depth on instructions of the Engineer and the resulting cavities filled with suitable material and thoroughly compacted in an appropriate manner.

After excavation, the sides of excavated area shall be trimmed and the area contoured to minimize erosion and ponding, allowing for natural drainage to take place.

301.3.4 Methods, Tools and Equipment

Only such methods, tools and equipment as approved by the Engineer shall be adopted/used in the work. If so desired by the Engineer, the Contractor shall demonstrate the efficacy of the type of equipment to be used before the commencement of work.

301.3.5 Rock Excavation

Rock, when encountered in road excavation, shall be removed upto the formation level or as otherwise indicated in the drawings. Where, however, unstable shales or other unsuitable materials are encountered at the formation level, these shall be excavated to the extent of 500 mm below the formation level or as otherwise specified. In all cases, the excavation operations shall be so carried out that at no point on cut formations the rock protrudes above the specified levels. Rocks and boulders which are likely to cause differential settlement and also local drainage problems shall be removed to the extent of 500 mm below the formation level in the formation width including side drains.

Where excavation is done to levels lower than those specified, the excess excavation shall be made good as per Clauses 301.3.3 and 301.6 to the satisfaction of the Engineer.

Slopes in rock cutting shall be finished to uniform lines corresponding to slope lines shown on the drawings or as directed by the Engineer. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface which move when pierced by a crowbar shall be removed.

Where blasting is to be resorted to, the same shall be carried out as per Clause 302 and all precautions indicated therein observed.

Where presplitting is prescribed to be done for the establishment of a specified slope in rock excavation, the same shall be carried out as per Clause 303.

301.3.6 Marsh Excavation

The excavation of soil from marshes/swamps shall be carried out as per the programme approved by the Engineer.

Excavation of marshes shall begin at one end and proceed in one direction across the entire marsh immediately ahead of backfilling with materials like boulders, sand moorum, bricks bats, dismantled concrete as approved by the Engineer. The method and sequence of excavating and backfilling shall be such as to ensure, to the extent practicable, the complete removal or displacement of all muck from within the lateral limits indicated on the drawings or as staked by the Engineer.

301.3.7 Excavation of Road Shoulders Nerge /Median for Widening of Pavement or Providing Treated Shoulders

In the works involving widening of existing pavements or providing paved shoulders, the existing shoulders/verge/median shall be removed to its full width and upto top of the subgrade. The subgrade material within 500 mm from the bottom of the pavement for the widened portion or paved shoulders shall be loosened and recompactd as per Clause 305. Any unsuitable material found in this portion shall be removed and replaced with the suitable material. While doing so, care shall be taken to see that no portion of the existing pavement designated for retention is loosened or disturbed. If the existing pavement gets disturbed or loosened, it shall be dismantled and cut to a regular shape with sides vertical and the disturbed/loosened portion removed completely and relaid as directed by the Engineer, at the cost of the Contractor.

301.3.8 Excavation for Surface/Sub-Surface Drains

Where the Contract provides for construction of surface/sub-surface drains, the same shall be done as per Clause 309. Excavation for these drains shall be carried out in proper sequence with other works as approved by the Engineer.

301.3.9 Slides

If slips, slides, over-breaks or subsidence occur in cuttings during the process of construction, they shall be removed at the cost of the Contractor as ordered by the Engineer. Adequate precautions shall be taken to ensure that during construction, the slopes are not rendered unstable or give rise to recurrent slides after construction. If

finished slopes slide into the roadway subsequently, such slides shall be removed and paid for at the Contract rate for the class of excavation involved, provided the slides are not due to any negligence on the part of the Contractor. The classification of the debris material from the slips, slides etc. shall conform to its condition at the time of removal and payment made accordingly regardless of its condition earlier.

301.3.10 Dewatering

If water is met with in the excavations due to springs, seepage, rain or other causes, it shall be removed by suitable diversions, pumping or bailing out and the excavation kept dry whenever so required or directed by the Engineer. Care shall be taken to discharge the drained water into suitable outlets as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair/restore to the original condition at his own cost or compensate for the damage.

301.3.11 Use and Disposal of Excavated Materials

All the excavated materials shall either be reused with the approval of the Engineer or disposed off with all leads and lifts as directed by the Engineer.

301.3.12 Backfilling

Backfilling of masonry/concrete hume pipe or drain excavation shall be done with approved material with all leads and lifts after concrete/masonry/hume pipe is fully set and carried out in such a way as not to cause undue thrust on any part of the structure and/or not to cause differential settlement. All space between the drain walls and the side of the excavation shall be backfilled to the original surface making due allowance for settlement, in layers not exceeding 150 mm compacted thickness to the required density, using suitable compaction equipment such as trench compactor, mechanical tamper, rammer or plate compactor as directed by the Engineer.

301.4 Plying of Construction Traffic

Construction traffic shall not use the cut formation and finished subgrade without the prior permission of the Engineer. Any damage arising out of such use shall be made good by the Contractor at his own cost.

301.5 Preservation of Property

The Contractor shall undertake all reasonable precautions for the protection and preservation of any or all existing roadside trees, drains, sewers, sub-surface drains, pipes, conduits and any other structures under or above ground, which may be affected by construction operations and which, in the opinion of the Engineer, shall be continued in use without any change. Safety measures taken by the Contractor in this respect, shall be got approved from the Engineer. However, if any, of these objects is damaged by reason of the Contractor's negligence, it shall be replaced or restored to the original condition at his cost. If the Contractor fails to do so, within the required time as directed by the Engineer or if, in the opinion of the Engineer, the actions initiated by the Contractor to replace/restore the damaged objects are not satisfactory, the Engineer shall arrange the replacement/restoration directly through any other agency at the risk and cost of the Contractor after issuing prior notice to the effect.

301.6 Preparation of Cut Formation

The cut formation, which serves as a sub-grade, shall be prepared to receive the sub-base/ base course as directed by the Engineer.

Where the material in the subgrade has a density less than specified in Table 300-1 , the same shall be loosened to a depth of 500 mm and compacted in layers in accordance with the requirements of Clause 305 adding fresh material, if any required, to maintain the formation level as shown on the drawings. Any unsuitable material encountered in the subgrade level shall be removed as directed by the Engineer, replaced with suitable material and compacted in accordance with Clause 305.

In rocky formations, the surface irregularities shall be corrected and the levels brought up to the specified elevation with granular base material as directed by the Engineer, laid and compacted in accordance with the respective Specifications for these materials. The unsuitable material shall be disposed of in accordance with Clause 301.3.11. After satisfying the density requirements, the cut formation shall be prepared to receive the sub-base/base course in accordance with Clauses 310 and 311.

301.7 Finishing Operations

Finishing operations shall include the work of properly shaping and dressing all excavated surfaces.

When completed, no point on the slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock (ordinary or hard) where no point shall vary more than 300 mm from the designated slope. In no case shall any portion of the slope encroach on the roadway.

The finished cut formation shall satisfy the surface tolerances described in Clause 902.

Where directed, the topsoil removed and conserved (Clauses 301.3.2 and 305.3.3) shall be spread over cut slopes, shoulders and other disturbed areas. Slopes may be roughened and moistened slightly, prior to the application of topsoil, in order to provide satisfactory bond. The depth of topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 100 mm.

302 BLASTING OPERATIONS

302.1 General

Blasting shall be carried out in a manner that completes the excavation to the lines indicated in drawings, with the least disturbance to adjacent material. It shall be done only with the written permission of the Engineer. All the statutory laws, regulations, rules, etc., pertaining to the acquisition, transportation, storage, handling and use of explosives shall be strictly followed by the contractor.

The Contractor may adopt any method or methods of blasting consistent with the safety and job requirements. Prior to starting any phase of the operation, the Contractor shall provide information describing pertinent blasting procedures, dimensions and notes.

The magazine for the storage of explosives shall be built to the designs and specifications of the Explosives Department concerned and located at the approved site. The storage places shall be clearly marked "DANGER-EXPLOSIVES". The Contractor shall be liable for property damage, injury or death resulting from the use of explosives. All permits shall be obtained by the Contractor. No unauthorized person shall be admitted into the magazine which, when not in use, shall be kept securely locked. No matches or inflammable material shall be allowed in the magazine. The magazine shall have an effective lightning conductor. The following shall be hung in the lobby of the magazine:

- a) A copy of the relevant rules regarding safe storage both in English and in the language with which the workers concerned are familiar,
- b) A statement of up-to-date stock in the magazine,
- c) A certificate showing the last date of testing of the lightning conductor, and

- d) A notice that smoking is strictly prohibited.

All explosives shall be stored in a secure manner in compliance with all laws and ordinances, and all such storage places shall be marked. Where no local laws or ordinances apply, storage shall be provided to the satisfaction of the Engineer and in general not closer than 300 m from the road or from any building or camping area or place of human occupancy. In addition to these, the Contractor shall also observe the following instructions and any further additional instructions which may be given by the Engineer and shall be responsible for damage to property and any accident which may occur to workmen or public on account of any operations connected with the storage, handling or use of explosives and blasting. The Engineer shall frequently check the Contractor's compliance with these precautions.

302.2 Materials, Tools and Equipment

All the materials, tools and equipment used for blasting operations shall be of approved type. The Engineer may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be sufficiently water-resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a length being cut as will permit sufficient time to the firer to reach safely before explosion takes place. Detonators shall be capable of giving effective blasting of the explosives. The blasting powder, explosives, detonators, fuses, etc., shall be fresh and not damaged due to dampness, moisture or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed from the site immediately.

302.3 Personnel

The blasting operation shall remain in the charge of competent and experienced supervisor and workmen who are thoroughly acquainted with the details of handling explosives and blasting operations.

302.4 Blasting Operations

The blasting shall be carried out during the pre-determined hours of the day preferably during the mid-day luncheon hour or at the close of the work as ordered in writing by the Engineer. The hours shall be made known to the people in the vicinity.

The Contractor shall notify each public utility company having structures in proximity to the site of the work of his intention to use explosives. Such notice shall be given sufficiently

in advance to enable the companies to take such steps as they may deem necessary to protect their property from injury. In advance of any blasting work within 50 m of any railway track or structures, the Contractor shall notify the concerned Railway Authority of the location, date, time and approximate duration of such blasting operation.

Red danger flags shall be displayed prominently in all directions during the blasting operations. The flags shall be planted 200 m from the blasting site in all directions. People, except those who actually light the fuse, shall be prohibited from entering this area and all persons including workmen shall be kept away from the flagged area, and all persons including workmen shall be removed from the flagged area at least 10 minutes before the firing. A warning siren shall be sounded for the above purpose.

Only controlled blasting shall be resorted to along with the safeguard above at locations where built-up area, huts and structures in use lie within 200 m. Similarly excavation of hard rock without blasting is mandatory where people live within 20 m of blast site.

The charge holes shall be drilled to required depths and at suitable places. Blasting should be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued.

When blasting is done with powder, the fuse cut to the required length shall be inserted into the hole and the powder dropped shall be gently tamped with copper rods with rounded ends. The explosive powder shall then be covered with tamping material which shall be tamped lightly but firmly.

302.5 Misfire

In case of misfire, the following procedure shall be observed:

- i) Sufficient time shall be allowed to account for the delayed blast. The man-in-charge shall inspect all the charges and determine the missed charge.
- ii) If it is the blasting powder charge, it shall be completely flooded with water. A new hole shall be drilled at about 450 mm from the old hole and fired. This should blast the old charge. In case, it does not blast the old charge, the procedure shall be repeated till the old charge is blasted.
- iii) In case of charges of gelignite, dynamite, etc., the man-in-charge shall gently remove the tamping and the primer with the detonator. A fresh detonator and primer shall then be used to blast the charge. Alternatively, the hole may be cleared of 300 mm of tamping and the direction then ascertained by placing a stick in the hole. Another hole may then be drilled 150 mm away and parallel to it. This hole shall then be charged and fired when the misfired

hole should explode at the same time. The man-in-charge shall at once report to the Contractor's office and the Engineer all cases of misfire, the cause of the same and what steps were taken in connection therewith.

If a misfire has been found to be due to defective detonator or dynamite, the whole quantity in the box from which defective article was taken must be sent to the authority directed by the Engineer for inspection to ascertain whether all the remaining materials in the box are also defective.

302.6 Account

A careful and day to day account of the explosive shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer at all times.

303 PRESPLITTING ROCK EXCAVATION SLOPES

303.1 General

Presplitting is defined as the establishment of a specified excavation slope in rock by the controlled use of explosives and blasting accessories in properly aligned and spaced drill holes. The presplitting technique shall be used for forming rock excavation slopes at locations shown on the drawings or as otherwise decided by the Engineer.

303.2 Construction Operations

Prior to starting drilling operations for presplitting, the Contractor shall furnish the Engineer a plan outlining the position of all drill holes, depth of drilling, type of explosives to be used, loading pattern and sequence of firing. The drilling and blasting plan is for record purposes only and will not absolve the Contractor of his responsibility for using proper drilling and blasting procedures. Controlled blasting shall begin with a short test section of a length approved by the Engineer. The test section shall be presplit, production drilled and blasted and sufficient material excavated whereby the Engineer can determine if the Contractor's method have produced an acceptable slope.

All overburden soil and weathered rock along the top of the excavation for a distance of about 5 to 15 m beyond the drilling limits, or to the end of the excavation, as decided by the Engineer shall be removed before drilling the presplitting holes. Particular care and attention shall be directed to the beginning and end of excavations to ensure complete removal of all overburden soil and weathered rock and to expose fresh rock to an elevation equal to the bottom of the adjacent lift of the presplitting holes being drilled.

Slope holes for presplitting shall be drilled along the line of the planned slope within the specified tolerances. The drill holes shall not be less than 60 mm nor more than 75 mm in diameter. Drilling operations shall be controlled by the use of proper equipment and technique to ensure that no hole shall deviate from the plane of the planned slope by more than 300 mm nor shall any hole deviate from being parallel to an adjacent hole by more than two-third of the planned horizontal spacing between holes.

The length of presplit holes for any individual lift shall not exceed 9 m.

The spacing of presplit holes shall not exceed 900 mm on centres and shall be adjusted to result in a uniform shear face between holes.

Auxiliary drill holes along the presplit line, not loaded or stemmed, may be ordered by the Engineer. Except for spacing, auxiliary drill holes shall conform to the provisions for presplit holes.

The line of production holes shall be placed inside the presplit lines in such a manner as to avoid damage to the presplit face.

If necessary, to reduce shatter and overbreak of the presplit surface, the first line of the production holes shall be drilled parallel to the slope line at the top of the cut and at each bench level thereafter.

Any blasting technique, which results in damage to the presplit surface, shall be immediately discontinued.

No portion of any production holes shall be drilled within 2.5 m of a presplit plane except as approved by the Engineer. The bottom of the production holes shall not be lower than the bottom of the presplit holes.

A maximum offset of 600 mm will be permitted for a construction working bench at the bottom of each lift for use in drilling the next lower presplitting pattern. The drilling operations shall be adjusted to compensate for drift of previous levels and for the offset at the start of new levels to maintain the specified slope plane.

The maximum diameter of explosives used in presplit holes shall not be greater than one-half the diameter of the presplit hole.

Only standard cartridge explosives prepared and packaged by explosive manufacturing firms shall be used in presplit holes. These shall be fired as recommended by the

manufacturer. Ammonium nitrate composition blasting agents will not be permitted in presplitting operations.

Stemming may be required to achieve a satisfactory presplit face. Stemming material shall be dry free-running material all of which passes 11.2 mm sieve and 90 percent of which is retained on 2.80 mm sieve. Stemmed presplit holes shall be completely filled to the collar.

All charges in each presplitting pattern shall be detonated simultaneously.

303.3 Tolerances

The presplit face shall not deviate more than 300 mm from the plane passing through adjacent drill holes, except where the character of the rock is such that, as determined by the Engineer, irregularities are unavoidable. When completed, the average plane of the slopes shall conform to the slopes indicated on the plans and no point on the completed slopes shall vary from the designated slopes by more than 300 mm. These tolerances shall be measured perpendicular to the plane of the slope. In no case shall any portion of the slope encroach on the side drains.

As long as equally satisfactory presplit slopes are obtained, then either the slope face may be presplit before drilling for production blasting or presplitting the slope face and production blasting may be done at the same time, provided that the presplitting drill holes are fired with zero delay and the production holes are delayed starting at the row of holes farthest from the slope and progressing in steps to the row of holes nearest the presplit lines, which row shall be delayed at least 50 milliseconds. In either case the presplitting holes shall extend either to the end of the excavation or for a distance of not less than 15 m beyond the limits of the production holes to be detonated.

304 EXCAVATIONS FOR STRUCTURES

304.1 Scope

Excavation for structures shall consist of the removal of material for the construction of foundations for bridges, culverts, retaining walls, headwalls, cutoff walls, pipe culverts and other similar structures, in accordance with the requirements of these Specifications and the lines and dimensions shown on the drawings or as indicated by the engineer. The work shall include construction of the necessary cofferdams and cribs and their subsequent removal; all necessary sheeting, shoring, bracing, draining and pumping; the removal of all logs, stumps, grubs and other deleterious matter and obstructions,

necessary for placing and foundations; trimming bottoms of excavations; backfilling and clearing up the site and the disposal of all surplus material.

304.2 Classification of excavation

All materials involved in excavation shall be classified in accordance with clause 300.1.2.

304.3. Construction operations

304.3.1 Setting out

After the site has been cleared according to clause 200.1, all limits of excavation shall be set out true to lines, curves and slopes to clause 300.1.3.1.

304.3.2. Excavation

Excavation shall be taken to the width of the lowest step of the footing and the sides shall be left plumb where the nature of soil allows it. Where the nature of soil or the depth of the trench and season of the year do not permit vertical sides, the contractor shall put up necessary shoring, strutting and planking or cut slopes to a safer angle or both with due regard to the safety of personnel and works and to the satisfaction of the engineer.

The depth to, which the excavation is to be carried out shall be as shown on the drawings, unless the type of material encountered is such as to require changes, in which case the depth shall be as ordered by the engineer. Propping shall be undertaken when any foundation or stressed zone from an adjoining structure is within a line of 1 vertical to 2 horizontal from the bottom of the excavation.

Where blasting is to be resorted to, the same shall be carried out in accordance with clause 300.2 and all precautions indicated therein observed. Where blasting is likely to endanger adjoining foundations or other structures, necessary precautions such as controlled blasting, providing rubber mat cover to prevent flying of debris etc shall be taken to prevent any damage.

304.3.3. Dewatering and protection

Normally, open foundations shall be laid dry. Where water is met with in excavation due to stream flow, seepage, springs, rain or other reasons, the contractor shall take adequate measures such as bailing, pumping, constructing diversion channels, drainage channels, bunds, depression of water level by well-point system, cofferdams and other necessary works to keep the foundation trenches dry when so required and to protect the green concrete/masonry against damage by erosion or sudden rising of water level. The

methods to be adopted in this regard and other details thereof shall be left to the choice of the contractor but subject to approval of the engineer. Approval of the engineer shall, however, not relieve the contractor of the responsibility for the adequacy of dewatering and protection arrangements and for the quality and safety of the works.

Where cofferdams are required, these shall be carried out adequate depths and heights, be safely designed and constructed and be made as watertight as is necessary for facilitating construction to be carried out inside them. The interior dimensions of the cofferdams shall be such as to give sufficient clearance for the construction and inspection and to permit installation of pumping equipments, etc., inside the enclosed area. If it is determined beforehand that the foundations cannot be laid dry or the situation is found that the percolation is too heavy for keeping the foundation dry, the foundation concrete shall be laid under water by tremie pipe only. In case of flowing water or artesian springs, the flow shall be stopped or reduced as far as possible at the time of placing the concrete. Pumping from the interior of any foundation enclosure shall be done in such a manner as to preclude the possibility of the movement of water through any fresh concrete. No pumping shall be permitted during the placing of concrete or for any period of at least 24 hours thereafter, unless it is done from a suitable sump separated from the concrete work by a watertight wall or other similar means.

At the discretion of the contractor, cement grouting or other approved methods may be used to prevent or reduce seepage and to protect the excavation area. The contractor shall take all precautions in diverting channels and in discharging the drained water as not to cause damage to the works, crops or any other property.

304.3.4 Preparation of Foundation

The bottom of the foundation shall be levelled both longitudinally and transversely or stepped as directed by the Engineer. Before footing is laid, the surface shall be slightly watered and rammed. In the event of excavation having been made deeper than that shown on the drawings or as otherwise ordered by the Engineer, the extra depth shall be made up with concrete as per Clause 2104.1 at the cost of the Contractor. Ordinary filling shall not be permitted to bring the foundation to the design level as shown in the drawing.

When rock or other hard strata is encountered, it shall be freed of all soft and loose material, cleaned and cut to a firm surface either level or stepped as directed by the Engineer. All seams shall be cleaned out and filled with cement mortar or grout to the

satisfaction of the Engineer. In the case of excavation in rock, annular space around footing shall be filled with lean concrete M 15 upto the top level of rock.

If the depth of fill required is more than 1.5 m in soft rock or 0.6 m in hard rock above the foundation level, the filling upto this level shall be done with M-15 concrete and portion above shall be filled by concrete or by boulders grouted with cement.

When foundation piles are used, the excavation for pile cap shall be done after driving/casting of all piles forming the group. After pile driving operations in a given pit are completed, all loose and displaced materials therein shall be removed to the level of the bottom of the pile cap.

304.3.5 Slips and Slip-Outs

If there are any slips or slip-outs in the excavation, these shall be removed by the Contractor at his own cost.

304.3.6 Public Safety

Near towns, villages and all frequented places, trenches and foundation pits shall be securely fenced, provided with proper caution signs and marked with red lights at night to avoid accidents. The Contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures. For safety precautions, guidance may be taken from IS:3764.

304.3.7 Backfilling

Backfilling shall be done with approved material after concrete or masonry is fully set and carried out in such a way as not to cause undue thrust on any part of the structure. All space between foundation masonry or concrete and the sides of excavation shall be refilled to the original surface in layers not exceeding 150 mm compacted thickness. The compaction shall be done with the help of suitable equipment such as trench compactor, mechanical tamper, rammer, plate vibrator etc., after necessary watering, so as to achieve the maximum dry density.

304.3.8 Disposal of Surplus Excavated Materials

Clause 301.3.11 shall apply.

305 EMABANKMENT CONSTRUCTION

305.1 General

305.1.1 Description

These Specifications shall apply to the construction of embankments including sub-grades, earthen shoulders and miscellaneous backfills with approved material obtained from approved source, including material from roadway and drain excavation, borrow pits or other sources. 'All embankments sub-grades, earthen shoulders and miscellaneous backfills shall be constructed in accordance with the requirements of these Specifications and in conformity with the lines, grades, and cross-sections shown on the drawings or as directed by the Engineer.

305.2 Materials and General Requirements

305.2.1 Physical Requirements

305.2.1.1 The materials used in embankments, subgrades, earthen shoulders and miscellaneous backfills shall be soil, moorum, gravel, reclaimed material from pavement, fly ash, pond ash, a mixture of these or any other material as approved by the Engineer. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment.

The following types of material shall be considered unsuitable for embankment:

- a) Materials from swamps, marshes and bogs;
- b) Peat, log, stump and perishable material; any soil that classifies as OL, O1, OH or Pt in accordance with IS:1498;
- c) Materials susceptible to spontaneous combustion;
- d) Materials in a frozen condition;
- e) Clay having liquid limit exceeding 50 and plasticity index exceeding 25; and
- f) Materials with salts resulting in leaching in the embankment.

305.2.1.2 Expansive clay exhibiting marked swell and shrinkage properties ('free swelling index" exceeding 50 percent when tested as per IS:2720 — Part 40) shall not be used as a fill material. Where an expansive clay having "free swelling index" value less than 50 percent is used as a fill material, subgrade and top 500 mm portion of the embankment just below sub-grade shall be non-expansive in nature.

305.2.1.3 Any fill material with a soluble sulphate content exceeding 1.9 grams of sulphate (expressed as SO₃) per litre when tested in accordance with BS:1377, Part 3, but using a 2:1 water-soil ratio shall not be deposited within 500 mm distance (or any other distance

described in the Contract), of permanent works constructed out of concrete, cement bound materials or other cementitious material.

Materials with a total sulphate content (expressed as SO₃) exceeding 0.5 percent by mass, when tested in accordance with BS:1377, Part 3 shall not be deposited within 500 mm, or other distances described in the Contract, of metallic items forming part of the Permanent Works.

305.2.1.4 The size of the coarse material in the mixture of earth shall ordinarily not exceed 75 mm when placed in the embankment and 50 mm when placed in the sub-grade. However, the Engineer may at his discretion permit the use of material coarser than this also if he is satisfied that the same will not present any difficulty as regards the placement of fill material and its compaction to the requirements of these Specifications. The maximum particle size in such cases, however, shall not be more than two-thirds of the compacted layer thickness.

305.2.1.5 Ordinarily, only the materials satisfying the density requirements given in Table 300-1 shall be employed for the construction of the embankment and the sub-grade.

Table 300-1: Density Requirements of Embankment and Sub-grade Materials

Sl.No.	Type of work	Maximum laboratory dry unit weight when tested as per IS: 2720 (part 8)
1	Embankments up to 3 metres Height, not subjected to extensive Flooding.	Not less than 15.2. KN/Cu.m
2	Embankments exceeding 3 metres Height or embankments of any height Subject to long periods of inundation	Not less than 16.0 KN/cu.m.
3	Subgrade and earthen shoulders/ Verges/backfill	Not less than 17.5.KN/cu.m.

Notes:

- 1) This Table is not applicable for lightweight fill material, e.g., cinder, fly ash, etc.
- 2) The material to be used in subgrade shall be non-expansive and shall satisfy design CBR at the specified dry density and moisture content. In case the available materials fail to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 or by any stabilization method approved by the Engineer shall be followed.

305.2.1.6 The material to be used in subgrade shall conform to the design CBR value at the specified dry density and moisture content of the test specimen. In case the available materials fails to meet the requirement of CBR, use of stabilization methods in accordance with Clauses 403 and 404 or by any stabilization method approved by the Engineer or by the IRC Accreditation Committee shall be followed.

305.2.1.7 The material to be used in high embankment construction shall satisfy the specified requirements of strength parameters.

305.2.2 General Requirements

305.2.2.1 The materials for embankment shall be obtained from approved sources with preference given to acceptable materials becoming available from nearby roadway excavation under the same Contract.

The work shall be so planned and executed that the best available materials are saved for the subgrade and the embankment portion just below the subgrade.

305.2.2.2 Borrow Materials

The arrangement for the source of supply of the material for embankment and sub-grade and compliance with the guidelines, and environmental requirements, in respect of excavation and borrow areas as stipulated, from time to time by the Ministry of Environment and Forests, Government of India and the local bodies, as applicable shall be the sole responsibility of the Contractor.

Borrow pits along the road shall be discouraged. If permitted by the Engineer, these shall not be dug continuously. Ridges of not less than 8 m width should be left at intervals not exceeding 300 m. Small drains shall be cut through the ridges to facilitate drainage. The depth of the pits shall be so regulated that their bottom does not cut an imaginary line having a slope of 1 vertical to 4 horizontal projected from the edge of the final section of the bank, the maximum depth in any case being limited to 1.5 m. Also, no pit shall be dug within the offset width of a minimum of 10 m.

Haulage of material to embankments or other areas of fill shall proceed only when sufficient spreading and compaction plant is operating at the place of deposition.

Where the excavation reveals a combination of acceptable and unacceptable materials, the Contractor shall, unless otherwise agreed by the Engineer, carry out the excavation in such a manner that the acceptable materials are excavated separately for use in the

permanent works without contamination by the unacceptable materials. The acceptable materials shall be stockpiled separately.

The Contractor shall ensure that he does not adversely affect the stability of excavation or fills by the methods of stockpiling materials, use of plants or siting of temporary buildings or structures.

305.2.2.3 Fly-Ash

Use of fly-ash shall conform to the Ministry of Environment and Forest guidelines. Where fly-ash is used the embankment construction shall conform to the physical and chemical properties and requirements of IRC:SP:38-2001, "Guidelines for Use of Flyash in Road Construction". The term fly-ash shall cover all types of coal ash such as pond ash, bottom ash or mound ash.

Embankment constructed out of fly ash shall be properly designed to ensure stability and protection against erosion in accordance with IRC guidelines. A suitable thick cover may preferably be provided at intervening layers of pond ash for this purpose. A thick soil cover shall bind the edge of the embankment to protect it against erosion. Minimum thickness of such soil cover shall be 500 mm.

305.2.2.4 Compaction Requirements

The Contractor shall obtain representative samples from each of the identified borrow areas and have these tested at the site laboratory following a testing programme approved by the Engineer. It shall be ensured that the subgrade material when compacted to the density requirements as in Table 300-2 shall yield the specified design CBR value of the sub-grade.

Table 300-2: Compaction Requirements for Embankment and Sub-grade

Type of Material	Minimum Compaction (by weight)	Minimum CBR (%)
Sub-grade	95	10
Embankment	95	10
Sub-grade	95	10
Embankment	95	10

The Contractor shall at least 7 working days before commencement of compaction submit the following to the Engineer for approval:

- i) The values of maximum dry density and optimum moisture content obtained in accordance with IS:2720 (Part 8), appropriate for each of the fill materials he intends to use.
- ii) A graph of dry density plotted against moisture content from which each of the values in (i) above of maximum dry density and optimum moisture content were determined.

The maximum dry density and optimum moisture content approved by the Engineer shall form the basis for compaction.

305.3 Construction Operations

305.3.1 Setting Out

After the site has been cleared to Clause 201, the work shall be set out to Clause 301.3.1. The limits of embankment/sub-grade shall be marked by fixing batter pegs on both sides at regular intervals as guides before commencing the earthwork. The embankment/sub-grade shall be built sufficiently wider than the design dimension so that surplus material may be trimmed, ensuring that the remaining material is to the desired density and in position specified and conforms to the specified side slopes.

305.3.2 Dewatering

If the foundation of the embankment is in an area with stagnant water, and in the opinion of the Engineer it is feasible to remove it, the same shall be removed by bailing out or pumping, as directed by the Engineer and the area of the embankment foundation shall be kept dry. Care shall be taken to discharge the drained water so as not to cause damage to the works, crops or any other property. Due to any negligence on the part of the Contractor, if any such damage is caused, it shall be the sole responsibility of the Contractor to repair/restore it to original condition or compensate for the damage at his own cost.

If the embankment is to be constructed under water, Clause 305.4.6 shall apply.

305.3.3 Stripping and Storing Topsoil

When so directed by the Engineer, the topsoil from all areas of cutting and from all areas to be covered by embankment foundation shall be stripped to specified depths not exceeding 150 mm and stored in stockpiles of height not exceeding 2 m for covering embankment slopes, cut slopes and other disturbed areas where re-vegetation is desired. Topsoil shall not be unnecessarily subjected to traffic either before stripping or when in a

stockpile. Stockpiles shall not be surcharged or otherwise loaded and multiple handling shall be kept to a minimum.

305.3.4 Compacting Ground Supporting Embankment/Sub-Grade

Where necessary, the original ground shall be levelled to facilitate placement of first layer Of embankment, scarified, mixed with water and then compacted by rolling in accordance with Clauses 305.3.5 and 305.3.6 so as to achieve minimum dry density as given in Table 300-2.

In case where the difference between the sub-grade level (top of the sub-grade on which pavement rests) and ground level is less than 0.5 m and the ground does not have 97 percent relative compaction with respect to the dry density (as given in Table 300-2), the ground shall be loosened upto a level 0.5 m below the sub-grade level, watered and compacted in layers in accordance with Clauses 305.3.5 and 305.3.6 to achieve dry density not less than 97 percent relative compaction as given in Table 300-2.

Where so directed by the Engineer, any unsuitable material occurring in the embankment foundation (500 mm portion just below the sub-grade) shall be removed, suitably disposed and replaced by approved materials laid in layers to the required degree of compaction.

Any foundation treatment specified for embankments especially high embankments, resting on suspect foundations as revealed by borehole logs shall be carried out in a manner and to the depth as desired by the Engineer. Where the ground on which an embankment is to be built has any of such material types (a) to (f) in Clause 305.2.1.1 at least 500 mm of such material must be removed and replaced by acceptable fill material before embankment construction commences.

305.3.5 Spreading Material in Layers and Bringing to Appropriate Moisture Content

305.3.5.1 The embankment and sub-grade material shall be spread in layers of uniform thickness in the entire width with a motor grader. The compacted thickness of each layer shall not be more than 250 mm when vibratory roller/vibratory soil compactor is used and not more than 200 mm when 80-100 kN static roller is used. The motor grader blade shall have hydraulic control suitable for initial adjustment and maintain the same so as to achieve the specific slope and grade. Successive layers shall not be placed until the layer under construction has been thoroughly compacted to the specified requirements as in Table 300-2 and got approved by the Engineer. Each compacted layer shall be finished parallel to the final cross-section of the embankment.

305.3.5.2 Moisture content of the material shall be checked at the site of placement prior to commencement of compaction; if found to be out of agreed limits, the same shall be made good. Where water is required to be added in such constructions, water shall be sprinkled from a water tanker fitted with sprinkler capable of applying water uniformly with a controllable rate of flow to variable widths of surface but without any flooding. The water shall be added uniformly and thoroughly mixed in soil by blading, using disc harrow until a uniform moisture content is obtained throughout the depth of the layer.

If the material delivered to the roadbed is too wet, it shall be dried, by aeration and exposure to the sun, till the moisture content is acceptable for compaction. Should circumstances arise, where owing to wet weather, the moisture content cannot be reduced to the required amount by the above procedure, compaction work shall be suspended.

Moisture content of each layer of soil shall be checked in accordance with IS:2720 (Part 2), and unless otherwise mentioned, shall be so adjusted, making due allowance for evaporation losses, that at the time of compaction it is in the range of 1 percent above to 2 percent below the optimum moisture content determined in accordance with IS:2720 (Part 8) as the case may be. Expansive clays shall, however, be compacted at moisture content corresponding to the specified dry density, but on the wet side of the optimum moisture content obtained from the laboratory compaction curve.

After adding the required amount of water, the soil shall be processed by means of graders, harrows, rotary mixers or as otherwise approved by the Engineer until the layer is uniformly wet.

Clods or hard lumps of earth shall be broken to have a maximum size of 75 mm when being placed in the embankment and a maximum size of 50 mm when being placed in the subgrade.

305.3.5.3 Embankment and other areas of fill shall, unless otherwise required in the Contract or permitted by the Engineer, be constructed evenly over their full width and their fullest possible extent and the Contractor shall control and direct construction plant and other construction vehicles. Damage by construction plant and other vehicular traffic shall be made good by the Contractor with material having the same characteristics and strength of the material before it was damaged.

Embankments and unsupported fills shall not be constructed with steeper side slopes or to greater widths than those shown in the drawings, except to permit adequate compaction

at the edges before trimming back, or to obtain the final profile following any settlement of the fill and the underlying material, whenever fill is to be deposited against the face of a natural slope, or sloping earthworks face including embankments, cuttings, other fills and excavations steeper than 1 vertical to 4 horizontal, such faces shall be benched as per Clause 305.4.1 immediately before placing the subsequent fill.

All permanent faces of side slopes of embankments and other areas of fill shall, subsequent to any trimming operations, be reworked and sealed to the satisfaction of the Engineer by tracking a tracked vehicle, considered suitable by the Engineer, on the slope or any other method approved by the Engineer.

305.3.6 Compaction

Only the compaction equipment approved by the Engineer shall be employed to compact the different material types encountered during construction. Static three-wheeled roller, self propelled single drum vibratory roller, tandem vibratory roller, pneumatic tyre roller, pad foot roller, etc., of suitable size and capacity as approved by the Engineer shall be used for the different types and grades of materials required to be compacted either individually or in suitable combinations.

The compaction shall be done with the help of self-propelled single drum vibratory roller or pad foot vibratory roller of 80 to 100 kN static weight or heavy pneumatic tyre roller of adequate capacity capable of achieving the required compaction. The Contractor shall demonstrate the efficacy of the equipment he intends to use by carrying out compaction trials. The procedure to be adopted for the site trials shall be submitted to the Engineer for approval.

Earthmoving plant shall not be accepted as compaction equipment nor shall the use of a lighter category of plant to provide any preliminary compaction to assist the use of heavier plant be taken into account.

Each layer of the material shall be thoroughly compacted to the densities specified in Table 300-2. Subsequent layers shall be placed only after the finished layer has been tested according to Clause 903.2.2 and accepted by the Engineer. The Engineer may permit measurement of field dry density by a nuclear moisture/density gauge used in accordance with agreed procedure and provided the gauge is calibrated to give results identical to that obtained from tests in accordance with IS:2720 (Part 28). A record of the same shall be maintained by the Contractor.

When density measurements reveal any soft areas in the embankment/sub-grade/earthen shoulders, further compaction shall be carried out as directed by the Engineer. If inspite of that the specified compaction is not achieved, the material in the soft areas shall be removed and replaced by approved material, compacted using appropriate mechanical means such as light weight vibratory roller, double drum walk behind roller, vibratory plate compactor, trench compactor or vibratory tamper to the density requirements and satisfaction of the Engineer.

305.3.7 Drainage

The surface of the embankment/sub-grade at all times during construction shall be maintained at such a cross fall (not flatter than that required for effective drainage of an earthen surface) as will shed water and prevent ponding.

305.3.8 Repairing of Damages Caused by Rain/Spillage of Water

The soil in the affected portion shall be removed in such areas as directed by the Engineer before next layer is laid and refilled in layers and compacted using appropriate mechanical means such as small vibratory roller, plate compactor or power rammer to achieve the required density in accordance with Clause 305.3.6. If the cut is not sufficiently wide for use of required mechanical means for compaction, the same shall be widened suitably to permit their use for proper compaction. Tests shall be carried out as directed by the Engineer to ascertain the density requirements of the repaired area. The work of repairing the damages including widening of the cut, if any, shall be carried out by the Contractor at his own cost, including the arranging of machinery/equipment for the purpose.

305.3.9 Finishing Operations

Finishing operations shall include the work of shaping and dressing the shoulders/verge/roadbed and side slopes to conform to the alignment, levels, cross-sections and dimensions shown on the drawings or as directed by the Engineer subject to the surface tolerance described in Clause 902. Both the upper and lower ends of the side slopes shall be rounded off to improve appearance and to merge the embankment with the adjacent terrain.

The topsoil, removed and conserved earlier (Clauses 301.3.2 and 305.3.3) shall be spread over the fill slopes as per directions of the Engineer to facilitate the growth of vegetation. Slopes shall be roughened and moistened slightly prior to the application of the topsoil in

order to provide satisfactory bond. The depth of the topsoil shall be sufficient to sustain plant growth, the usual thickness being from 75 mm to 150 mm.

Where directed, the slopes shall be turfed with sods in accordance with Clause 307. If seeding and mulching of slopes is prescribed, this shall be done to the requirements of Clause 308.

When earthwork operations have been substantially completed, the road area shall be cleared of all debris, and ugly scars in the construction area responsible for objectionable appearance eliminated.

305.4 Construction of Embankment and Sub-grade under Special Conditions

305.4.1 Earthwork for Widening Existing Road Embankment

When an existing embankment and/or sub-grade is to be widened and its slopes are steeper than 1 vertical on 4 horizontal, continuous horizontal benches, each at least 300 mm wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment/sub-grade material to be added. The material obtained from cutting of benches could be utilized in the widening of the embankment/subgrade. However, when the existing slope against which the fresh material is to be placed is flatter than 1 vertical on 4 horizontal, the slope surface may only be ploughed or scarified instead of resorting to benching.

Where the width of the widened portions is insufficient to permit the use of conventional rollers, compaction shall be carried out with the help of light weight vibratory roller, doubled rum walk behind roller, vibratory plate compactor or vibratory tamper or any other appropriate equipment approved by the Engineer. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other types of hauling equipment.

305.4.2 Earthwork for Embankment and Sub-Grade to be Placed Against Sloping Ground

Where an embankment/subgrade is to be placed against sloping ground, the latter shall be appropriately benched or ploughed/scarified as required in Clause 305.4.1 before placing the embankment/sub-grade material. Extra earthwork involved in benching or due to ploughing/ scarifying etc. shall be considered incidental to the work.

For wet conditions, benches with slightly inward fall and subsoil drains at the lowest point shall be provided as per the drawings, before the fill is placed against sloping ground.

Where the Contract requires construction of transverse subsurface drain at the cut-fill interface, work on the same shall be carried out to Clause 309 in proper sequence with the embankment and sub-grade work as approved by the Engineer.

305.4.3 Earthwork over Existing Road Surface

Where the embankment is to be placed over an existing road surface, the work shall be carried out as indicated below:

- i) If the existing road surface is of granular type and lies within 1 m of the new formation levels, it shall be scarified to a depth of 50 mm or as directed so as to provide ample bond between the old and new material ensuring that at least 500 mm portion below the top of new sub-grade level is compacted to the desired density;
- ii) If the existing road surface is of bituminous type or cement concrete and lies within 1 m of the new formation level, the bituminous or cement concrete layer shall be removed completely;
- iii) If the level difference between the existing road surface and the new formation level is more than 1 m, the existing surface shall be roughened after ensuring that the minimum thickness of 500 mm of subgrade is available.

305.4.4 Embankment and Sub-Grade Around Structures

To avoid interference with the construction of abutments, wing walls or return walls of culvert/bridge structures, the Contractor shall, at points, to be determined by the Engineer suspend work on embankment forming approaches to such structures, until such time as the construction of the latter is sufficiently advanced to permit the completion of approaches without the risk of damage to the structure.

Unless directed otherwise, the filling around culverts, bridges and other structures upto a distance of twice the height of the road from the back of the abutment shall be carried out independent of the work on the main embankment. The fill material shall not be placed against any abutment or wing wall, unless permission has been given by the Engineer but in any case not until the concrete or masonry has been in position for 14 days. The embankment and sub-grade shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the Engineer.

The material used for backfill shall not be an organic soil or highly plastic clay having plasticity index and liquid limit more than 20 and 40 respectively when tested according to IS:2720 (Part 5). Filling behind abutments and wing walls for all structures shall conform

to the general guidelines given in IRC:78. The fill material shall be deposited in horizontal layers in loose thickness and compacted thoroughly to the requirements of Table 300-2.

Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter shall conform to the requirements for filter medium spelt out in Clause 2504 unless otherwise specified in the Contract.

Where it may be impracticable to use conventional rollers, the compaction shall be carried out by appropriate mechanical means such as small vibratory roller, plate compactor or power rammer. Care shall be taken to see that the compaction equipment does not hit or come too close to any structural member so as to cause any damage to them or excessive pressure against the structure.

305.4.5 Construction of Embankment over Ground Incapable of Supporting Construction Equipment

Where embankment is to be constructed across ground which will not support the weight of repeated heavy loads of construction equipment, the first layer of the fill may be constructed by placing successive loads of material in a uniformly distributed layer of a minimum thickness required to support the construction equipment as permitted by the Engineer. The Contractor, if so desired by him, may also use suitable geosynthetic material to increase the bearing capacity of the foundation. This exception to normal procedure will not be permitted where, in the opinion of the Engineer, the embankments could be constructed in the approved manner over such ground by the use of tighter or modified equipment after proper ditching and drainage have been provided. Where this exception is permitted, the selection of the material and the construction procedure to obtain an acceptable layer shall be the responsibility of the Contractor. The cost of providing suitable traffic conditions for construction equipment over any area of the Contract will be the responsibility of the Contractor and no extra payment will be made to him. The remainder of the embankment shall be constructed as specified in Clause 305.3.

305.4.6 Embankment Construction under Water and Waterlogged Areas

305.4.6.1 Embankment Construction under Water

Where filling or backfilling is to be placed under water, only acceptable granular material or rock shall be used unless otherwise approved by the Engineer. Acceptable granular material shall be of GW, SW, GP, SP as per IS: 1498 and consist of graded, hard durable particles with maximum particle size not exceeding 75 mm. The material should be non-

plastic having uniformity coefficient of not less than 10. The material placed in open water shall be deposited by end tipping without compaction.

305.4.6.2 Embankment Construction in Waterlogged and Marshy Areas

The work shall be done as per IRC:34.

305.4.7 Earthwork for High Embankment

The material for high embankment construction shall conform to Clause 305.2.1.7. In the case of high embankments (more than 6 m), the Contractor shall normally use fly ash in conformity with Clause 305.2.1.1 or the material from the approved borrow area.

Where provided, stage construction of embankment and controlled rates of filling shall be carried out in accordance with the Contract including installation of instruments and its monitoring.

Where required, the Contractor shall surcharge embankments or other areas of fill with approved material for the periods specified in the Contract. If settlement of surcharged fill results the Contractor shall bring the resultant level up to formation level with acceptable material for use in fill.

305.4.8 Settlement Period

Where settlement period is specified in the Contract, the embankment shall remain in place for the required settlement period before excavating for abutment, wing wall, retaining wall, footings, etc., or driving foundation piles. The duration of the required settlement period at each location shall be as provided for in the Contract or as directed by the Engineer.

305.5 Plying of Traffic

Construction and other vehicular traffic shall not use the prepared surface of the embankment and/or sub-grade without the prior permission of the Engineer. Any damage arising out of such use shall, however, be made good by the Contractor at his own cost as directed by the Engineer.

305.6 Surface Finish and Quality Control of Work

The surface finish of construction of sub-grade shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised in accordance with Clause 903.

305.7 Sub-grade Strength

305.7-1 It shall be ensured prior to actual execution that the material to be used in the sub-grade satisfies the requirements of design CBR.

305-7.2 Sub-grade shall be compacted and finished to the design strength consistent with other physical requirements. The actual laboratory CBR values of constructed subgrade shall be determined on remoulded samples, compacted to the field density at the field moisture content and tested for soaked/unsoaked condition as specified in the Contract.

306 SOIL EROSION AND SEDIMENTATION CONTROL

306.1 Description

This work shall consist of measures as shown on drawings or as directed by the Engineer to control soil erosion, sedimentation and water pollution, through use of berms, dikes, sediment basins, fibre mats, mulches, grasses, slope drains, and other devices.

306.2 Materials

All materials shall meet commercial grade standards and shall be approved by the Engineer before being used in the work

306.3 Construction Operations

Prior to the start of the relevant construction, the Contractor shall submit to the Engineer for approval his schedules for carrying out temporary and permanent erosion/sedimentation control works as are applicable for the items of clearing and grubbing, roadway and drainage excavation, embankment/sub-grade construction, bridges and other structures across water courses, pavement courses and shoulders. He shall also submit for approval his proposed method of erosion/sedimentation control on service road and borrow pits and his plan for disposal of waste materials. Work shall not be started until the erosion/sedimentation control schedules and methods of operations for the applicable construction have been approved by the Engineer.

The surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and fill operations shall be limited to the extent practicable. The Contractor shall provide immediate permanent or temporary erosion, slope protection and sedimentation control measures to prevent soil erosion and sedimentation that will adversely affect construction operations, damage adjacent properties, or cause contamination of nearby streams or other water courses, lakes, reservoirs etc. Such work may involve the

construction of temporary berms, dikes, sediment basins, slope drains and use of temporary mulches, fabrics, mats seeding , or other control devices or methods as necessary to control erosion and sedimentation. Cut and fill slopes shall be seeded and turfed as shown on the drawings.

The Contractor shall be required to incorporate all permanent erosion and sedimentation control features project at the earliest practicable time as outlined in his accepted schedule to minimize the need for temporary erosion and sedimentation control measures.

Temporary erosion/sedimentation and pollution control measures shall be used to control the phenomenon of erosion, sedimentation and pollution that may develop during normal construction practices but may neither be foreseen during design stage nor associated with permanent control features on the Project.

Where erosion or sedimentation is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion or sedimentation control features can follow immediately thereafter if the project conditions permit; otherwise temporary erosion or sedimentation control measures may be required between successive construction stages. Under no conditions shall a large surface area of erodible earth material be exposed at one time by clearing and grubbing or excavation without prior approval of the Engineer..

The Engineer may limit the area of excavation, borrow and embankment operations in progress, commensurate with the Contractor's capability and progress in keeping the finish . grading, mulching, seeding and other such permanent erosion, sedimentation and pollution control measures, in. accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion/sedimentation control measures shall be taken immediately to the extent feasible and justified.

In the event temporary erosion sedimentation and pollution control measures become necessary due to the Contractor's negligence, carelessness or failure to install permanent controls as a part of the work as scheduled or ordered by the Engineer, these shall be carried out at the Contractor's own cost. Temporary erosion, sedimentation and pollution control work required, which is not attributed to the Contractor's negligence, carelessness or failure to install permanent controls, will be performed as ordered by the Engineer.

Temporary erosion, sedimentation and pollution control may include construction work outside the right-of-way where such work is necessary as a result of road construction such as borrow pit operations, service roads and equipment storage sites.

307 TURFING WITH SODS

307.1 Scope

This work shall consist of furnishing and laying of the live sod of perennial turf forming grass on embankment slopes, verges (earthen shoulders) or other locations shown on the drawings or as directed by the engineer. Unless otherwise specified, the work shall be taken up as soon as possible following construction of the embankment provided the season is favorable for establishment of the sod.

307.2 Materials

The sod shall consist of dense, well-rooted growth of permanent and desirable grasses, indigenous to the locality where it is to be used, and shall be practically free from weeds or other undesirable matter. At the time the sod is cut, the grass on the sod shall have a length of approximately 50mm and the sod shall have been freed of debris.

Thickness of the sod shall be as uniform as possible, with some 50 – 80 mm or so of soil covering the grass roots depending on the nature of the sod, so that practically all the dense root system of the grasses is retained in the sod strip. The sods shall be cut in rectangular strips of uniform width, not less than about 250 mm x 300 mm in size but not so large that it is inconvenient to handle and transport these without damage. During wet weather, the sod shall be allowed to dry sufficiently to prevent rearing during handling and during dry weather shall be watered before lifting to ensure its vitality and prevent the dropping of the soil in handling.

300.7.3 Construction operations

307.3.1 Preparation of the earth bed

The area to be sodded shall have been previously constructed to the required slope and cross section. Soil on the area shall be loosened, freed of all stones larger than 50mm size, sticks, stumps and any undesirable foreign matter, and brought to a reasonably fine granular texture to a depth of not less than 25 mm for receiving the sod.

Where required, topsoil shall be spread over the slopes. Prior to placing the topsoil, the slopes shall be scarified to a depth, which, after settlement, will provide the required

nominal depth shown on the plans. Spreading shall not be done when the ground is excessively wet.

Following soil preparation and top soiling, where required, fertilizer and ground limestone when specified shall be spread uniformly at the rate indicated on the plans.

307.3.2 Placing the sods

The prepared sod bed shall be moistened to the loosened depth, if not already sufficiently moist, and the sod shall be placed thereon within approximately 24 hours after the same had been cut. Each sod strip shall be laid edge to edge and such that the joints caused by abutting ends are staggered. Every strip, after it is snugly placed against the strips already in position, shall be lightly tamped with suitable wooden or metal tampers so as to eliminate air pockets and to press it into the underlying soil.

On side slopes steeper than 2 (horizontal) to 1 (vertical), the laying of sods shall be started from bottom upwards. At points where water may flow over a sodded area, the upper edges of the sod strips shall be turned into the soil below the adjacent area and a layer of earth placed over this followed by its thorough compaction.

307.3.3 Staking the sods

Where the side slope is 2 (horizontal) to 1 (vertical) or steeper and the distance along the slope is more than 2 m, the sods shall be staked with pegs or nails spaced approximately 500 to 1000 mm along the longitudinal axis of the sod strips. Stakes shall be driven approximately plumb through the sods to be almost flush with them.

307.3.4 Top dressing

After the sods have been laid in position, the surface shall be cleaned of loose sod, excess soil and other foreign material. Thereafter, a thin layer of topsoil shall be scattered over the surface of top dressing and the area thoroughly moistened by sprinkling with water.

307.3.5 Watering and maintenance

The sods shall be watered by the contractor for a period of at least four weeks after laying. Watering shall be so done as to avoid erosion and prevent damage to sodded areas by wheels of water tanks. The contractor shall erect necessary warning signs and barriers, repair or replace sodded areas failing to show uniform growth of grass or damaged by his operations and shall otherwise maintain the sod at his cost until final acceptance.

308 SPECIFICATIONS FOR SEEDING AND MULCHING

308.1 Scope

This shall consist of preparing slopes, placing topsoil, furnishing all seeds, commercial or organic fertilizers and mulching materials, providing jute netting and placing and incorporating the same on embankment slopes or other locations designated by the engineer or shown in the contract documents.

308.2 Materials

A. Seeds - The seeds shall be of approved quality and type suitable for the soil on , which these are to be applied, and shall have acceptable purity and germination to requirements set down by the engineer. Fertilizer shall consists of standard commercial materials and conform to the grade specified. Organic manure shall be fully putrefied organic matter such as cow dung.

Mulching materials shall consists of straw, lay, wood shavings or sawdust, and shall be delivered dry. They shall be reasonably free of weed seed, and such foreign materials as may detract from their effectiveness as a mulch or be injurious to the plant growth.

B. Topsoil - Topsoil shall not be obtained from an area known to have noxious weeds growing in it. If treated with herbicides or sterilents, it shall be got tested by appropriate agricultural authority to determine the residual in the soil. Topsoil shall not contain less than 2 per cent and more than 12 per cent organic matter.

C. Bituminous emulsion - A suitable grade of bituminous cutback or emulsion used as a tie down for mulch shall be as described in the contract document or as desired by the engineer. Emulsified bitumen shall not contain any solvent or diluting agent toxic to plant life.

D. Netting: Jute netting shall be undyed jute yarn woven into a uniform open weave with approximate 2.5 cm square openings. Geo-netting shall be made of uniformly extruded rectangular mesh having mesh opening of 2 cm x 2 cm, the colour may be black or green. It shall weigh not less than 3.8 kg per 1000 sq. m.

308.3 Seeding operations

308.3.1 Seedbed preparation

The area to be seeded shall be brought to the required slope and cross-section by filling, reshaping eroded areas and refinishing slopes, medians, etc. Topsoil shall be evenly spread over the specified areas to the depth shown on the plans, unless otherwise approved by the engineer. The seedbed preparation shall consist of eliminating all live plants by suitable means using agricultural implements. All stones 150 mm in smallest dimension and larger shall be removed. The soil shall be excavated on the contour to a depth of 100 mm. All clods larger than 25 mm in diameter shall be crushed and packed. Where necessary, water shall then be applied. All topsoil shall be compacted unless otherwise specified or approved by the engineer. Compaction shall be by slope compactor, cleated tractor or similar equipment approved by the engineer. Equipment shall be so designed and constructed as to produce a uniform rough textured surface ready for seeding and mulching and, which will bond the topsoil to the underlying material. The entire area shall be covered by a minimum of 4 passes or 2 round strips of the roller or approved equipment.

308.3.2 Fertilizer application

Fertilizer to the required quantities shall be spread and thoroughly incorporated into the soil surface as a part of the seedbed preparation.

308.3.3 Planting of seeds

All seeds shall be planted uniformly at the approved rate. Immediately after sowing, the area shall be raked, dragged or otherwise treated so as to cover the seeds to a depth of 6 mm.

The operation of seed sowing shall not be performed when the ground is muddy or when the soil or weather conditions would otherwise prevent proper soil preparation and subsequent operations.

308.3.4 Soil moisture and watering requirements

Soil-moisture shall exist throughout the zone from 25 mm to at least 125 mm below the surface at the time of planting.

Watering of the seeded areas shall be carried out as determined by the engineer.

308.4 Mulching, applying bituminous emulsion and jute netting / geonetting

Within 24 hours of seeding, mulching material mixed with organic manure shall be placed so as to form a continuous, unbroken cover of approximate uniform thickness of 25 mm using an acceptable mechanical blower. Mulching material shall be held in place and made resistant to being blown away by suitable means approved by the engineer. When called for in the contract documents, mulch material shall be anchored in place with bituminous emulsion applied at the rate of 2300 litres per hectare. Any mulch disturbed or displaced following application shall be removed, reseeded and remulched as specified. Jute netting/Geonetting shall be unrolled and placed parallel to the flow of water immediately following the bringing, to finished grade, the area specified on the plans or the placing of seed and fertilizer. Where more than one strip is required to cover the given areas, they shall overlap a minimum of 100 mm. Jute netting / Geonetting shall be held in place by approved wire staples, pins, spikes or wooden stakes driven vertically into the soil.

308.5 Maintenance

The contractor shall maintain all seeded and mulched areas until final acceptance. Maintenance shall include protection of traffic by approved warning signs or barricades and repairing any areas damaged following the seeding and mulching operations. If mulched areas become damaged, the area shall be reshaped and then seeded and mulched again as originally specified.

309 SPECIFICATIONS FOR SURFACE / SUB-SURFACE DRAINS

309.1. Scope

This work shall consist of constructing surface and/ or sub-surface drains in accordance with the requirements of these Specifications and to the lines, grades, dimensions and other particulars shown on the drawings or as directed by the engineer. Schedule of work shall be so arranged that the drains are completed in proper sequence with road works to ensure that no excavation of the completed road works is necessary subsequently or any damage is caused to these works due to lack of drainage.

309.2 Surface drains

Surface drains shall be excavated to the specified lines, grades, levels and dimensions to the requirements of clause 300.1. The excavated material shall be removed from the area adjoining the drains and if found suitable, utilised in embankment/subgrade construction. All unsuitable material shall be disposed of as directed.

The excavated bed and sides of the drains shall be dressed to bring these in close conformity with specified dimensions, levels and slopes. Where so indicated, drains shall be lined or turfed with suitable materials in accordance with details shown on the drawings. All works on drain construction shall be planned and executed in proper sequence with other works as approved by the engineer, with a view to ensuring adequate drainage for the area and minimising erosion./ sedimentation.

309.3 Sub-surface Drains

309.3.1 Scope

Sub-surface drains shall be of close-jointed perforated pipes, open-jointed unperforated pipes, surrounded by granular material laid in a trench or aggregate drains to drain the pavement courses. Sub-surface drains designed using geosynthetics and approved by the engineer can also be used.

309.3.2 Materials

A. Pipe: Perforated pipes for the drains may be of metal/asbestos cement/cement concrete/PVC, and unperforated pipes of vitrified clay/cement concrete/asbestos cement. The type, and grade of the pipe to be used shall be as specified in the contract. In no case, however, shall the internal diameter of the pipe be less than 100 mm. Holes for perforated pipes shall be on one half of the circumference only and conform to the spacing indicated on the drawings. Size of the holes shall not ordinarily be greater than half of D 85 size of the material surrounding the pipe, subject to being minimum 3 mm and maximum 6 mm. D 85 stands for the size of the sieve that allows 85 per cent of the material to pass through it.

B. Backfill material: Backfill material shall consist of sound, tough, hard, durable particles of free draining sand-gravel material or crushed stone and shall be free of organic material, clay balls or other deleterious matter. Unless the contract specifies any particular gradings for the backfill material or requires these to be designed on inverted filter criteria for filtration and permeability to the approval of the engineer, the backfill material shall be provided on the following lines:

- i) Where the soil met with the trench is of fine grained type (e.g. silt, clay or a mixture thereof), the backfill material shall conform to Class I grading set out in-Table 3.
- ii) Where the soil met with in the trench is of coarse silt to medium sand or sandy type, the backfill material shall correspond to Class II grading of Table 3.
- iii) Where soil met with in the trench is gravelly sand, the backfill material shall correspond to Class III grading of Table 3.

Thickness of backfill material around the pipe shall be as shown on the drawings subject to being at least 150 mm all-round in all cases. Geosynthetics for use with subsurface drain shall conform to the requirements as per Section 700.

Table 3. Grading requirements for filter material

Sieve Designation	Per cent passing by weight		
	Class I	Class II	Class III
53 mm	-	-	100
45 mm	-	-	97-100
26.5 mm	-	100	-
22.4 mm	-	95-100	58-100
11.2 mm	100	48-100	20-60
5.6 mm	92-100	28-54	4-32
2.8 mm	83-100	20-35	0-10
1.4 mm	59-96	-	0-5
710 microns	35-80	6-18	-
355 microns	14-40	2-9	-
180 microns	3-15	-	-
90 microns	0-5	0-4	0-3

309.3.3 Trench excavation

Trench for sub-surface drain shall be excavated to the specified lines, grades and dimensions shown in the drawings provided that width of trench at pipe level shall not be less than 450 mm. The excavation shall begin at the outlet end of the drain and proceed towards the upper end. Where unsuitable material is met with at the trench bed, the same shall be removed to such depth as directed by the engineer and backfilled with approved material that shall be thoroughly compacted to the specified degree.

309.3.4 Laying of pipe and backfilling

Laying of pipe in the trench shall be started at the outlet end and proceed towards the upper end, true to the lines and grades specified. Unless otherwise provided, longitudinal gradient of the pipe shall not be less than 1 in 100.

Before placing the pipe, backfill of the required grading(s) shall be laid for full width of the trench bed and compacted to a minimum thickness of 150 mm or as shown on the drawings. The pipe shall then be embedded firmly on the bed.

Perforated pipes, unless otherwise specified, shall be placed with their perforations down to minimise clogging. The pipe sections shall be joined securely with appropriate coupling fittings or bands.

Non-perforated pipes shall be laid with joints as close as possible with the open joints wrapped with suitable pervious material (like double layer of hessian, suitable geosynthetics or some other material of not less than 150 mm width) to permit entry of water but prevent fines entering the pipes. In the case of non – perforated pipes with bell end, the bell shall face upgrade.

Upgrade end sections of the pipe installation shall be tightly closed by means of concrete plugs or plugs fabricated from the same material as the pipe and securely held in place to prevent entry of soil materials.

After the pipe installation has been completed and approved, backfill material of the required grading(s) (see clause 300.9.3.2B) shall be placed over the pipe to the required level in horizontal layers not exceeding 150 mm in thickness and thoroughly compacted. The minimum thickness of material above the top of the pipe shall be 300 mm.

Unless otherwise provided, sub-surface drains not located below the road pavement shall be sealed at the top by means of 150mm thick layer of compacted clay so as to prevent percolation of surface water.

309.3.5 Use of geosynthetic in laying of pipe and backfilling

After excavating the trench for substance drain, the filter fabric shall be placed, the pipe installed and the trench backfilled with permeable material according to dimensions and details shown on the plans. Surfaces to receive filter fabric prior to placing shall be free of loose or extraneous material and sharp objects that may damage the filter fabric during installation. Adjacent rolls of the fabric shall be overlapped a minimum of 4.90 mm. The preceding roll shall overlap the following roll in the direction the material is being spread.

Damage to the fabric resulting from contractor's vehicles, equipment or operations shall be replaced or repaired by the contractor at his expense.

309.3.6 Drain outlet

The outlet for a sub-drain shall not be under water or plugged with debris but should be a free outlet discharging into a stream, culvert or open ditch. The bottom of the pipe shall be kept above high water in the ditch and the end protected with a grate or screen. For a length of 500 mm from the outlet end, the trench for pipe shall not be provided with granular material but backfilled with excavated soil and thoroughly compacted so as to stop water

directly percolating from the backfill material around the pipe. The pipe in this section shall not have any perforations.

309.3.7 Aggregate drains

Aggregate drains shall be placed within the verge/shoulders after completion of the pavement. Depth, thickness and spacing of the aggregate drains shall be as shown on the plan. Trenches for aggregate drains shall be excavated to a minimum width of 300 mm and to the depth shown on the plans or ordered by the engineer. The bottom of the trench shall be sloped to drain and shall be free from loose particles of soil. The trench shall be excavated so as to expose clearly the granular pavement courses to be drained. Aggregate for the drains shall be durable gravel, stone or slag and shall be free from vegetable matter and other deleterious substances. The grading requirements are given at Table 4. Type B grading may be used only where the drain is designed to intercept surface water flowing to the pipe and is likely to get slowly blocked. Type A grading allows a much wider range.

Table 4. Grading requirements for aggregate drains

Sieve Size	Percent passing by weight	
	Type A	Type B
63 mm	-	100
37.5 mm	100	85-100
19 mm	-	0-20
9.5 mm	45-100	0-5
3.35 mm	25-80	-
600 microns	8-45	-
150 microns	0-10	-
75 microns	0-5	-

310 SPECIFICATIONS FOR PREPARATION AND SURFACE TREATMENT OF FORMATION

Preparation and surface treatment of the formation, that is top of the subgrade, shall be carried out only after completion of any specified subgrade drainage and unless otherwise agreed by the engineer, immediately prior to laying the sub-base or the road base where no sub-base is required. The sequence of operations shall be as follows: -

- (i) All surfaces below carriageway, laybys, footways and hard shoulders shall, after reinstatement of any soft areas to the required specifications be well cleaned and freed of mud and slurry.

(ii) The surface shall be compacted by 4 passes of a smooth wheeled roller of 80 to 100 KN weight after spraying requisite amount of water, if required, before the commencement of rolling.

(iii) The formation shall, wherever necessary, be regulated and trimmed to the requirements of clause 305.3.9 with motor grader.

(iv) The trimmed formation shall be rolled by one pass of smooth wheeled roller of 80 to 100 KN weight after spraying requisite amount of water, if required, before the commencement of rolling.

Where the completed formation is not immediately covered with sub-base or road base material, its moisture content shall be maintained to prevent cracking in the formation by suitable measures as approved by the engineer. The entire work of surface treatment of formation shall be deemed, as incidental to the work of sub-base/base course to be provided on the subgrade and as such no extra payment shall be made for the same.

311 SPECIFICATIONS FOR WORKS TO BE KEPT FREE OF WATER

311.1 The contractor shall arrange for the rapid dispersal of water collected/accumulated on the earthwork or completed formation during construction or on the existing roadway or , which enters the earthwork or any other item of work from any source, and where practicable, the water shall be discharged into the permanent outfall of the drainage system. The arrangements shall be made in respect of all earthwork including excavation for pipe trenches, foundations or cuttings.

311.2 The contractor shall provide, where necessary, temporary water courses, ditches, drains, pumping or other means for maintaining the earthwork free from water. Such provisions shall include carrying out the work of forming the cut sections and embankments in such manner that their surfaces have at all times a sufficient minimum crossfall and, where practicable, a sufficient longitudinal gradient to enable them to shed water and prevent ponding. The works involved in keeping the earthwork or any other item of works free of water shall be deemed as incidental to the respective item of work and as such no separate payment shall be made for the same.

312 SPECIFICATIONS FOR WATER COURSES AT CULVERTS

312.1 Excavation carried out in the diversion, enlargement, deepening or straightening water courses at culverts, where necessary, shall include the operations such as clearing,

grubbing, removal of vegetation, trimming of slopes, grading of beds, disposal of excavated materials, pumping, timbering etc. necessary for dealing with the flow of water.

312.2 The beds and sloping sides of watercourses shall, where shown on the Drawings, be protected against the action of water by rubble paving to form a flat or curved surface as indicated. The protection shall consist of large smooth faced stones or of blocks of precast concrete. Stones for rubble paving shall be roughly dressed square. No stone shall be less than 255 mm in depth nor less than 0.02 cu. m. in volume and no rounded boulders shall be used. After completion of construction of culverts, temporary diversion of watercourse, if any, shall be closed and watercourse restored for flow through the culvert as per the direction of the engineer.

313 SPECIFICATIONS FOR CONSTRUCTION OF ROCKFILL EMBANKMENT

313.1 Scope

In normal circumstances, the embankment should not be constructed with rockfill material. However, where specifically permitted by the engineer because of imperative economic or technical reasons, construction of rock fill embankments shall be in accordance with the lines, grades and cross-sections as shown in drawings or as directed by the engineer.

Rock fill shall not be used at least for a depth of 500 mm below the formation level. There should be minimum of 500mm thick earthen cushion over the rock fill.

313.2 Material

The size of rock pieces used in rock fill embankments shall be such that they can be deposited in layers so as to suit the conditions evacuated in the field compaction trials or as directed by the engineer. The rock fill shall consist of hard, durable and inert material, preferably maximum size not exceeding 300 mm and per cent finer than 125 mm not exceeding 10 per cent.

Argillaceous rocks (clay, shales etc) unburnt colliery stock and chalk shall not be used in rockfill.

The rock fragments and blinding material required for filling the voids shall also satisfy the above requirements.

313.3 Spreading and compaction

The material shall be tipped, spread and levelled in layers extending to the full width of embankment by a suitable dozer. Fragments of rock shall then be spread on the top of layer to the required extent and layer compacted by minimum of 5 passes of vibratory roller having static weight 8-10 tonnes. The compacted thickness of each layer shall not exceed 500 mm. After compaction of each layer, the surface voids shall be filled with broken fragments. Next layer, where required, shall be placed in the same manner, above the earlier compacted layer.

The top layer of rock fill, on, which normal earth fill will rest shall be thoroughly blinded with suitable granular material to seal its surface.

401 GRANULAR SUB-BASE

401.1 Scope

This work shall consist of laying and compacting well-graded material on prepared subgrade in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as sub-base or lower sub-base and upper sub-base (termed as subbase hereinafter) as necessary according to lines, grades and cross-sections shown on the drawings or as directed by the Engineer.

401.2 Materials

401.2.1 The material to be used for the work shall be natural sand, crushed gravel, crushed stone, crushed slag, or combination thereof depending upon the grading required. Use of materials like brick metal, Kankar and crushed concrete shall be permitted in the lower sub-base. The material shall be free from organic or other deleterious constituents and shall conform to the gradings given in Table 400-1 and physical requirements given in Table 400-2. Gradings III and IV shall preferably be used in lower sub-base. Gradings V and VI shall be used as a sub-base-cum-drainage layer. The grading to be adopted for a project shall be as specified in the Contract. Where the sub-base is laid in two layers as upper sub-base and lower sub-base, the thickness of each layer shall not be less than 150 mm.

401.2.2 If the water absorption of the aggregates determined as per IS:2386 (Part 3) is greater than 2 percent, the aggregates shall be tested for Wet Aggregate Impact Value (AIV) (IS:5640). Soft aggregates like Kankar, brick ballast and laterite shall also be tested for Wet AIV (IS:5640).

TABLE 401.3.1: PREPARATION OF SUB-GRADE						
Item No.	Description	Unit	Quantity	Rate	Amount	Remarks
1	Preparation of sub-grade	Sq. m	1000	100	100000	
2	Removal of vegetation and other extraneous matter	Sq. m	1000	50	50000	
3	Lightly sprinkled with water	Sq. m	1000	10	10000	
4	Rolled with two passes of 80—100 kN smooth wheeled roller	Sq. m	1000	20	20000	
5	Transportation of material	Sq. m	1000	10	10000	
6	Compaction of material	Sq. m	1000	10	10000	
7	Grading of material	Sq. m	1000	10	10000	
8	Final grading	Sq. m	1000	10	10000	
9	Final grading	Sq. m	1000	10	10000	
10	Final grading	Sq. m	1000	10	10000	
11	Final grading	Sq. m	1000	10	10000	
12	Final grading	Sq. m	1000	10	10000	
13	Final grading	Sq. m	1000	10	10000	
14	Final grading	Sq. m	1000	10	10000	
15	Final grading	Sq. m	1000	10	10000	
16	Final grading	Sq. m	1000	10	10000	
17	Final grading	Sq. m	1000	10	10000	
18	Final grading	Sq. m	1000	10	10000	
19	Final grading	Sq. m	1000	10	10000	
20	Final grading	Sq. m	1000	10	10000	
21	Final grading	Sq. m	1000	10	10000	
22	Final grading	Sq. m	1000	10	10000	
23	Final grading	Sq. m	1000	10	10000	
24	Final grading	Sq. m	1000	10	10000	
25	Final grading	Sq. m	1000	10	10000	
26	Final grading	Sq. m	1000	10	10000	
27	Final grading	Sq. m	1000	10	10000	
28	Final grading	Sq. m	1000	10	10000	
29	Final grading	Sq. m	1000	10	10000	
30	Final grading	Sq. m	1000	10	10000	
31	Final grading	Sq. m	1000	10	10000	
32	Final grading	Sq. m	1000	10	10000	
33	Final grading	Sq. m	1000	10	10000	
34	Final grading	Sq. m	1000	10	10000	
35	Final grading	Sq. m	1000	10	10000	
36	Final grading	Sq. m	1000	10	10000	
37	Final grading	Sq. m	1000	10	10000	
38	Final grading	Sq. m	1000	10	10000	
39	Final grading	Sq. m	1000	10	10000	
40	Final grading	Sq. m	1000	10	10000	
41	Final grading	Sq. m	1000	10	10000	
42	Final grading	Sq. m	1000	10	10000	
43	Final grading	Sq. m	1000	10	10000	
44	Final grading	Sq. m	1000	10	10000	
45	Final grading	Sq. m	1000	10	10000	
46	Final grading	Sq. m	1000	10	10000	
47	Final grading	Sq. m	1000	10	10000	
48	Final grading	Sq. m	1000	10	10000	
49	Final grading	Sq. m	1000	10	10000	
50	Final grading	Sq. m	1000	10	10000	
51	Final grading	Sq. m	1000	10	10000	
52	Final grading	Sq. m	1000	10	10000	
53	Final grading	Sq. m	1000	10	10000	
54	Final grading	Sq. m	1000	10	10000	
55	Final grading	Sq. m	1000	10	10000	
56	Final grading	Sq. m	1000	10	10000	
57	Final grading	Sq. m	1000	10	10000	
58	Final grading	Sq. m	1000	10	10000	
59	Final grading	Sq. m	1000	10	10000	
60	Final grading	Sq. m	1000	10	10000	
61	Final grading	Sq. m	1000	10	10000	
62	Final grading	Sq. m	1000	10	10000	
63	Final grading	Sq. m	1000	10	10000	
64	Final grading	Sq. m	1000	10	10000	
65	Final grading	Sq. m	1000	10	10000	
66	Final grading	Sq. m	1000	10	10000	
67	Final grading	Sq. m	1000	10	10000	
68	Final grading	Sq. m	1000	10	10000	
69	Final grading	Sq. m	1000	10	10000	
70	Final grading	Sq. m	1000	10	10000	
71	Final grading	Sq. m	1000	10	10000	
72	Final grading	Sq. m	1000	10	10000	
73	Final grading	Sq. m	1000	10	10000	
74	Final grading	Sq. m	1000	10	10000	
75	Final grading	Sq. m	1000	10	10000	
76	Final grading	Sq. m	1000	10	10000	
77	Final grading	Sq. m	1000	10	10000	
78	Final grading	Sq. m	1000	10	10000	
79	Final grading	Sq. m	1000	10	10000	
80	Final grading	Sq. m	1000	10	10000	
81	Final grading	Sq. m	1000	10	10000	
82	Final grading	Sq. m	1000	10	10000	
83	Final grading	Sq. m	1000	10	10000	
84	Final grading	Sq. m	1000	10	10000	
85	Final grading	Sq. m	1000	10	10000	
86	Final grading	Sq. m	1000	10	10000	
87	Final grading	Sq. m	1000	10	10000	
88	Final grading	Sq. m	1000	10	10000	
89	Final grading	Sq. m	1000	10	10000	
90	Final grading	Sq. m	1000	10	10000	
91	Final grading	Sq. m	1000	10	10000	
92	Final grading	Sq. m	1000	10	10000	
93	Final grading	Sq. m	1000	10	10000	
94	Final grading	Sq. m	1000	10	10000	
95	Final grading	Sq. m	1000	10	10000	
96	Final grading	Sq. m	1000	10	10000	
97	Final grading	Sq. m	1000	10	10000	
98	Final grading	Sq. m	1000	10	10000	
99	Final grading	Sq. m	1000	10	10000	
100	Final grading	Sq. m	1000	10	10000	

401.3 Construction Operations

401.3.1 Preparation of Sub-grade

Immediately prior to the laying of sub-base, the subgrade already finished to Clause 301 or 305 as applicable shall be prepared by removing all vegetation and other extraneous matter, lightly sprinkled with water, if necessary and rolled with two passes of 80—100 kN smooth wheeled roller.

401.3.2 Spreading and Compacting

The sub-base material of the grading specified in the Contract and water shall be mixed mechanically by a suitable mixer equipped with provision for controlled addition of water and mechanical mixing. So as to ensure homogenous and uniform mix. The required water content shall be determined in accordance with IS:2720 (Part 8). The mix shall be spread on the prepared subgrade with the help of a motor grader of adequate capacity, its blade having hydraulic controls suitable for initial adjustment and for maintaining the required slope and grade during the operation, or other means as approved by the Engineer.

Moisture content of the mix shall be checked in accordance with IS:2720 (Part 2) and suitably adjusted so that, at the time of compaction, it is from 1 to 2 percent below the optimum moisture content.

Immediately after spreading the mix, rolling shall be done by an approved roller. If the thickness of the compacted layer does not exceed 100 mm, a smooth wheeled roller of 80 to 100 kN weight may be used. For a compacted single layer upto 200 mm the compaction shall be done with the help of a vibratory roller of minimum 80 to 100 kN static weight capable of achieving the required compaction. Rolling shall commence at the lower edge and proceed towards the upper edge longitudinally for portions having unidirectional crossfall or on superelevation. For carriageway having crossfall on both sides, rolling shall commence at the edges and progress towards the crown.

Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. During rolling, the grade and crossfall (camber) shall be checked and any high spots or depressions which become apparent, corrected by removing or adding fresh material. The speed of the roller shall not exceed 5 km per hour.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material determined as per IS:2720 (Part 8). The surface of any layer of material on completion of compaction shall be well closed, free from movement under compaction equipment and from compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of layer and re-compacted.

401.4 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

401.5 Arrangements for Traffic

During the period of construction, arrangements for the traffic shall be provided and maintained in accordance with Clause 112.

406 WET MIX MACADAM SUB-BASE/BASE

406.1 Scope

This work shall consist of laying and compacting clean, crushed, graded aggregate and granular material, premixed with water, to a dense mass on a prepared sub-grade/sub-base/ base or existing pavement as the case may be in accordance with the requirements of these Specifications. The material shall be laid in one or more layers as necessary to lines, grades and cross-sections shown on the approved drawings or as directed by the Engineer.

The thickness of a single compacted Wet Mix Macadam layer shall not be less than 75 mm. When vibrating or other approved types of compacting equipment are used, the compacted depth of a single layer of the sub-base course may be upto 200 mm with the approval of the Engineer.

406.2 Materials

406.2.1 Aggregates

406.2.1.1 Physical Requirements

Coarse aggregates shall be crushed stone. If crushed gravel/shingle is used, not less than 90 percent by weight of the gravel/shingle pieces retained on 4.75 mm sieve shall have at least two fractured faces. The aggregates shall conform to the physical requirements set forth in Table 400-12.

If the water absorption value of the coarse aggregate is greater than 2 percent, the soundness test shall be carried out on the material delivered to site as per IS:2386 (Part-5).

Table 400-12 : Physical Requirements of Coarse Aggregates for Wet Mix Macadam for Sub-base/Base Courses

Sl. No.	Test	Test Method	Requirements
1)	Los Angeles Abrasion value or Aggregate Impact value	IS:2386 (Part-4) IS:2386 (Part-4) or 18.5640	40 percent (Max.) 30 percent (Max.)
2)	Combined Flakiness and Elongation indices (Total)	IS:2386 (Part-I)	35 percent (Max.)*

To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining

(non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

406.2.1.2 Grading Requirements

The aggregates shall conform to the grading given in Table 400-13.

Table 400-13 : Grading Requirements of Aggregates for Wet Mix Macadam

IS Sieve Designation	Percent by weight passing the IS Sieve
53.00 mm	100
45.00 mm	95-100
26.50 mm	-
22.40 mm	60-80
11.20 mm	40-60
4.75 mm	25-40
2.36 mm	15-30
600.00 micron	8-22
75.00 micron	0-5

Material finer than 425 micron shall have Plasticity Index (PI) not exceeding 6.

The final gradation approved within these limits shall be graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve or vice versa.

406.3 Construction Operations

406.3.1 Preparation of Base

Clause 404.3.1 shall apply.

406-3.2 Provision of Lateral Confinement of Aggregates

While constructing wet mix macadam, arrangement shall be made for the lateral confinement of wet mix. This shall be done by laying materials in adjoining shoulders along with that of wet mix macadam layer and following the sequence of operations described in Clause 404.3.3.

406.3.3 Preparation of Mix

Wet Mix Macadam shall be prepared in an approved mixing plant of suitable capacity having provision for controlled addition of water and forced/ positive mixing arrangement like pugmill or pan type mixer of concrete batching plant. The plant shall have following features:

- For feeding aggregates— three/ four bin feeders with variable speed motor
- Vibrating screen for removal of oversize aggregates
- Conveyor Belt
- Controlled system for addition of water
- Forced/positive mixing arrangement like pug-mill or pan type mixer
- Centralized control panel for sequential operation of various devices and precise process control
- Safety devices

Optimum moisture for mixing shall be determined in accordance with IS:2720 (Part-8) after replacing the aggregate fraction retained on 22.4 mm sieve with material of 4.75 mm to 22 .4 mm size. While adding water, due allowance should be made for evaporation losses. However, at the time of compaction, water in the wet mix should not vary from the optimum q value by more than agreed limits. The mixed material should be uniformly wet and no segregation should be permitted.

406.3.4 Spreading of Mix

Immediately after mixing, the aggregates shall be spread uniformly and evenly upon the prepared sub-grade/sub-base/base in required quantities. In no case shall these be dumped in heaps directly on the area where these are to be laid nor shall their hauling over a partly completed stretch be permitted.

The mix may be spread by a paver finisher. The paver finisher shall be self-propelled of adequate capacity with following features:

- i) Loading hoppers and suitable distribution system, so as to provide a smooth uninterrupted material flow for different layer thicknesses from the tipper to the screed.
- ii) Hydraulically operated telescopic screed for paving width upto to 8.5 m and fixed screed beyond this. The screed shall have tamping and vibrating arrangement for initial compaction of the layer.
- iii) Automatic levelling control system with electronic sensing device to maintain mat thickness and cross slope of mat during laying procedure.

In exceptional cases where it is not possible for the paver to be utilized, mechanical means like motor grader may be used with the prior approval of the Engineer. The motor grader shall be capable of spreading the material uniformly all over the surface.

The surface of the aggregate shall be carefully checked with templates and all high or low spots remedied by removing or adding aggregate as may be required. The layer may be tested by depth blocks during construction. No segregation of larger and fine particles should be allowed. The aggregates as spread should be of uniform gradation with no pockets of fine materials.

The Engineer may permit manual mixing and /or laying of wet mix macadam where small quantity of wet mix macadam is to be executed. Manual mixing/laying in inaccessible/ remote locations and in situations where use of machinery is not feasible can also be permitted. Where manual mixing/laying is intended to be used, the same shall be done with the approval of the Engineer.

406.3.5 Compaction

After the mix has been laid to the required thickness, grade and crossfall/camber the same shall be uniformly compacted to the full depth with suitable roller. If the thickness of single compacted layer does not exceed 100 mm, a smooth wheel roller of 80 to 100kN weight may be used. For a compacted single layer upto 200 mm, the compaction shall be done with the help of vibratory roller of minimum static weight of 80 to 100 kN with an arrangement for adjusting the frequency and amplitude. An appropriate frequency and amplitude may be selected. The speed of the roller shall not exceed 5 km/h.

In portions having unidirectional cross fall/superelevation, rolling shall commence from the lower edge and progress gradually towards the upper edge. Thereafter, roller should progress parallel to the center line of the road, uniformly over-lapping each preceding track by at least one-third width until the entire surface has been rolled. Alternate trips of the roller shall be terminated in stops at least 1 m away from any preceding stop.

In portions in camber, rolling should begin at the edge with the roller running forward and backward until the edges have been firmly compacted. The roller shall then progress gradually towards the center parallel to the center line of the road uniformly overlapping each of the preceding track by at least one-third width until the entire surface has been rolled.

Any displacement occurring as a result of reversing of the direction of a roller or from any other cause shall be corrected at once as specified and/or removed and made good. .

Along forms, kerbs, walls or other places not accessible to the roller, the mixture shall be thoroughly compacted with mechanical tampers or a plate compactor. Skin patching of an area without scarifying the surface to permit proper bonding of the added material shall not be permitted.

Rolling should not be done when the sub-grade is soft or yielding or when it causes a wavelike motion in the sub-base/base course or sub-grade. If irregularities develop during rolling which exceed 12 mm when tested with a 3 m straight edge, the surface should be loosened and premixed material added or removed as required before rolling again so as to achieve a uniform surface conforming to the desired grade and crossfall. In no case shall the use of unmixed material be permitted to make up the depressions.

Rolling shall be continued till the density achieved is at least 98 percent of the maximum dry density for the material as determined by the method outlined in IS:2720 (Part-8). .

After completion, the surface of any finished layer shall be well-closed, free from movement under compaction equipment or any compaction planes, ridges, cracks and loose material. All loose, segregated or otherwise defective areas shall be made good to the full thickness of the layer and recompacted.

406.3.6 Setting and Drying

After final compaction of wet mix macadam course, the road shall be allowed to dry for 24 hours.

406.4 Opening to Traffic

No vehicular traffic shall be allowed on the finished wet mix macadam surface. Construction equipment may be allowed with the approval of the Engineer.

406.5 Surface Finish and Quality Control of Work

406.5.1 Surface Evenness

The surface finish of construction shall conform to the requirements of Clause 902.

406.5.2 Quality Control

Control on the quality of materials and works shall be exercised by the Engineer in accordance with Section 900.

406.6 Rectification of Surface Irregularity

Where the surface irregularity of the wet mix macadam course exceeds the permissible tolerances or where the course is otherwise defective due to sub-grade soil getting mixed with the aggregates, the full thickness of the layer shall be scarified over the affected area, re-shaped with added premixed material or removed and replaced with fresh premixed material as applicable and recompacted in accordance with Clause 406.3. The area treated in the aforesaid manner shall not be less than 5 m long and 2 m wide. In no case shall depressions be filled up with unmixed and ungraded material or fines.

406.7 Arrangement for Traffic

During the period of construction, arrangements for traffic shall be done as per Clause 112.

408 SHOULDERS, ISLANDS AND MEDIANS

408.1 Scope

The work shall consist of constructing shoulder (hard/paved/earthen with brick or stone block edging) on either side of the pavement, median in the road dividing the carriageway into separate lanes and islands for channelising the traffic at junctions in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings or as directed by the Engineer.

408.2 Materials

Shoulder on either side of the road may be of selected earth/granular material/paved conforming to the requirements of Clause 305/401 and the median may be of selected earth conforming to the requirements of Clause 305.

Median/Traffic islands shall be raised and kerbed at the perimeter and the enclosed area filled with earth and suitably covered with grass turf/shrubs as per Clause 307 and/or paved as per Clauses 410.3.4 or 410.3.5.

Paved shoulders shall consist of sub-base, base and surfacing courses, as shown in the drawings and materials for the same shall conform to relevant Specifications of the

corresponding items. Where paved or hard shoulders are not provided, the pavement shall be provided with brick/stone block edgings as shown in the drawings. The brick shall conform to Clause 1003 of these Specifications. Stone blocks shall conform to Clause 1004 of these Specifications and shall be of size 225 mm x 110 mm x 75 mm.

408.3 Size of Shoulders/Medians/Islands

Shoulder (earthen/hard/paved)/median/traffic island dimensions shall be as shown on the drawings or as directed by the Engineer.

408.4 Construction Operations

408.4.1 Shoulders

The sequence of operations shall be such that the construction of paved shoulder is done in layers each matching the thickness of adjoining pavement layer. Only after a layer of pavement and corresponding layers in paved and earth shoulder portion have been laid and compacted, the construction of next layer of pavement and shoulder shall be taken up.

Where the materials in adjacent layers are different, these shall be laid together and the pavement layer shall be compacted first. The corresponding layer in paved shoulder portion shall be compacted thereafter, which shall be followed by compaction of each shoulder layer. The adjacent layers having same material shall be laid and compacted together.

In all cases where paved shoulders have to be provided along side of existing carriageway, the existing shoulders shall be excavated in full width and to the required depth as per Clause 301.3.7. Under no circumstances, box cutting shall be done for construction of shoulders.

Compaction requirement of earthen shoulder shall be as per Table 300-3. In the case of bituminous courses and concrete pavement, work on shoulder shall start only after the pavement course has been laid and compacted.

During all stages of shoulder construction, the required crossfall shall be maintained to drain off surface water.

Regardless of the method of laying, all shoulder construction material shall be placed directly on the shoulder. Any spilled material dragged on to the pavement surface shall be

immediately removed, without damage to the pavement, and the area so affected thoroughly cleaned.

408.4.2 Median and islands

Median and Islands shall be constructed in a manner similar to shoulder up to the road level. Thereafter the median and Islands, if raised, shall be raised at least 300 mm by using kerb stones of approved material and dimensions and suitably finished and painted as directed by the engineer. If not raised, the median and islands shall be filled with local earth or granular material or any other approved material and compacted by plate compactor/power rammer. The confined area after filling with earth shall be turfed with grass or planted with shrubs and in case of granular fill it can be finished with tiles/slabs as directed by the engineer.

408.4.3 Brick/stone block edging

The bricks/stone blocks shall be laid on edge, with the length parallel to the transverse direction or the road. They shall be laid on a bed of 25 mm sand, set carefully, rolled into position by a light roller and made flush with the finished level of the pavement.

408.5 Surface finish and quality control of works

The surface finish of construction shall conform to the requirements of clause 900.2. Control on the quality of materials and works shall be exercised by the engineer in accordance with section 900.

409 CEMENT CONCRETE KERB AND KERB WITH CHANNEL

409.1 Scope

This work shall consist of constructing cement concrete kerbs and kerbs with channel in the central median and/or along the footpaths or separators in conformity with the lines, levels and dimensions as specified in the drawings or as directed by the Engineer.

409.2 Materials

Kerbs and kerb with channel shall be provided in cement concrete of Grade M 20 in accordance with Section 1700 of these Specifications.

409.3 Type of Construction

These shall be cast-in-situ construction with suitable kerb casting machine in all situations except at locations where continuous casting with equipment is not practicable. In those locations precast concrete blocks shall be used.

409.4 Equipment

A continuous kerb casting equipment of adequate capacity and controls, capable of laying the kerbs in required cross-sections and producing a well-compacted mass of concrete free of voids and honeycombs, shall be used.

409.5 Construction Operations

409.5.1 Kerb shall be laid on firm foundation of minimum 150 mm thickness of cement concrete of M 15 grade cast in-situ or on extended width of pavement. The foundation shall have a projection of 50 mm beyond the kerb stone. Before laying the foundation of lean concrete, the base shall be leveled and slightly watered to make it damp.

409.5.2 In the median portions in the straight reaches, the kerb shall be cast in continuous lengths. In the portions where footpath is provided and/or the slope of the carriageway is towards median (as in case of superelevated portion), there shall be sufficient gap/recess left in the kerb to facilitate drainage openings.

409.5.3 After laying the kerbs and just prior to hardening of the concrete, saw cut grooves shall be provided at 5 m intervals up to finished road level or as specified by the Engineer

409.5.4 Kerbs on the drainage ends such. as along the footpath or the median in superelevated portions, shall be cast with monolithic concrete channels as indicated in drawings. The slope of the channel towards drainage pipes shall be ensured for efficient drainage of the road surface.

409.5.5 Vertical and horizontal tolerances with respect to true line and level shall be mm.

410 FOOTPATHS AND SEPARATORS

410.1 Scope

The work shall consist of constructing footpaths and/or separators at locations as specified in the drawings or as directed by the Engineer.

The lines, levels and dimensions shall be as per the drawings. The scope of the work shall include provision of all drainage arrangements as shown in the drawings or as directed by the Engineer.

410.2 Materials

The footpaths and separators shall be constructed with any of the following types:

- a) Cast-in-situ cement concrete of Grade M 20 as per Section 1700 of the Specifications. The minimum size of the panels shall be as specified in the drawings.
- b) Precast cement concrete blocks and interlocking blocks/tiles of grade not less than M 30 as per Section 1700 of the Specifications. The thickness and size of the cement concrete blocks or interlocking blocks/ tiles shall be as specified in the drawings.
- c) Natural stone slab cut and dressed from stone of good and sound quality, uniform in texture, free from defects and at least equal to a sample submitted by the Contractor and approved by the Engineer. The thickness and size of the natural stone slab shall be as specified in the drawings.
- d) The material for chequered tiles shall confirm to specifications of IS CODE 13801-2013 "CHEQUERED CEMENT CONCRETE TILES — SPECIFICATION"

410.3 Construction Operations

410.3.1 Drainage pipes below the footpath originating from the kerbs shall be first laid in the required slope and connected to the drains/sumps/storm water drain/drainage chutes as per provisions of the drawings, or as specified.

410.3.2 Portion on back side of kerbs shall be filled and compacted with granular sub-base material as per Clause 401 of the Specifications in specified thickness.

410.3.3 The base for cast-in-situ cement concrete panels/ tiles/ nature stone slab shall be prepared and finished to the required lines, levels and dimensions as indicated in the drawings.

Over the prepared base, precast concrete interlocking blocks/tiles/natural stone slabs and/or cast-in- situ slab shall be set/laid as described in Clauses 410.3.4 and 410.3.5.

410.3.4 Tiles/Natural Stone Slabs

The blocks/tiles/slabs shall be set on a layer of average 12 mm thick cement-sand mortar (1:3) laid on prepared base in such a way that there is no rocking. The gaps between the blocks/tiles/slabs shall not be more than 12 mm and shall be filled with cement-sand mortar

410.3.5 Cast-in-Situ Cement Concrete

The panels of specified size shall be cast on the prepared base in panels of specified size in a staggered manner. Construction joints shall be provided as per Section 1700 of the Specifications.

410.3.6 Precast Concrete Blocks and Interlocking Concrete Block Pavements

The precast concrete blocks and interlocking concrete block pavement shall be laid on a bedding of sand of thickness specified in the drawing. The grading of the sand layer shall be as in Table 400-16.

Table 400-16

IS Sieve Size	Percent Passing
9.52 mm	100
4.75 mm	95-100
2.36 mm	80-100
1.18 mm	50-95
600 micron	25-60
300 micron	10-30
150 micron	0-15
75 micron	0-10

The joints shall be filled with sand passing a 2.35 mm size with the grading as in Table 400-17.

Table 400-17

IS Sieve Size	Percent Passing
2.36 mm	100
1.18 mm	90-100
600 micron	60-90
300 micron	30-60
150 micron	15-30
75 micron	0-10

The bedding sand slightly moist, the moisture content being about 4 percent. The bedding sand shall be compacted by vibratory plate compactor.

The blocks shall be laid to the levels indicated on the drawings and to the pattern directed by the Engineer. The surface tolerance shall be ± 10 mm with respect to the design level. The blocks shall be embedded using a hammer.

500 BASES AND SURFACE COURSES (BITUMINOUS)

501 GENERAL REQUIREMENTS BITUMINOUS PAVEMENT LAYERS FOR

501.1 General

Bituminous pavement courses shall be made using the materials described in the Specifications.

The use of machinery and equipment mentioned in various Clauses of these Specifications is mandatory. Details of the machinery and equipment are available in the Manual for Construction and Supervision of Bituminous Works. The equipment mandatory for any particular project shall be in accordance with the Contract Specifications for that project.

501.2 Materials

501.2.1 Binder

The binder shall be an appropriate type of bituminous material complying with the relevant Indian Standard, as defined in the appropriate Clauses of these Specifications, or as otherwise specified herein. The choice of binder shall be stipulated in the Contract or by the Engineer. Where viscosity grades of bitumen are specified, they are referred to by a designation in accordance with IS:73. Where modified bitumen is specified, it shall conform to the requirements of IRC:SP:53 and IS: 15462; and the following provision of this Specification shall apply.

- Modified bitumen from refinery sources or blended at approved central plant or at site using appropriate industrial process and plant with high shear mill, and testing facilities to achieve stable and homogenous mix shall be used. The use of high shear mixer or any other device capable of producing a homogeneous blend is essential when the modifier is in powder form.
- Transportation tanks and storage tanks shall be insulated and equipped with effective heating system and circulation/ agitating device to maintain the specified temperature, homogeneity and viscosity of the bitumen during transit and storage.
- Separation, difference in softening point (R&B), shall not be more than 30C for any type of specified modified bitumen when tested as per Annex B of IS:15462.

Selection criteria for viscosity grade bitumen, based on highest and lowest daily mean temperatures at a particular site, are given in Table 500-1.

Selection criteria for modified bitumen shall be in accordance with IRC: SP:53.

**Table 500-1 : Selection Criteria for Viscosity-Graded (VG) Paving Bitumens
Based on Climatic Conditions**

Lowest Daily Mean Air Temperature, °C	Highest Daily Mean Air Temperature, °C		
	Less than 20 °C	20 to 30°C	More than 30°C
More than —1 °C	VG-10	VG-20	VG-30
-1 °C or lower	VG-10	VG-10	VG-20

Both the highest daily mean air temperature and the lowest daily mean air temperatures mentioned in Tables 500-5 and 500-6 can be obtained for the weather station nearest to the project site from the Indian Meteorological Organization (IMO). This daily mean high temperature on a specific day is the same as daily "normal" high temperature for that day as usually reported in some newspapers. The highest of the 365 daily mean high air temperatures (which usually occurs on some day in May or June) is used in Tables 500-5 and 500-6. Likewise, the lowest daily mean air temperature (which usually occurs on some day in January) can also be obtained from the IMO. Since these are mean temperatures based on the average of 3040 years data, these temperatures are significantly lower than the absolute maximum temperatures, which may have occurred in a specific year.

501.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on the 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious matter. Where the Contractor's selected source of aggregates has poor affinity for bitumen, the Contractor shall demonstrate through test results that with the use of anti-stripping agents, the stripping value is improved to satisfy the specification requirements. The Engineer may approve such a source and, as a condition for the approval of that source, the bitumen shall be treated with approved antistripping agents, as per the manufacturer's recommendations, at the cost of the Contractor.

Where crushed gravel is proposed for use as aggregate not less than 90 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured

faces, except that in the case of bituminous concrete the requirement in this regard shall be 95 percent.

The aggregates shall satisfy the physical requirements set forth in the individual relevant clause for the material.

501.2.3 Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring material, or a combination of the two, passing 2.36 mm sieve and retained on the 75 micron sieve. They shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder and wearing courses. However, natural sand upto 50 percent of the fine aggregates may be allowed in base courses. Fine aggregates shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part 37). The plasticity index of the fraction passing 0.425 mm shall not exceed 4 when tested in accordance with IS:2720 (Part 5). The fine aggregates shall satisfy the physical requirements set forth in the individual relevant clause for the material in question.

501.2.4 Sources of Material

The sources of materials proposed to be used by the Contractor shall be tested to the satisfaction of the Engineer who shall give the necessary approval. The Engineer may from time to time withdraw approval of a specific source, or attach conditions to the existing in approval. Any change in aggregate source for bituminous mixes shall require a new mix In design, and laying trials, where the mix is based on a job mix design. Stockpiles from different sources, approved or otherwise, shall be kept separate, such that there is no contamination between one material and another. Each source submitted for approval shall contain material sufficient for at least 5 days' work.

501.3 Mixing

Pre-mixed bituminous materials shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregates. Appropriate mixing temperatures are given in Table 500-2 of these Specifications. the d difference in temperature between the binder and aggregate shall at no time exceed 140C. In s order to ensure uniform quality of the mix and better coating of aggregates, the hot mix plant shall be calibrated from time to time. The essential features of the hot mix plants are given in Annex A of IRC:27.

Table 500-2 : Mixing, Laying and Rolling Temperatures for Bituminous Mixes (Degree Celcius)

Bitumen Viscosity Grade	Bitumen Temperature	Aggregate Temperature	Mixed Material Temperature	Laying Temperature	Temperature
VG40	160-170	160-175	160-170	150 Min	100 Min
VG-30	150-165	150-170	150-165	140 Min	90 Min
VG-20	145-165	145-170	145-165	135 Min	85 Min
VG-10	140-160	140-165	140-160	130 Min	80 Min

Rolling must be completed before the mat cools to these minimum temperatures.

If a continuous type mixing plant is used, the Contractor must demonstrate by laboratory analysis that the cold feed combined grading is within the grading limits specified for that bituminous bound material. In the case of a designed job mix, the bitumen and filler content shall be derived using this combined grading.

501.4 Transporting

Bituminous materials shall be transported in clean insulated and covered vehicles. An asphalt release agent, such as soap or lime water, may be applied to the interior of the vehicle to prevent sticking and to facilitate discharge of the material.

501.5 Laying

501.5.1 Weather and Seasonal Limitations

Laying shall be suspended:

- In presence of standing water on the surface;
- When rain is imminent, and during rains, fog or dust storm;
- When the base/binder course is damp;
- When the air temperature on the surface on which it is to be laid is less than 1 OOC for mixes with conventional bitumen and is less than 150C for mixes with modified bitumen;
- When the wind speed at any temperature exceeds the 40 km per hour at 2 m height.

501.5.2 Cleaning of Surface

The surface on which the bituminous work is to be laid shall be cleaned of all loose and extraneous matter by means of a mechanical broom and air jet. The equipment for applying a high pressure air jet from a compressor to remove dust or loose matter shall be available full time at the site.

501.5.3 Spreading

Prior to spreading the mix, the base shall be prepared by carrying out the required operations as per Clause 501.8 depending upon the site conditions. Except in areas where paver cannot get access, bituminous materials shall be spread, levelled and tamped by an approved selfpropelled paving machine equipped with an electronic sensing device. The essential features of the paver finisher shall conform to Annex A of IRC:27. As soon as possible after arrival at site, the materials shall be supplied continuously to the paver and laid without delay. The rate of delivery of material to the paver shall be regulated to enable the paver to operate It continuously. The travel rate of the paver, and its method of operations, shall be adjusted It to ensure an even and uniform flow of bituminous material across the screed, free from dragging, tearing and segregation of the material. In areas with restricted space (such as confined space, foot ways, of irregular shape and varying thickness, approaches to expansion joints, etc.) where paver cannot be used, the material shall be spread, raked and leveled with suitable hand tools by trained staff.

The minimum thickness of material laid in each paver pass shall be in accordance with the minimum values given in the relevant parts of these Specifications. When laying binder course or wearing course approaching an expansion joint of a structure, machine laying shall stop 300 mm short of the joint. The remainder of the pavement up to the joint, and the corresponding area beyond it, shall be laid by hand, and the joint or joint cavity shall be kept clear of surfacing material.

Bituminous material, with a temperature greater than 145 0 C, shall not be laid or deposited on bridge deck water-proofing systems, unless precautions against heat damage have been approved by the Engineer.

501.5.4 Cleanliness and Overlaying

Bituminous material shall be kept clean and uncontaminated. The only traffic permitted to run on bituminous material to be overlaid shall be that engaged in laying and compacting the next course or, where a binder course is to be sealed or surface dressed, that engaged on such surface treatment. Should any bituminous material become contaminated, the Contractor shall make it good to the satisfaction of the Engineer, in compliance with Clause 501.8.

Binder course material shall be covered by either the wearing course or surface treatment, whichever is specified in the Contract.

501.6 Compaction

Bituminous materials shall be laid and compacted in layers, which enable the specified thickness, surface level, regularity requirements and compaction to be achieved.

Compaction of bituminous materials shall commence as soon as possible after laying. Compaction shall be substantially completed before the temperature falls below the minimum rolling temperatures stated in the relevant part of these Specifications. Rolling of the longitudinal joints shall be done immediately behind the paving operation. After this, rolling shall commence at the edges and progress towards the center longitudinally except that on Super-elevated and unidirectionally cambered portions, it shall progress from the lower to the upper edge parallel to the center line of the pavement. Rolling shall continue until all roller marks have been removed from the surface. All deficiencies in the surface after laying shall be made good by the attendants behind the paver, before initial rolling is commenced. The initial or breakdown rolling shall be done with 8—10 tonne static weight smooth-wheel rollers. The intermediate rolling shall be done with 8—10 tonne static weight or vibratory roller or with a pneumatic tyre roller of 12 to 15 tonne weight, with a tyre pressure of at least 0.56 MPa. The Contractor shall demonstrate the efficiency of the equipment proposed to be used by carrying compaction trials. The procedure for site trials shall be submitted to the Engineer for approval. The finish rolling shall be done with 6 to 8 tonne smooth wheel tandem rollers. Rolling shall continue until the specified compaction is achieved.

Where compaction is to be determined by density of cores, the requirements to prove the performance of rollers shall apply in order to demonstrate that the specified density can be achieved. In such cases the Contractor shall specify the plant, and the method by which he intends to achieve the specified level of compaction and finish at temperatures above the minimum specified rolling temperature. Laying trials shall then demonstrate the acceptability of the plant and method used.

Bituminous materials shall be rolled in a longitudinal direction, with the driven rolls nearest the paver. The roller shall first compact material adjacent to joints and then work from the lower to the upper side of the layer, overlapping on successive passes by at least one-third of the width of the rear roll or, in the case of a pneumatic-tyred roller, at least the nominal width of 300 mm.

In portions with super-elevated and unidirectional camber, after the edge has been rolled, the roller shall progress from the lower to the upper edge.

Rollers should move at a speed of not more than 5 km per hour. The roller shall not be permitted to stand on pavement which has not been fully compacted, and necessary precautions shall be taken to prevent dropping of oil, grease, petrol/ diesel or other foreign matter on the pavement either when the rollers are operating or standing. The wheels of roller machine shall be in good working order, to prevent the mix from adhering to the Wheels. Only sufficient moisture to prevent adhesion between the wheels of rollers and the mix should be used. Surplus water shall not be allowed to stand on the partially compacted pavement.

501.7 Joints

501.7.1 Where joints are made, the material shall be fully compacted, and the joint made flush in one of the following ways:

- a) All joints shall be cut vertical to the full thickness of the previously laid mix. All loosened material shall be discarded and the vertical face coated with a suitable viscosity grade hot bitumen, or cold applied emulsified bitumen. While spreading the material along the joint the material spread shall overlap 25 mm to 50 mm on the previously laid mix beyond the vertical face of the joint. The thickness of the loose overlap material should be approximately a quarter more than the final compacted thickness. The overlapped mix shall be dragged back to the hot lane so that the roller can press the small excess into the hot side of the joint to obtain a high joint density.
- b) By using two or more pavers operating in echelon, where this is practicable and in sufficient proximity for adjacent widths to be fully compacted by continuous rolling.

All longitudinal joints shall be offset at least 300 mm from parallel joints in the layer beneath or as directed, and in a layout approved by the Engineer. Joints in the wearing course shall coincide with either the lane edge or the lane marking, whichever is appropriate. Longitudinal joints shall not be situated in wheel track zones.

501.7.2 For transverse joints method a) above shall apply. Transverse joints in the successive and adjoining layers shall have a minimum offset of 2 m.

501.8 Preparation of Surface

501.8.1 Scope

This work shall consist of preparing an existing granular or black-topped surface for laying bituminous course. The work shall be performed on such widths and lengths as shown on the drawings or as instructed by the Engineer. The existing surface shall be firm and clean, and treated with Prime or Tack coat where specified in the Contract.

501.8.2 Materials

501.8.2.1 Scarifying and Re-laying the Granular Surface

The material used shall be coarse aggregates salvaged from the scarification of the existing granular base course supplemented by fresh coarse aggregates and screenings so that aggregates and screenings thus supplemented correspond to Clauses 404 or 406.

501.8.2.2 For Patching Potholes and Sealing Cracks

Where the existing surface to be overlaid is bituminous, material required for patching and sealing cracks shall be in accordance with Clauses 3004.2 and 3004.3, or as directed by the Engineer.

501.8.2.3 For Profile Corrective Course

The type of material for use as profile corrective course shall be as shown on the drawing or as directed by the Engineer. Where it is to be laid as part of the overlay/ strengthening course, the profile corrective course material shall be of the same specification as that of the overlay/ strengthening course. However, if provided as a separate layer, it shall be of the specification and details given in the Contract.

501.8.3 Construction Operations

501.8.3.1 Preparing Existing Granular Surface

Where the existing surface is granular, all loose materials shall be removed, and the surface lightly watered where the profile corrective course to be provided as a separate layer is also granular. Where the profile corrective course of bituminous material is to be laid over the existing granular surface, the latter shall, after removal of all loose material, be primed in accordance with Clause 502 and a tack coat applied in accordance with Clause 503.

The surface of all granular layers on which bituminous works are to be placed, shall be free from dust. All such layers must be capable of being swept, after the removal of any non-integral loose material, by means of a mechanical broom, without shedding significant quantities of material and dust removed by air jet, washing, or other means approved by the Engineer.

After cleaning, the surface shall be correct to line and level within the tolerances specified for base course.

501.8.3.2 Scarifying Existing Bituminous Surface

Where specified or shown on the drawings, the existing bituminous layer in the specified width shall be removed with care and without causing undue disturbance to the underlying

layer, by a suitable method approved by the Engineer. After removal of all loose and disintegrated material, the underlying layers which might have been disturbed shall be suitably reworked supplementing the base material as necessary with suitable fresh stone aggregates and compacted to line and level. The compacted finished surface shall be primed in accordance with Clause 502. Reusable materials shall be stacked as directed by the Engineer with all leads and lifts.

501.8.3.3 Patching of Potholes and Sealing of Cracks

Where the existing surface to be overlaid is bituminous, any existing potholes and cracks shall be repaired and sealed in accordance with Clauses 3004.2 and 3004.3, or as directed by the Engineer.

501.8.3.4 Profile Corrective Course

a) Application of Profile Corrective Course

- i. A profile corrective course for correcting the existing pavement profile shall be laid to varying thickness as shown on the Drawings.
- ii. Any high spots in the existing black-topped surface shall be removed by a milling machine or other approved method, and all loose material shall be removed to the satisfaction of the Engineer.
- iii. Where the maximum thickness of profile corrective course will be not more than 40 mm, the profile corrective course shall be constructed as an integral part of the overlay course. In other cases, the profile corrective course shall be constructed as a separate layer, adopting such construction procedures and using such equipment as approved by the Engineer, to lay the specified type of material, to thickness and tolerance as specified for the course to be provided.
- iv. The profile corrective course shall be laid to tolerances and densities as specified for wearing course if it is laid integral with the wearing course. The profile corrective course shall be laid to tolerances and densities as specified for base course, if it is to be covered with a wearing course layer.

b) **Laying on Granular Base** : After preparing the granular surface in accordance with Clauses 501.8.3.1 and 501.8.3.2, the profile corrective course shall be laid using material as described in Clauses 501.8.2.3 and 501.8.3.4 (a), or as otherwise described in the Contract, and compacted to the requirements of the particular Specification.

c) **Laying on Existing Bituminous Surface** : The existing bituminous surface shall be prepared in accordance with Clause 501.8.3.3, and after applying a tack coat conforming to Clause 503, the bituminous profile corrective course shall be laid using material as

described in Clauses 501.82.3 and 501.8.3.4(a) and compacted to the requirements of the Specification.

- d) **Correction of Local Depressions, Camber and Super-Elevation** : Where local sags or depressions occur in the existing pavement, a specific filling operation shall be instructed by the Engineer, which should be laid in accordance with Fig. 500-1. Normally, the maximum layer thickness at any point should not exceed 100 mm. In placing multiple lifts, they should be arranged according to the correct method as illustrated.



(B) INCORRECT METHOD

Note: Profile corrective course material to be in accordance with the lift thickness

Fig. 500-1 : Methods for Providing Corrective Course for Short Sags and Depressions

For correction of camber or super-elevation of the existing carriageway, the method shown in Fig. 500-2 shall be adopted, depending on the profile of the existing carriageway.

501.8.3.5 Covering the Profile Corrective Courses

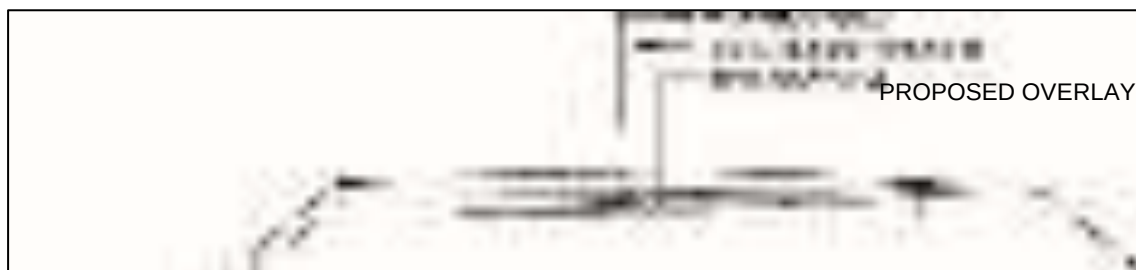
Profile corrective course shall be so planned that the layer shall be covered by the designed base/wearing course at the earliest opportunity, before opening to regular traffic.

501.8.4 Surface Finish and Quality Control of Work

The relevant provisions of Section 900 shall apply.

501.8.5 Arrangements for Traffic

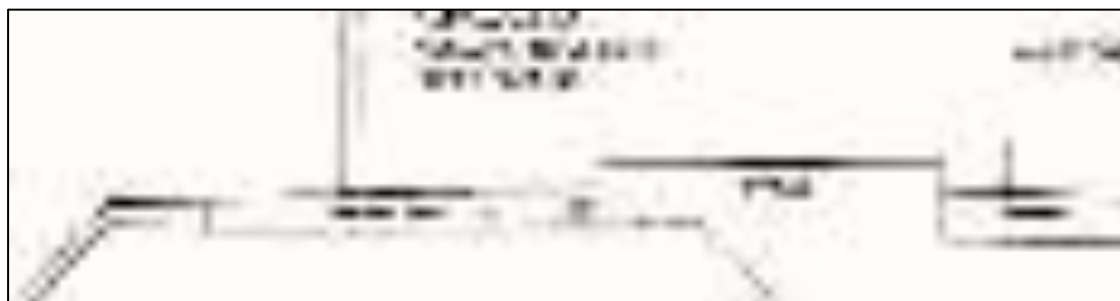
During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.



Case I : Deficiency in camber being rectified by profile corrective course



Case II : Deficiency in super elevation being rectified by profile corrective course



Case III : Converting two-sided camber to one-sided cross-fall during provision of a dual carriageway

Fig. 500-2 : Correction of Camber or Super-Elevation

501.8.6 Environmental Protection

The provisions of Clause 111 and the provision of Annex A to Clause 501 shall apply.

501.8.7 Measurement for Payment

501.8.7.1 Cleaning of the Surface

The work of cleaning of the surface using mechanical broom and air-jet shall be incidental to the work of preparation of surface.

501.8.7.2 Scarifying

Scarifying the existing bituminous surface shall be measured and paid for on a square metre basis.

501.8.7.3 Prime Coat

Prime coat shall be measured and paid for on a square metre basis.

501.8.7.4 Tack Coat

Tack coat shall be measured and paid for on a square metre basis.

501.8.7.5 Potholes and Crack Sealing

The work of filling potholes shall be measured separately and be paid for in square metres or on weight basis in tonnes as specified in the Contract.

The work of sealing cracks by applying fog spray or emulsion slurry seaq shall be measured in square metres, for the area covered by the spray.

The work of sealing cracks of size 3 mm to 6 mm in width shall be measured in square metres or in linear meters as specified in the Contract.

The work of sealing cracks of size greater than 6 mm width shall be measured in linear metres.

501.8.7.6 Profile Corrective Course

Profile corrective course shall be measured as the volume laid in position in cubic metres, or in tonnage, as stipulated in the Contract. The volume shall be calculated by plotting the exact profile of corrective course as required, and laid, superimposed on the existing pavement profile. Cross-sectional areas of the profile corrective course shall be measured at intervals of 10 m centre to centre on straight sections and at 5 m center to centre on curves longitudinally and at seven locations transversely, for two lane carriageway, and at three locations transversely for single lane and the volume shall be calculated using the method of end areas.

501.8.7.7 Filling of Local Depressions

The work of filling depressions where instructed to be carried out separately shall be measured by the weight of the bituminous material placed in position.

501.8.8 Rates

501.8.8.1 Rate for Scarifying

The contract unit rate for scarifying existing bituminous surfaces, including repairing/reworking disturbed underlying layers and removing and stacking reusable and unusable materials, shall include but not necessarily be limited to, the cost of all labour, supply of materials needed for repair/reworking, hire charges of tools and plant, and transportation of scarified material with all leads and lifts

501.8.8.2 Rate for Premixed Bituminous Material

The contract unit rate for premixed bituminous material shall be payment in full for carrying out the required operations including full compensation for, but not necessarily limited to:

- i. Making arrangements for traffic to Clause 112 except for initial treatment to verge, shoulders and construction of diversions;
- ii. Cleaning of the surface;
- iii. Providing all materials to be incorporated in the work including arrangement for stock yards, all royalties, fees, rents where necessary and all leads and lifts;
- iv. Mixing, transporting, laying and compacting the mix, as specified including all wastage in cutting joints;
- v. All labour, tools, equipment, plant including installation of hot mix plant, power supply units and all machinery, incidental to complete the work to these Specifications;
- vi. Carrying out the work in part widths of the road where directed;
- vii. Carrying out alt tests for control of quality;
- viii. The rate shall cover the provision of bitumen at the application rate specified in the contract, with the provision that the variation in actual percentage of bitumen used shall be assessed and the payment adjusted accordingly as per Contract;
- ix. The rates include for all testing, mix design, transporting and testing of samples, and cores and tests as directed by the Engineer; and
- x. The cost of all plant and laying trials as specified to prove the mixing and laying methods shall be deemed to be included in the Contractor's rates.

501.8.8.3 Rate for Potholes and Crack Sealing

The rate for patching potholes shall be as per Clause 3004.2.6.

The rate for sealing cracks by applying fog spray shall be as per Clause 513.9.

The rate for sealing of cracks of width 3 mm or more shall be as per Clause 3004.3.3.5.

The contract unit rate for cracks between 6 mm and 15 mm shall be measured on a linear metre basis, and the rate is to include for all materials, tools, plant, labour, and transport.

501.8.8.4 Rate for Prime Coat

The Contract unit rate for prime coat shall be as per Clause 502.8.

501.8.8.5 Rate for Tack Coat

The Contract unit rate for tack coat shall be as per Clause 503.8.

501.8.8.6 Rate for Filling of Local Depressions

The Contract unit rate for filing of local depressions shall be payment in full for (i) furnishing all materials, (ii) all works involved including trimming, cleaning, backfilling, priming, application of tack coat, filling with bituminous material in layers and compacting each layer (iii) all labour, tools, equipment and incidentals to complete the works in accordance with the Specifications.

501.8.8.7 Rate for Profile Corrective Course

The Contract unit rate for profile corrective course when laid separately shall be payment in full for carrying out the required operations as specified and shall include all components listed in Clause 501.8.8.2.

Annex 'A' to Clause 501

Annex 'A'

PROTECTION OF THE ENVIRONMENT

1. GENERAL

- This Appendix sets out limitations on the Contractor's activities specifically intended to protect the environment.
- The Contractor shall take all necessary measures and precautions and otherwise ensure that the execution of the works and all associated operations on or off site are carried out in conformity with statutory and regulatory environmental requirements including those prescribed elsewhere in these specifications.
- The Contractor shall take all measures and precautions to avoid any J, nuisance or disturbance arising from the execution of the Works. This shall wherever possible be achieved by suppression of the nuisance at source rather than abatement of the nuisance once generated.
- In the event of any spoil, debris, waste or any deleterious substance from the site being deposited on any adjacent land, the Contractor shall immediately remove all such material and restore the affected area to its original state to the satisfaction of the Engineer.

2. WATER QUALITY

- The Contractor shall prevent any interference with the supply to or abstraction from, and prevent any pollution of, water resources (including underground percolating water) as a result of the execution of the Works.
- Areas where water is regularly or repetitively used for dust suppression purposes shall be laid to fall to specially-constructed settlement tanks to permit sedimentation of particulate matter. After settlement, the water may be reused for dust suppression and rinsing.
- All water and other liquid waste products arising on the site shall be collected and disposed of at a location on or off the site and in a manner that shall not cause nuisance or pollution.
- The Contractor shall not discharge or deposit any matter arising from the execution of the Works into any waters except with the permission of the Engineer and the regulatory authorities concerned.
- The Contractor shall at all times ensure that all existing stream courses and drains within, and adjacent to, the site are kept safe and free from any debris and any materials arising from the Works.

- The Contractor shall protect all watercourses, waterways, ditches, canals, drains, lakes and the like from pollution as a result of the execution of the Works.

3. AIR QUALITY

- The Contractor shall devise and arrange methods of working to minimize dust, gaseous or other air-borne emissions and carry out the Works in such a manner as to minimize adverse impacts on air quality.
- The Contractor shall utilize effective water sprays during delivery, manufacture, processing and handling of materials when dust is likely to be created, and to dampen stored materials during dry and windy weather. Stockpiles of friable materials shall be covered with clean tarpaulins, with application of sprayed water during dry and windy weather. Stockpiles of material or debris shall be dampened prior to their movement, except where this is contrary to the Specifications.
- Any vehicle with an open load-carrying area used for transporting potentially dust producing material shall have properly fitting side and tail boards. Materials having the potential to produce dust shall not be loaded to a level higher than the side and tail boards, and shall be covered with a clean tarpaulin in good condition. The tarpaulin shall be properly secured and extended at least 300 mm over the edges of the side and tail boards.
- In the event that the Contractor is permitted to use gravel or earth roads for haulage, he shall provide suitable measures for dust palliation, if these are, in the opinion of the Engineer, necessary. Such measures may include sprinkling water on the road surface at regular intervals.

4. NOISE

- The Contractor shall consider noise abatement measures in his planning and execution of the Works.
- The Contractor shall take all necessary measures so that the operation of all mechanical equipment and construction processes on and off the site shall not cause any unnecessary or excessive noise, taking into account applicable environmental requirements. The Contractor shall use all necessary measures and shall maintain all plant and silencing equipment in good condition so as to minimize the noise emission during construction works.

5. CONTROL OF WASTES

- The Contractor shall control the disposal of all forms of waste generated by the construction operations and in all associated activities. No uncontrolled deposition or dumping shall be permitted. Wastes to be so controlled shall include, but shall not be limited to, all forms of fuel and engine oils, all types of bitumen, cement, surplus aggregates, gravels, bituminous mixes etc. The Contractor shall make specific

provision for the proper disposal of these and any other waste products, conforming to local regulations and acceptable to the Engineer.

6. EMERGENCY RESPONSE

- The Contractor shall plan and provide for remedial measures to be implemented in the event of occurrence of emergencies such as spillages of oil or bitumen or chemicals.
- The Contractor shall provide the Engineer with a statement of the measures he intends to implement in the event of such an emergency, which shall include a statement of how he intends to provide personnel adequately trained to implement such measures.

7. MEASUREMENT

- No separate measurement shall be made in respect of compliance by the Contractor with these provisions. The Contractor shall be deemed to have made allowance for such compliance with these provisions in the preparation of his prices for items of work included in the Bill of Quantities and full compensation for such compliance will be deemed to be covered by them.

502 PRIME COAT OVER GRANULAR BASE

502.1 Scope

This work shall consist of the application of a single coat of low viscosity liquid bituminous material to a porous granular surface preparatory to the superimposition of bituminous treatment or mix. The work shall be carried out on a previously prepared granular/stabilized surface to Clause 501.8.

502.2 Materials

The primer shall be cationic bitumen emulsion SSI grade conforming to IS:8887 or medium curing cutback bitumen conforming to IS:217 or as specified in the contract.

Quantity of SSI grade bitumen emulsion for various types of granular surface shall be as given in Table 500-3

Table 500-3 : Quantity of Bitumen Emulsion for Various Types of Granular Surfaces

Type of Surface	Rate of Spray (kg/sq.m)
WMM/WBM	0.7-1.0
Stabilized soil bases/Crusher Run Macadam	0.9-1.2

Cutback for primer shall not be prepared at the site. Type and quantity of cutback bitumen for various types of granular surface shall be as given in Table 500-4.

Table 500-4 : Type and Quantity of Cutback Bitumen for Various Types of Granular Surface

Type of Surface	Type of Cutback	Rate of Spray (kg/sq.m)
WMM/WBM	MC 30	0.6-0.9
Stabilized soil bases/ Crusher Run Macadam	MC 70	0.9-1.2

The correct quantity of primer shall be decided by the Engineer and shall be such that it can be absorbed by the surface without causing run-off of excessive primer and to achieve desired penetration of about 8-10 mm.

502.3 Weather and Seasonal Limitations

Primer shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Cutback bitumen as primer shall not be applied to a wet surface. Surfaces which are to receive emulsion primer should be damp, but no free or standing water shall be present. Surface can be just wet by very light sprinkling of water.

502.4 Construction

502.4.1 Equipment

The primer shall be applied by a self-propelled or towed bitumen pressure sprayer equipped for spraying the material uniformly at specified rates and temperatures. Hand spraying shall not be allowed except in small areas, inaccessible to the distributor, or in narrow strips where primer shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

502.4.2 Preparation of Road Surface

The granular surface to be primed shall be swept clean by power brooms or mechanical sweepers and made free from dust. All loose material and other foreign material shall be removed completely. If soil/ moorum binder has been used in the WBM surface, part of this should be brushed and removed to a depth of about 2 mm so as to achieve good penetration.

502.4.3 Application of Bituminous Primer

After preparation of the road surface as per Clause 502.4.2, the primer shall be sprayed uniformly at the specified rate. The method for application of the primer will depend on the type of equipment to be used, size of nozzles, at the spray bar and speed of forward movement. The Contractor shall demonstrate at a spraying trial, that the equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

No heating or dilution of SSI bitumen emulsion and shall be permitted at site. Temperature of cutback bitumen shall be high enough to permit the primer to be sprayed effectively though the jets of the spray and to cover the surface uniformly.

502.4.4 Curing of Primer and Opening to Traffic

A primed surface shall be allowed to cure for at least 24 hours or such other higher period as is found to be necessary to allow all the moisture/volatiles to evaporate before any

subsequent surface treatment or mix is laid. Any unabsorbed primer shall first be blotted with a light application of sand, using the minimum quantity possible. A primed surface shall not be opened to traffic other than that necessary to lay the next course.

502.5 Quality Control of Work

For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

502.6 Arrangements for Traffic

During construction operations, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

502.7 Measurement for Payment

Prime coat shall be measured in terms of surface area of application in square metres.

502.8 Rate

The contract unit rate for prime coat shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 401.7 (i) to (v) and as applicable to the work specified in these Specifications. Payment shall be made on the basis of the provision of prime coat at an application rate of quantity at 0.6 kg per square metre or at the rate specified in the Contract, with adjustment, plus or minus, for the variation between this quantity and the actual quantity approved by the Engineer after the preliminary trials referred to in Clause 502.4.3.

503 TACK COAT

503.1 Scope

The work shall consist of the application of a single coat of low viscosity liquid bituminous material to existing bituminous, cement concrete or primed granular surface preparatory to the superimposition of a bituminous mix, when specified in the Contract or as instructed by the Engineer. The work shall be carried out on a previously prepared surface in accordance with Clause 501.8.

503.2 Materials

The binder used for tack coat shall be either Cationic bitumen emulsion (RS I) complying with IS:8887 or suitable low viscosity paving bitumen of VG 10 grade conforming to IS:73. The use of cutback bitumen RC:70 as per IS:217 shall be restricted only for sites at sub-

zero temperatures or for emergency applications as directed by the Engineer. The type and grade of binder for tack coat shall be as specified in the Contract or as directed by the Engineer.

503.3 Weather and Seasonal Limitations

Bituminous material shall not be applied during a dust storm or when the weather is foggy, rainy or windy or when the temperature in the shade is less than 10°C. Where the tack coat consists of emulsion, the surface shall be slightly damp, but not wet. Where the tack coat is of cutback bitumen, the surface shall be dry.

503.4 Construction

503.4.1 Equipment

The tack coat shall be applied by a self-propelled or towed bitumen pressure sprayer, equipped for spraying the material uniformly at a specified rate. Hand spraying shall not be permitted. except in small areas, inaccessible to the distributor, or narrow strips, shall be sprayed with a pressure hand sprayer, or as directed by the Engineer.

503.4.2 Preparation of Base

The surface on which the tack coat is to be applied shall be clean and free from dust, dirt, and in any extraneous material, and be otherwise prepared in accordance with the requirements of Clause 501.8. The granular or stabilized surfaces shall be primed as per Clause 502. Immediately before the application of the tack coat, the surface shall be swept clean with a mechanical broom, and high-pressure air jet, or by other means as directed by the Engineer.

503.4.3 Application of Tack Coat

The application of tack coat shall be at the rate specified in Table 500-5, and it shall be applied uniformly. If rate of application of Tack Coat is not specified in the contract, then it shall be the rate specified in Table 500-5. No dilution or heating at site of RSI bitumen emulsion shall be permitted. Paving bitumen if used for tack coat shall be heated to appropriate temperature in bitumen boilers to achieve viscosity less than 2 poise. The normal range of spraying temperature for a bituminous emulsion shall be 200°C to 700°C and for cutback, 500°C to 800°C. The method of application of tack coat will depend on the type of equipment to be used, size of nozzles, pressure at the spray bar, and speed or forward movement. The Contractor shall demonstrate at a spraying trial, that the

equipment and method to be used is capable of producing a uniform spray, within the tolerances specified.

Table 500-5 : Rate of Application of Tack Coat

Type of Surface	Rate of Spray of Binder in Kg per sq. m
Bituminous surfaces	0.20 - 0.30
Granular surfaces treated with primer	0.25 - 0.30
Cement concrete pavement	0.30 - 0.35

503.4.4 Curing of Tack Coat

The tack coat shall be left to cure until all the volatiles have evaporated before any subsequent construction is started. No plant or vehicles shall be allowed on the tack coat other than those essential for the construction.

503.4.5 Quality Control of Work

For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

503.5 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

503.6 Measurement for Payment

Tack coat shall be measured in terms of surface area of application in square metres.

503.7 Rate

The contract unit rate for tack coat shall be payment in full for carrying out the required operations including for all components listed in Clause 401.8 (i) to (v) and as applicable to the work specified in these Specifications. The rate shall cover the provision of tack coat, at 0.2 kg per square metre or at the rate specified in the Contract, with the provision that the variation between this quantity and actual quantity of bitumen used will be assessed and the payment adjusted accordingly.

504 BITUMINOUS MACADAM

504.1 Scope

This work shall consist of construction in a single course having 50 mm to 100 mm thickness or fin multiple courses of compacted crushed aggregates premixed with a bituminous binder on a previously prepared base to the requirements of these Specifications. Since the bituminous macadam is an open-graded mix, there is a potential that it may trap water or moisture vapour within the pavement system. Therefore, adjacent layer (shoulders) should have proper drainage quality to prevent moisture-induced damage to the BM.

504.2 Materials

504.2.1 Bitumen

The bitumen shall be viscosity graded paving bitumen complying with Indian Standard Specification for paving bitumen, IS:73 or as specified in the Contract. The type and grade of bitumen to be used would depend upon the climatic conditions and the traffic. Guidelines for selection of bitumen are given in Table 500-1.

504.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material retained on 2.36 mm sieve. It shall be clean, hard, durable and cubical shape, free from dust and soft organic and other deleterious substances. The aggregate shall satisfy the physical requirements specified in Table 500-6. Where crushed gravel is proposed for use as aggregate, not less than 90 percent by weight of the crushed material retained on 4.75 mm sieve shall have at least two fractured faces resulting from crushing operation. Before approval of the source, the aggregates shall be tested for stripping. Where the Contractor's selected source of aggregates have poor affinity for bitumen, as a condition for the approval of that source, the bitumen shall be treated with approved anti-stripping agents, as per the manufacturer's recommendations, without additional payment.

504.2.3 Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a combination of two, passing 2.36 mm sieve and retained on 75 micron sieve. It shall be clean, hard, durable, free from dust and soft organic and other deleterious substances. Natural sand shall not be used in the binder course.

Table 500-6 : Physical Properties of Coarse Aggregate

Property	Test	Requirement	Test method
Cleanliness	Grain size analysis	Max. 5% passing 0.075 micron	IS:2386 Part
Particle shape	Combined Flakiness and Elongation Indices	Max. 35%	IS:2386 Part I
Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max. 40%	IS:2386 Part IV
		Max. 30%	IS:2386 Part IV
Durability	Soundness (Sodium or Magnesium) Sodium Sulphate Magnesium Sulphate	5 cycles	IS.2386 Part V IS:2386 Part V
		Max. 12% Max. 18%	
Water absorption	Water absorption	Max. 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate	Min. Retained Coating 95%	IS:6241
Water sensitivity	Retained Tensile strength*	Min. 80%	AASHTO 283

If the minimum retained tensile strength falls below 80 percent, use of anti-stripping agent is recommended to meet the minimum requirements.

504.2.4 Aggregate Grading and Binder Content

The combined grading of the coarse aggregates and fine aggregates, when tested accordance with IS:2386 Part 1, wet sieving method, shall conform to limits given in Table 500-8. The type and quantity of bitumen and appropriate thickness is also given Table 500-7.

504.2.5 Proportioning of Material

The combined aggregate grading shall not vary from the lower limit on one sieve to the higher limit on the adjacent sieve to avoid gap grading. The aggregate may be proportioned and blended to produce a uniform mix complying with the requirements in Table 500-7. The binder content shall be within a tolerance of ± 0.3 percent by weight of total mix when individual specimens are taken for quality control tests in accordance with the provisions of section 900.

504.3 Construction Operation

504.3.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

Table 500-7: Aggregate Grading and Bitumen Content

Grading	1	2
Nominal maximum aggregate size*	40 mm	19 mm
Layer thickness	80 -100 mm	50 -75 mm
IS Sieve size (mm)	Cumulative % by weight of total aggregate passing	
45	100	
37.5	90-100	
26.5	75-100	100
19	-	90 - 100
13.2	35-61	56 - 88
4.75	13 - 22	16 -36
2.36	4 — 19	4- 19
0.3	2- 10	2-10
0.075	0-8	0-8
Bitumen content ** percent by mass of total mix	3.3**	3.4**

Nominal maximum aggregate size is the largest specified sieve size upon which any of the aggregate material is retained.

** Corresponds to specific gravity of the Aggregate being 2.7. In case aggregates have specific gravity more than 2.7, bitumen content can be reduced proportionately. Further, infor regions where highest daily mean air temperature is 30oC or lower and lowest daily in mean air temperature is 10oC or lower, the bitumen content may be increased by in 0.5 percent.

504.3.2 Preparation of the Base

The base on which bituminous macadam is to be laid shall be prepared, shaped and compacted to the required profile in accordance with Clauses 501.8 and 902.3 as appropriate, and a prime coat, shall be applied in accordance with Clause 502 where specified, or as directed by the Engineer. The surface shall be thoroughly swept clean by a mechanical broom, and the dust removed by compressed air. In locations where mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer.

504.3.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied as required under the Contract or as directed by the Engineer.

504.3.4 Preparation and Transportation of the Mix

The provisions of Clauses 501.3 and 501.4 shall apply.

504.3.5 Spreading

The provisions of Clause 501.5.3 shall apply.

504.3.6 Rolling

Compaction shall be carried out in accordance with the provisions of Clauses 501.6 and 501.7. Rolling shall be continued until the specified density is achieved, or where no density is specified, until there is no further movement under the roller. The required frequency of testing is defined in Clause 903.

504.4 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of f Clause 902 For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

504.5 Protection of the Layer

The bituminous macadam shall be covered with either the next pavement course or wearing course, as the case may be, within a maximum of forty-eight hours. If there is to be any delay, by the Contractor the course shall be covered by a seal coat to the requirement of Clause 512 before opening to any traffic. The seal coat in such cases shall be considered incidental to the work and shall not be paid for separately.

504.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

504.7 Measurement for Payment

Bituminous macadam shall be measured as finished work in cubic metres, or by weight in metric tonnes, where used as regulating course, or square metres at the specified thickness as indicated in the Contract or shown on the drawings, or as otherwise directed by the Engineer.

504.8 Rate

The contract unit rate for bituminous macadam shall be payment in full for carrying out the required operations as specified. The rate shall include cost for all components listed in Clause 501.8.8.2.

505 DENSE BITUMINOUS MACADAM

505.1 Scope

The specification describes the design and construction procedure for Dense Bituminous Macadam, (DBM), for use mainly, but not exclusively, in base/binder and profile corrective courses. The work shall consist of construction in a single or multiple layers of DBM on a previously prepared base or sub-base. The thickness of a single layer shall be 50 mm to 100 mm.

505.2 Materials

505.2.1 Bitumen

The bitumen shall be viscosity grade paving bitumen complying with the Indian Standard Specification IS:73, modified bitumen complying with Clause 501.2.1 or as otherwise specified in the Contract. The type and grade of bitumen to be used shall be specified in the Contract.

505.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock, crushed gravel or other hard material . any retained on 2.36 mm sieve. They shall be clean, hard, durable, of cubical shape, free from dust and soft or friable matter, organic or other deleterious substances. Where the Contractor's selected source of aggregates has poor affinity for bitumen, the Contractor shall produce test . results that with the use of anti-stripping agents, the stripping value is improved to satisfy the . specification requirements. The Engineer may approve such a source and as a condition for . the approval of that source, the bitumen shall be treated with an approved anti-stripping agent, as per the manufacturer's recommendations, at the cost of the Contractor. The aggregates . shall satisfy the requirements specified in Table 500-8.

Where crushed gravel is proposed for use as aggregate, not less than 90 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

505.2.3 Fine Aggregates

Fine aggregates shall consist of crushed or naturally occurring mineral material, or a the combination of the two, passing the 2.36 mm sieve and retained on the 75 micron sieve. These shall be clean, hard, durable, dry and free from dust, and soft or friable matter, organic or other deleterious matter. Natural sand shall not be allowed in binder courses. However, natural sand upto 50 percent of the fine aggregate may be allowed in base courses. The fine aggregate shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part 37). The plasticity index of the fraction passing the in 0.425 mm sieve shall not exceed 4, when tested in accordance with IS:2720 (Part 5).

505.2.4 Filter

Filler shall consist of finely divided mineral matter such as rock dust, hydrated lime or cement approved by the Engineer. The filler shall be graded within the limits indicated in Table 500-9.

The filler shall be free from organic impurities and have a plasticity Index not greater a than 4. The Plasticity Index requirement shall not apply if filler is cement or lime. Where the to aggregates fail to meet the requirements of the water sensitivity test in Table 500-8, then 2 percent by total weight of aggregate, of hydrated lime shall be used and percentage of fine aggregate reduced accordingly.

505.2.5 Aggregate Grading and Binder Content

When tested in accordance with IS:2386 Part 1 (wet sieving method), the combined grading of the coarse and fine aggregates and filler for the particular mixture shall fall within the limits given in Table 500-10 for grading 1 or 2 as specified in the Contract. To avoid gap grading, the combined aggregate gradation shall not vary from the lower limit on one sieve to higher limit on the adjacent sieve.

Table 500-8 : Physical Requirements for Coarse Aggregate for Dense Bituminous Macadam

Property	Test	Specification	Method of Test
Cleanliness (dust)	Grain size analysis	Max 5% passing 0.075 mm sieve	IS:2386 Part I
Particle shape	Combined Flakiness and Elongation Indices*	Max 35%	IS:2386 Part I

Strength	Los Angeles Abrasion Value or Aggregate Impact Value	Max 35%	IS:2386 Part IV
		Max 27%	
Durability	Soundness either: Sodium Sulphate or Magnesium Sulphate	Max 12%	IS:2386 Part V
		Max 18%	
Water Absorption	Water Absorption	Max 2%	IS:2386 Part III
Stripping	Coating and Stripping of Bitumen Aggregate Mix	Minimum retained coating 95%	IS:6241
Water Sensitivity	Retained Tensile Strength**	Min.	A-ASHTO 283

* To determine this combined proportion, the flaky stone from a representative sample should first be separated out. Flakiness index is weight of flaky stone metal divided by weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles. The values of flakiness index and elongation index so found are added up.

** If the minimum retained tensile test strength falls below 80 percent, use of anti stripping agent is recommended to meet the requirement.

Table 500-9 : Grading Requirements for Mineral Filler

IS SIEVE (MM)	Cumulative Percent Passing by Weight of Total Aggregate
0.6	100
0.3	95 - 100
0.075	85- 100

Table 500-10 : Composition of Dense Graded Bituminous

Grading	1	2
Nominal aggregate size*	37.5 mm	26.5 mm
Layer thickness	75 - 100 mm	50 - 75 mm
IS Sieve ¹ (mm)	Cumulative % by weight of total aggregate passing	
45	100	

37.5	95 - 100	100
26.5	63-93	90-100
19	-	
13.2	55-75	56-80
9.5	-	
4.75	38-54	38-54
2.36	28-42	
1.18	-	
0.6	-	
0.3	7-21	7-21
0.15	-	
0.075	2-8	2-8
Bitumen content % by mass of total mix	Min 4.0**	Min 4.5**

* The nominal maximum particle size is the largest specified sieve size upon which any of the aggregate is retained. .

** Corresponds to specific gravity of aggregates being 2.7. In case aggregate have specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is — 10°C or lower, the bitumen content may be increased by 0.5 percent.

Bitumen content indicated in Table 500-10 is the minimum quantity. The quantity shall be determined in accordance with Clause 505.3.

505.3 Mix Design

The bitumen content required shall be determined following the Marshall mix design procedure contained in Asphalt Institute Manual MS—2.

The Fines to Bitumen (FIB) ratio by weight of total mix shall range from 0.6 to 1.2.

505.3.1 Requirement of the mix

Apart from conformity with the grading and quality requirements for individual ingredients, the mixture shall meet the requirements set out in Table 500-11.

Table 500-11: Requirements for Dense Graded Bituminous Macadam

[illegible]

505.3.2 Binder Content

The binder content shall be optimized to achieve the requirements of the mix set out in Table 500-11. The binder content shall be selected to obtain 4 percent air voids in the mix design. The Marshall method for determining the optimum binder content shall be adopted as described in the Asphalt Institute Manual MS-2.

Where maximum size of the aggregate is more than 26.5 mm, the modified Marshall method using 150 mm diameter specimen described in MS-2 and ASTM D 5581 shall be used. This method requires modified equipment and procedures. When the modified Marshall test is used, the specified minimum stability values in Table 500-12 shall be multiplied by 2.25, and the minimum flow shall be 3 mm.

Table 500-12 : Minimum Percent Voids In Mineral Aggregate (VMA)

Air Voids in Bituminous Mix, %	Percent Voids in Mineral Aggregate, %		
	10	15	20
1.0	12	14	16
2.0	13	15	17
3.0	14	16	18
4.0	15	17	19
5.0	16	18	20
6.0	17	19	21
7.0	18	20	22
8.0	19	21	23
9.0	20	22	24
10.0	21	23	25

Note: Interpolate minimum voids in the mineral aggregate (VMA) for designed percentage air voids values between those listed.

505.3.3 Mix Formula

The Contractor shall submit to the Engineer for approval at least 21 days before the start the work, the job mix formula proposed for use in the works, together with the following details:

- i) Source and location of all materials;
- ii) Proportions of all materials expressed as follows:
 - a) Binder type, and percentage by weight of total mix;
 - b) Coarse aggregate/Fine aggregate/Mineral filler as percentage by weight of total aggregate including mineral filler;
- iii) A single definite percentage passing each sieve for the mixed aggregate;
- iv) The individual gradings of the individual aggregate fraction, and the proportion of each in the combined grading;
- v) The results of mix design such as maximum specific gravity of loose mix (Gmm), compacted specimen densities, Marshall stability, flow, air voids, VMA, VFB and related graphs and test results of AASHTO T 283 Moisture susceptibility test;
- vi) Where the mixer is a batch mixer, the individual weights of each type of aggregate, and binder per batch;
- vii) Test results of physical characteristics of aggregates to be used;
- viii) Mixing temperature and compacting temperature.

While establishing the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the

work and that the mix and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer for which samples of all ingredients of the mix shall be furnished by the Contractor as required by the Engineer.

The approved job mix formula shall remain effective unless and until a revised Job Mix Formula is approved. Should a change in the source of materials be proposed, a new job mix formula shall be forwarded by the Contractor to the Engineer for approval before the placing of the material.

505.3.4 Plant Trials — Permissible Variation in Job Mix Formula

Once the laboratory job mix formula is approved, the Contractor shall carry out plant trials to establish that the plant can produce a uniform mix conforming to the approved job mix formula. The permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used shall be within the limits as specified in Table 500-13 and shall remain within the gradation band. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

Table 500-13 : Permissible Variations in the Actual Mix from the Job Mix Formula

Item	Permissible Variation (%)
Percentage of Bitumen in the Mix	± 1%
Percentage of Filler in the Mix	± 1%
Percentage of Sand in the Mix	± 1%
Percentage of Coarse Aggregate in the Mix	± 1%
Percentage of Fine Aggregate in the Mix	± 1%
Percentage of Water in the Mix	± 1%
Percentage of Air in the Mix	± 1%
Percentage of Compaction	± 1%
Percentage of Density	± 1%
Percentage of Strength	± 1%

505.3.5 Laying Trials

Once the plant trials have been successfully completed and approved, the Contractor shall carry out laying trials, to demonstrate that the proposed mix can be successfully laid and

compacted all in accordance with Clause 501. The laying trial shall be carried out on a for area which is not to form part of the works. The area of the laying trials shall be of 100 sq.m of construction similar to that of the project road, and it shall be in particularly compaction, the same as the project construction, on which the bituminous material is to be laid.

The Contractor shall previously inform the Engineer of the proposed method for laying and . compacting the material. The plant trials shall then establish if the proposed laying plant, compaction plant, and methodology is capable of producing satisfactory results. The density of the finished paving layer shall be determined by taking cores, no sooner than 24 hours after laying, or by other approved method. The compacted layers of Dense Graded Bituminous Macadam (DBM) shall have a minimum field density equal to or more than 92% of the density based on theoretical maximum specific gravity (G_m) obtained on the day of compaction in It accordance with ASTM D 2041.

Once the laying trials have been approved, the same plant and methodology shall be applied to the laying of the material on the project, and no variation of either shall be acceptable, unless approved in writing by the Engineer, who may at his discretion require further laying trials.

505.4 Construction Operations

505.4.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

505.4.2 Preparation of Base

The base on which Dense Graded Bituminous Material is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer.

505.4.3 Geosynthetics

Where Geosynthetics are specified in the Contract, this shall be in accordance with the requirements stated in Clause 703.

505.4.4 Stress Absorbing Layer

Where a stress absorbing layer is specified in the Contract, this shall be applied in accordance with the requirements of Clause 517.

505.4.5 Prime Coat

Where the material on which the dense bituminous macadam is to be laid is other than a bitumen bound layer, a prime coat shall be applied, as specified, in provisions of Clause 502, or as directed by the Engineer.

505.4.6 Tack Coat

Where the material on which the dense bituminous macadam is to be laid is either bitumen bound layer or primed granular layer, tack coat shall be applied, as specified, in accordance with the provisions of Clause 503, or as directed by the Engineer.

505.4.7 Mixing and Transportation of the Mix

The provisions as specified in Clauses 501.3 and 501.4 shall apply. Table 500-2 gives the mixing, laying and rolling temperature for dense mixes using viscosity grade bitumen. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to have uniform quality, the plant shall be calibrated from time to time.

505.4.8 Spreading

The provisions of Clauses 501.5.3 and 501.5.4 shall apply.

505.4.9 Rolling

The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials. The compaction process shall be carried out by the same plant, and using the same method, as approved in the laying trials, which may be varied only with the express approval of the Engineer in writing.

505.5 Opening to Traffic

It shall be ensured that the traffic is not allowed without the approval of the Engineer in writing, on the surface until the dense bituminous layer has cooled to the ambient temperature.

505.6 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of these Specifications.

505.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

505.8 Measurement for Payment .

Dense Graded Bituminous Materials shall be measured as finished work either in cubic metres, tonnes or by the square metre at a specified thickness as indicated in the Contract drawings, or documents, or as otherwise directed by the Engineer.

505.9 Rate

The contract unit rate for Dense Graded Bituminous Macadam shall be payment in full for carrying out all the required operations as specified and shall include, to all components listed in Clause 501.8.8.2. The rate shall include the provision of bitumen, at 4 percent and 4.5 percent by weight of the total mixture for grading 1 and grading 2 respectively.

The variation in actual percentage of bitumen used shall be assessed and the payment adjusted plus or minus accordingly.

506 SAND ASPHALT BASE COURSE

506.1 Scope

This work shall consist of a base course composed of a mixture of sand, mineral filler where required and bituminous binder, placed and compacted upon a prepared and accepted subbase in accordance with these Specifications and the Fnes, levels, grades, dimensions and cross sections shown on the Drawings or as directed by the Engineer.

Note: Sand Asphalt Base course is used in special situations like quality coarse aggregates not being available within economical leads and/or water needed for conventional base course not being readily available, as in desert areas.

506.2 Materials

506.2.1 Bitumen

The bitumen shall be paving bitumen of viscosity grade VG 30 or VG 20, as specified in the Contract, conforming to IS:73.

506.2.2 Sand

The sand shall be clean, naturally occurring or blended material free from any deleterious substances, dry and well graded within the limits given in Table 500-14 and with other physical properties conforming to the requirements of this Table.

Table 500-14 : Sand Grading and Physical Requirements

Sieve Size (mm)		Percentage of Sand (by weight)	
75	300	100	100
150	600	85	85
300	1200	70	70
425	1750	55	55
600	2400	40	40
750	3000	25	25
900	3600	15	15
1060	4250	10	10
1250	5000	5	5
1500	6000	2	2
1750	7000	1	1
2000	8000	0.5	0.5
2250	9000	0.2	0.2
2500	10000	0.1	0.1
2800	11200	0.075	0.075
3150	12500	0.05	0.05
3550	14000	0.025	0.025
4000	15750	0.015	0.015
4500	17700	0.0075	0.0075
5000	19750	0.004	0.004
5600	22000	0.002	0.002
6300	24500	0.001	0.001
7100	27500	0.0005	0.0005
8000	31500	0.0002	0.0002
9000	36500	0.0001	0.0001
10000	42500	0.00005	0.00005
11200	49000	0.00002	0.00002
12500	56000	0.00001	0.00001
14000	63500	0.000005	0.000005
15750	71750	0.000002	0.000002
17700	80750	0.000001	0.000001
19750	90500	0.0000005	0.0000005
22000	101000	0.0000002	0.0000002
24500	113250	0.0000001	0.0000001
27500	127250	0.00000005	0.00000005
31500	143000	0.00000002	0.00000002
35500	160500	0.00000001	0.00000001
40000	180750	0.000000005	0.000000005
45000	203750	0.000000002	0.000000002
50000	229500	0.000000001	0.000000001
56000	258000	0.0000000005	0.0000000005
63000	289250	0.0000000002	0.0000000002
71000	323250	0.0000000001	0.0000000001
80000	360000	0.00000000005	0.00000000005
90000	400000	0.00000000002	0.00000000002
100000	443250	0.00000000001	0.00000000001
112000	490000	0.000000000005	0.000000000005
125000	540000	0.000000000002	0.000000000002
140000	593250	0.000000000001	0.000000000001
157500	650000	0.0000000000005	0.0000000000005
177000	710250	0.0000000000002	0.0000000000002
197500	774000	0.0000000000001	0.0000000000001
220000	841250	0.00000000000005	0.00000000000005
245000	909000	0.00000000000002	0.00000000000002
275000	986250	0.00000000000001	0.00000000000001
315000	1073000	0.000000000000005	0.000000000000005
355000	1169250	0.000000000000002	0.000000000000002
400000	1275000	0.000000000000001	0.000000000000001
450000	1390250	0.0000000000000005	0.0000000000000005
500000	1515000	0.0000000000000002	0.0000000000000002
560000	1650250	0.0000000000000001	0.0000000000000001
630000	1795000	0.00000000000000005	0.00000000000000005
710000	1950250	0.00000000000000002	0.00000000000000002
800000	2115000	0.00000000000000001	0.00000000000000001
900000	2290250	0.000000000000000005	0.000000000000000005
1000000	2475000	0.000000000000000002	0.000000000000000002
1120000	2670250	0.000000000000000001	0.000000000000000001
1250000	2875000	0.0000000000000000005	0.0000000000000000005
1400000	3090250	0.0000000000000000002	0.0000000000000000002
1575000	3315000	0.0000000000000000001	0.0000000000000000001
1770000	3560250	0.00000000000000000005	0.00000000000000000005
1975000	3815000	0.00000000000000000002	0.00000000000000000002
2200000	4080250	0.00000000000000000001	0.00000000000000000001
2450000	4355000	0.000000000000000000005	0.000000000000000000005
2750000	4640250	0.000000000000000000002	0.000000000000000000002
3150000	4935000	0.000000000000000000001	0.000000000000000000001
3550000	5240250	0.0000000000000000000005	0.0000000000000000000005
4000000	5555000	0.0000000000000000000002	0.0000000000000000000002
4500000	5880250	0.0000000000000000000001	0.0000000000000000000001
5000000	6215000	0.00000000000000000000005	0.00000000000000000000005
5600000	6560250	0.00000000000000000000002	0.00000000000000000000002
6300000	6915000	0.00000000000000000000001	0.00000000000000000000001
7100000	7280250	0.000000000000000000000005	0.000000000000000000000005
8000000	7655000	0.000000000000000000000002	0.000000000000000000000002
9000000	8040250	0.000000000000000000000001	0.000000000000000000000001
10000000	8435000	0.0000000000000000000000005	0.0000000000000000000000005
11200000	8840250	0.0000000000000000000000002	0.0000000000000000000000002
12500000	9255000	0.0000000000000000000000001	0.0000000000000000000000001
14000000	9680250	0.00000000000000000000000005	0.00000000000000000000000005
15750000	10115000	0.00000000000000000000000002	0.00000000000000000000000002
17700000	10570250	0.00000000000000000000000001	0.00000000000000000000000001
19750000	11045000	0.000000000000000000000000005	0.000000000000000000000000005
22000000	11540250	0.000000000000000000000000002	0.000000000000000000000000002
24500000	12055000	0.000000000000000000000000001	0.000000000000000000000000001
27500000	12590250	0.0000000000000000000000000005	0.0000000000000000000000000005
31500000	13145000	0.0000000000000000000000000002	0.0000000000000000000000000002
35500000	13720250	0.0000000000000000000000000001	0.0000000000000000000000000001
40000000	14315000	0.00000000000000000000000000005	0.00000000000000000000000000005
45000000	14930250	0.00000000000000000000000000002	0.00000000000000000000000000002
50000000	15565000	0.00000000000000000000000000001	0.00000000000000000000000000001
56000000	16230250	0.000000000000000000000000000005	0.000000000000000000000000000005
63000000	16915000	0.000000000000000000000000000002	0.000000000000000000000000000002
71000000	17620250	0.000000000000000000000000000001	0.000000000000000000000000000001
80000000	18345000	0.0000000000000000000000000000005	0.0000000000000000000000000000005
90000000	19090250	0.0000000000000000000000000000002	0.0000000000000000000000000000002
100000000	19855000	0.0000000000000000000000000000001	0.0000000000000000000000000000001
112000000	20640250	0.00000000000000000000000000000005	0.00000000000000000000000000000005
125000000	21445000	0.00000000000000000000000000000002	0.00000000000000000000000000000002
140000000	22270250	0.00000000000000000000000000000001	0.00000000000000000000000000000001
157500000	23115000	0.000000000000000000000000000000005	0.000000000000000000000000000000005
177000000	23980250	0.000000000000000000000000000000002	0.000000000000000000000000000000002
197500000	24865000	0.000000000000000000000000000000001	0.000000000000000000000000000000001
220000000	25770250	0.0000000000000000000000000000000005	0.0000000000000000000000000000000005
245000000	26695000	0.0000000000000000000000000000000002	0.0000000000000000000000000000000002
275000000	27640250	0.0000000000000000000000000000000001	0.0000000000000000000000000000000001
315000000	28605000	0.00000000000000000000000000000000005	0.00000000000000000000000000000000005
355000000	29590250	0.00000000000000000000000000000000002	0.00000000000000000000000000000000002
400000000	30595000	0.00000000000000000000000000000000001	0.00000000000000000000000000000000001
450000000	31620250	0.000000000000000000000000000000000005	0.000000000000000000000000000000000005
500000000	32665000	0.000000000000000000000000000000000002	0.000000000000000000000000000000000002
560000000	33730250	0.000000000000000000000000000000000001	0.000000000000000000000000000000000001
630000000	34815000	0.0000000000000000000000000000000000005	0.0000000000000000000000000000000000005
710000000	35920250	0.0000000000000000000000000000000000002	0.0000000000000000000000000000000000002
800000000	37045000	0.0000000000000000000000000000000000001	0.0000000000000000000000000000000000001
900000000	38190250	0.00000000000000000000000000000000000005	0.00000000000000000000000000000000000005
1000000000	39355000	0.00000000000000000000000000000000000002	0.00000000000000000000000000000000000002
1120000000	40540250	0.00000000000000000000000000000000000001	0.00000000000000000000000000000000000001
1250000000	41745000	0.000000000000000000000000000000000000005	0.000000000000000000000000000000000000005
1400000000	42970250	0.000000000000000000000000000000000000002	0.000000000000000000000000000000000000002
1575000000	44215000	0.000000000000000000000000000000000000001	0.000000000000000000000000000000000000001
1770000000	45480250	0.0000000000000000000000000000000000000005	0.0000000000000000000000000000000000000005
1975000000	46765000	0.0000000000000000000000000000000000000002	0.0000000000000000000000000000000000000002
2200000000	48070250	0.0000000000000000000000000000000000000001	0.0000000000000000000000000000000000000001
2450000000	49395000	0.00000000000000000000000000000000000000005	0.00000000000000000000000000000000000000005
2750000000	50740250	0.00000000000000000000000000000000000000002	0.00000000000000000000000000000000000000002
3150000000	52115000	0.00000000000000000000000000000000000000001	0.00000000000000000000000000000000000000001
3550000000	53520250	0.000000000000000000000000000000000000000005	0.000000000000000000000000000000000000000005
4000000000	54955000	0.000000000000000000000000000000000000000002	0.000000000000000000000000000000000000000002
4500000000	56420250	0.000000000000000000000000000000000000000001	0.000000000000000000000000000000000000000001
5000000000	57915000	0.0000000000000000000000000000000000000000005	0.0000000000000000000000000000000000000000005
5600000000	59440250	0.0000000000000000000000000000000000000000002	0.0000000000000000000000000000000000000000002
6300000000	60995000	0.0000000000000000000000000000000000000000001	0.0000000000000000000000000000000000000000001
7100000000	62580250	0.00000000	

Table 500-15 : Requirements for Sand Asphalt Base Course

506.3.3 Job Mix Formula

The Contractor shall develop the job mix formula proposed for use in the works and submit it to the Engineer for approval together with the following details :

- i. Source and location of all materials;
- ii. Proportions of all materials expressed as follows where each is applicable:
 - a. Binder, as percentage by weight of total mixture;
 - b. Sand/Mineral filler as percentage by weight of total aggregate
- iii. A single definite percentage passing each sieve for the mixed aggregate;
- iv. The results of tests enumerated in Table 500-15 as obtained by the Contractor
- v. Test results of physical characteristics of aggregates to be used;
- vi. Mixing temperature and compacting temperature.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mixture and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer for which joint samples of all ingredients of the mix shall be furnished by the Contractor as required by the former.

The approved job mix formula shall remain effective unless and until modified by the Engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established by the Contractor and approved by the Engineer before actually using the materials.

506.3.4 Permissible Variation from Job Mix Formula

The Contractor shall produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Table 500-12, with the condition that the gradation after the variation remains within the gradation envelop. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

506.4 Construction Operations

506.4.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

506.4.2 Preparation of Base

The surface on which Sand Asphalt Base course Material is to be laid shall be prepared, shaped and graded in the profile required for the particular layer in accordance with . Clauses 501 and 902 as appropriate or as directed by the Engineer. The surface shall be thoroughly swept dean free from dust and foreign matter using a mechanical brush, and the dust blown off by compressed air. In confined locations where mechanical plant cannot .get access, other methods shall be used as approved by the Engineer. A prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

506.4.3 Tack Coat

A tack coat over the base shall be applied in accordance with Clause 503, or otherwise as directed by the Engineer.

506.4.4 Preparation and Transportation of the Mixture

The provisions of Clauses 501.3 and 501.4 shall apply.

506.4.5 Spreading

The provisions of Clauses 501.5.2 to 501.5.4 shall apply. Laying must be accomplished at a suitable temperature to ensure proper compaction. Guidance for mixing and compaction temperature for the particular bitumen may be taken from Table 500-3 and shall correspond to a viscosity of 2 Poise (0.2 Pa.s) and 3 poise (0.3 Pas) respectively, based on the original (unaged) bitumen properties.

506.4.6 Rolling

Clause 501.6 shall apply. Generally, the initial or breakdown rolling shall be done with 8_10 tonne static weight smooth-wheeled rollers. The intermediate rolling shall be done with 8_10 tonne static weight or vibratory rollers or with a pneumatic tyred roller of 12-15 tonne weight having a tyre pressure of at least 0.56 MPa. The finish rolling shall be done with 8—10 tonne deadweight smooth wheeled tandem rollers. The exact pattern of rolling shall be established at the laying trials.

506.5 Opening to Traffic

It shall be ensured that the traffic is not allowed without the express approval of the Engineer in writing, on the surface until the paved mat has cooled below 600 C in its entire depth.

506.6 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902. For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

506.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

506.8 Measurement for Payment

Sand Asphalt Base course materials shall be measured as finished work, for the area covered, in cubic metres, metric tonnes, or in square metres, at a specified thickness, as stated in the Contract.

506.9 Rate

The Contract unit rate for Sand Asphalt Base course materials shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2 (i) to (x). The rate shall cover provision of 5 percent of bitumen by weight of the total mixture. The variation in the actual percentage of bitumen used will be assessed and the rate, adjusted plus or minus, as applicable.

507 BITUMINOUS CONCRETE

507.1 Scope

This work shall consist of construction of Bituminous Concrete, for use in wearing and profile corrective courses. This work shall consist of construction in a single layer of bituminous concrete on a previously prepared bituminous bound surface. A single layer shall be 30 mm/40 mm/50 mm thick.

507.2 Materials

507.2.1 Bitumen

The bitumen shall conform to Clause 504.2.1.

507.2.2 Coarse Aggregates

The coarse aggregates shall be generally as specified in Clause 504.2.2, except that the aggregates shall satisfy the physical requirements of Table 500-16 and where crushed gravel is proposed for use as aggregate, not less than 95 percent by weight of the crushed material retained on the 4.75 mm sieve shall have at least two fractured faces.

Table 500-16 : Physical Requirements for Coarse Aggregate for Bituminous

Property	Unit	Minimum Value	Maximum Value
Specific Gravity	Dimensionless	2.4	2.8
Moisture Absorption	Percent by weight, Immersed 24 hrs.	0.5	1.0
Soundness	Percent by weight, after 5 cycles of soaking and drying	0	12
Crushing Value	Percent by weight, after 10 blows	30	40
Impact Value	Percent by weight, after 15 blows	10	20
Flakiness Index	Percent by weight	35	45
Surface Area	Sq. m per tonne	1.0	1.2
Polished Stone Value	Value	20	30
Resistance to Stripping	Percent by weight, after 7 days	80	100
Resistance to Abrasion	Percent by weight, after 1000 cycles	5	10

** If the minimum retained tensile test strength falls below 80 percent, use of anti-stripping agent is recommended to meet the requirement.

507.2.3 Fine Aggregates

The fine aggregates shall be all as specified in Clause 505.2.3.

507.2.4 Filler

Filler shall be as specified in Clause 505.2.4.

507.2.5 Aggregate Grading and Binder Content

When tested in accordance with IS:2386 Part 1 (Wet grading method), the combined grading of the coarse and fine aggregates and filler shall fall within the limits shown in Table 500-17. The grading shall be as specified in the Contract.

Table 500-17 : Composition of Bituminous Concrete Pavement Layers

Layer	1	2
Thickness (mm)	100	75
Bitumen Content (%)	4.5	4.5
Aggregate (mm)	2.0 to 75	0.075 to 75
Specific Gravity	2.7	2.7
Bitumen (kg/m ³)	100	100
Aggregate (kg/m ³)	1000	1000
Bitumen (kg/m ³)	100	100
Aggregate (kg/m ³)	1000	1000
Bitumen (kg/m ³)	100	100
Aggregate (kg/m ³)	1000	1000
Bitumen (kg/m ³)	100	100
Aggregate (kg/m ³)	1000	1000
Bitumen (kg/m ³)	100	100
Aggregate (kg/m ³)	1000	1000
Bitumen (kg/m ³)	100	100
Aggregate (kg/m ³)	1000	1000

Notes :

*The nominal maximum particle size is the largest specified sieve size up on which any of the aggregate is retained.

** Corresponds to specific gravity of aggregate being 2.7. In case aggregate have specific gravity more than 2.7, the minimum bitumen content can be reduced proportionately. Further the region where highest daily mean air temperature is 30°C or lower and lowest daily air temperature is — 10°C or lower, the bitumen content may be increased by 0.5 percent .

507.3 Mix Design

507.3.1 Requirements for the Mix

Clause 505.3.1 shall apply.

507.3.2 Binder Content

Clause 505.3.2 shall apply.

507.3.3 Job Mix Formula

Clause 505.3.3 shall apply.

507.3.4 Plant Trials — Permissible Variation in Job Mix Formula

The requirements for plant trials shall be as specified in Clause 505.3.4, and permissible limits for variation as given in Table 500-18.

Table 500-18 : Permissible Variations in Plant Mix from the Job Mix Formula

Material	Permissible Variation (%)
Bitumen	± 1.0
Coarse Aggregate	± 1.0
Fine Aggregate	± 1.0
Water	± 1.0
Surfactant	± 1.0
Stabilizer	± 1.0
Filler	± 1.0
Other	± 1.0

507.3.5 Laying trials

The requirements for laying trials shall be as specified in Clause 505.3.5. The compacted layers of bituminous concrete (BC) shall have a minimum field density equal to or more than 92 percent of the average theoretical maximum specific gravity (Gmm) obtained on the day of compaction in accordance with ASTM D2041.

507.4 Construction Operations

507.4.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply.

507.4.2 Preparation of Base

The surface on which the bituminous concrete is to be laid shall be prepared in accordance with Clauses 501 and 902 as appropriate, or as directed by the Engineer. The surface shall be thoroughly swept clean by mechanical broom and dust removed by compressed air. In locations where a mechanical broom cannot get access, other approved methods shall be used as directed by the Engineer.

507.4.3 Geosynthetics

Where Geosynthetics are specified in the Contract, this shall be in accordance with the requirements stated in Clause 703.

507.4.4 Tack Coat

The provisions as specified in Clause 504.4.6 shall apply.

507.4.5 Mixing and Transportation of the Mix

The provisions as specified in Clauses 501.3, 501.4 and 504.4.7 shall apply.

507.4.6 Spreading

The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

507.4.7 Rolling

The general provisions of Clauses 501.6 and 501.7 shall apply, as modified by the approved laying trials.

507.5 Opening to Traffic

Provisions in Clause 504.5 shall apply.

507.6 Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902. All materials and workmanship shall comply with the provisions set out in Section 900 of these Specifications.

507.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

507.8 Measurement for Payment

The measurement shall be as specified in Clause 505.8.

507.9 Rate

The contract unit rate shall be all as specified in Clause 504.9, except that the rate shall include the provision of bitumen at 5.2 percent & 5.4 percent for grading 1 and grading 2 by weight of total mix respectively. The variation in actual percentage of bitumen used will be assessed and the payment adjusted plus and minus accordingly.

508 CLOSE-GRADED PREMIX SURFACING/MIXED SEAL SURFACING

508.1 Scope

The work shall laying and compaction of a close graded premix surfacing material of 20 mm thickness composed of graded aggregates premixed with a bituminous binder on a previously prepared surface, in accordance with the requirements of these Specifications, to serve as a wearing course.

Close graded premix surfacing shall be of Type A or Type B as specified in the Contract documents. Type A grading is recommended for use in areas having rainfall more than 150 cm per year. In other areas Type B grading may be used.

508.2 Materials

508.2.1 Binder

The provisions of Clause 510.1.2.1 shall apply.

508.2.2 Coarse Aggregates

The provisions of Clause 511.1.2.2 shall apply. .

508.2.3 Fine Aggregates

The fine aggregates shall consist of crushed rock, or natural sand or a mixture of both. These shall be clean, hard, durable, un-coated, mineral particles, dry; and free from injurious, soft or flaky particles and organic or deleterious substances.

508.2.4 Aggregate Gradation

The coarse and fine aggregates shall be so graded or combined as to conform to one or the other gradings given in Table 500-19, as specified in the contract.

Table 500-19 : Aggregate Gradation

508.2.5 Proportioning of Materials

The total quantity of aggregates used for Type A or B close-graded premix surfacing shall be 0.27 cubic metre per square metre area. The quantity of binder used for premixing shall be 22.0 kg and 19.0 kg per 10 square metre area for Type A and Type B surfacing respectively.

508.3 Construction Operations

The provisions of Clause 510.1.3.1 through Clause 510.1.3.5 shall apply.

508.4 Opening to Traffic

Traffic may be allowed after completion of the final rolling when the mix has cooled down to the surrounding temperature. Speed restrictions may be imposed at initial stages.

508.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. For control on the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

508.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be in accordance with the provisions of Clause 112.

508.7 Measurement for Payment

Close-graded premix surfacing, Type A or B shall be measured as finished work, for the area specified to be covered, in square metres at a specified thickness. The area will be the net area covered.

508.8 Rate

The contract unit rate for close-graded premix surfacing, Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

509 SURFACE DRESSING

509.1 Scope

This work shall consist of the application of one coat or two coats of surface dressing, each coat consisting of a layer of bituminous binder sprayed on a previously prepared, base, followed by a cover of stone chips rolled in to form a wearing course to the requirements of these Specifications.

509.2 Materials

509.2.1 Binder

The binder shall either be bitumen conforming to IS:73 or rapid setting cationic bitumen emulsion (RS-2) conforming to IS:8887. Grade of bitumen shall depend upon the climatic condition. For selection of grade of bitumen guidance may be taken from Table 500-1. The type of binder to be used shall be stated in the Contract, or as directed by the Engineer.

509.2.2 Aggregates

The stone chips (cover aggregate) shall conform to the requirements of Clause 505.2.2., except that their water absorption shall be restricted to a maximum of 1 percent and they shall have a Polished Stone Value of minimum 60. [in BS:812 (Part-114)], of not less than 60. The size of the aggregate shall depend upon the type of surface on which it is laid and the traffic intensity. The chips shall be single sized, clean, hard, durable, of cubical shape; and free from dust and soft or friable matter, organic or other deleterious matter and conform to one of the gradings given in Table 500-21. The size of the aggregate shall depend upon the type of surface on which it is laid and the traffic intensity. Table 500-20 may be used as guidance.

Pre-coated Chips : As an alternative to the use of an adhesion agent or wherever specified in the Contract, the chips may be pre-coated before they are spread except when the sprayed binder film is a bitumen emulsion. Pre-coating the chips may be carried out by mixing aggregates with 0.75 to 1.0 percent of bitumen by weight of chips in a suitable mixer. The chips shall be heated to 160°C and mixed with the binder heated to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non sticky and can be spread easily.

Table 500-20 : Recommended Nominal Size of Aggregates (mm)

Type of Surface	Nominal Size of Aggregate (mm)		
	Surface Dressing	Prime Coat	Seal Coat
Wearing Course	75	75	75
Base Course	75	75	75
Sub-base Course	75	75	75
Sub-grade	75	75	75

Table 500-21 : Grading requirements for Aggregates used for Surface Dressing

Grading	Surface Dressing	Prime Coat	Seal Coat
75	100	100	100
150	100	100	100
300	100	100	100
475	100	100	100
750	100	100	100
1180	100	100	100
1900	100	100	100
2500	100	100	100
3750	100	100	100
4750	100	100	100
6000	100	100	100
7500	100	100	100
9000	100	100	100
11000	100	100	100
13000	100	100	100
15000	100	100	100
17000	100	100	100
19000	100	100	100
21000	100	100	100
23000	100	100	100
25000	100	100	100
27000	100	100	100
29000	100	100	100
31000	100	100	100
33000	100	100	100
35000	100	100	100
37000	100	100	100
39000	100	100	100
41000	100	100	100
43000	100	100	100
45000	100	100	100
47000	100	100	100
49000	100	100	100
51000	100	100	100
53000	100	100	100
55000	100	100	100
57000	100	100	100
59000	100	100	100
61000	100	100	100
63000	100	100	100
65000	100	100	100
67000	100	100	100
69000	100	100	100
71000	100	100	100
73000	100	100	100
75000	100	100	100
77000	100	100	100
79000	100	100	100
81000	100	100	100
83000	100	100	100
85000	100	100	100
87000	100	100	100
89000	100	100	100
91000	100	100	100
93000	100	100	100
95000	100	100	100
97000	100	100	100
99000	100	100	100
100000	100	100	100

509.2.3 Rates of Spread of Binder and Chips

The rate of spread of binder and chips will depend upon the nominal size of the aggregate and the extent of its embedment into the surface. The rate shall be determined as per the procedure given in Manual for Construction and Supervision of Bituminous Construction. Approximate rate of application of aggregates, and binder under average conditions are given in Table 500-22.

Table 500—22 : Approximate Rate of Application of Binder and Aggregates

Note :Bitumen for coated aggregates excludes quantity of bitumen required for coating.

509.2.4 Anti-Stripping Agent

Where the proposed aggregate fails to pass the stripping test then an approved antistripping agent (Appendix 4 for details) may be added to the binder in accordance with the manufacturer's instructions. The effectiveness of the proposed anti-stripping agent must be demonstrated by the Contractor, before approval by the Engineer.

509.3 Construction Operations

509.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

509.3.2 Preparation of Base

The base on which the surface dressing is to be (aid shall be prepared, shaped and conditioned to the specified lines, grade and cross section in accordance with Clause 501 or as directed by the Engineer. Prime coat, where needed, shall be provided as per Clause 502 or as directed by the Engineer. Where the existing surface shows signs of fatting up, the excess bitumen shall be removed as directed by the Engineer. The bituminous surface to be dressed shall be thoroughly cleaned either by using a mechanical broom and/or compressed air, or any other approved equipment/method as specified in the Contract or directed by the Engineer. The prepared surface shall be dust free, clean and dry, (except in the case of cationic emulsion where the surface shall be slightly damp).

509.3.3 Application of Binder

After preparation of base, paving grade binder heated to an appropriate temperature or bitumen emulsion shall be sprayed uniformly using mechanical sprayers. During the operation the ratio between truck speed and pump revolution shall be maintained constant with the help of automatic control. When work resumes, the binder shall not be sprayed on the earlier completed surface. This can be done by covering the completed work with

bitumen impregnated paper. Excessive deposit of bituminous material shall be immediately removed. The equipment described in IRC:SP:34withsynchronized spraying and compaction shall be preferred for better control and uniformity in construction

The spraying temperatures for binder are given below:



509.3.4 Application of Stone Chips

Immediately after application of the binder, clean, dry chips (in the case of emulsion the chippings may be slightly damp) shall be spread uniformly by means of a mechanical chip spreader on the surface so as to cover the surface completely with a single layer of chips.

509.3.5 Rolling

Rolling of the chips should preferably be carried out by a pneumatic tyre roller in accordance with Clauses 501.6 and 501.7. Rolling shall commence at the edges and progress towards the centre except in super-elevated and uni-directional cambered portions where it shall proceed from the lower edge to the higher edge. Each pass of the roller shall uniformly overlap not less than one-third of the track made in the preceding pass. While rolling is in progress, additional chips shall be spread by hand in necessary quantities required to make up irregularities. Rolling shall continue until all aggregate particles are firmly embedded in the binder and present a uniform closed surface.

509.3.6 Application of Second Coat of Surface Dressing

Where surface dressing in two coats is specified, the second coat should not be applied until the first coat has been open to traffic for two weeks. The surface on which the second coat is laid must be clean and free of dust. The construction operations for the second coat shall be the same as described in Clauses 510.3.3 to 510.3.5.

509.4 Opening to Traffic

Traffic shall not be permitted to run on any newly surface dressed area until the following day. In special circumstances, however, the Engineer may allow the road to be opened to traffic immediately after rolling, but in such cases traffic speed shall be limited to 20 km per hour until the following day.

509.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902.

For control on the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

509.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

509.7 Measurement for Payment

Each coat of surface dressing shall be measured as finished work for the area instructed to be covered, in square metres.

509.8 Rate

The Contract unit rate for surface dressing, based on the approximate rates of application for binder given in Table 500-22 and each size of chippings given in Clause 509.2.3, shall be adjusted, plus or minus, for the difference between the approximate rate of spread and the rate of spread determined based on design and approved by the Engineer. The adjusted rate shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

510 OPEN-GRADED PREMIX SURFACING

510.1 Open-Graded Premix Surfacing using Viscosity Grade Paving Bitumen

510.1.1 Scope

This work shall consist of preparation, laying and compaction of an open-graded premix surfacing material of 20 mm thickness composed of small-sized aggregate premixed with binder on a previously prepared base, in accordance with the requirements of these Specifications to serve as a wearing course.

510.1.2 Materials

510.1.2.1 Binder

The binder shall be viscosity grade bitumen of a suitable grade as specified in the Contract, or as directed by the Engineer, and satisfying the requirements of IS:73. For selection of grade of bitumen guidance may be taken from Table 500-1.

510.1.2.2 Aggregates

The aggregates shall conform to Clause 5042.2 except that the water absorption shall be limited to a maximum of 1 percent. The Polished Stone Value, shall not be less than 55, when tested as per BS:812-114.

510.1.2.3 Proportioning of Material

The materials shall be proportioned in accordance with Table 500-23.

Table 500-23 : Quantities of Materials Required for 10 m² of Road Surface for 20 mm Thick Open-graded Premix Surfacing

	Quantity	Unit
Ingredients		
1. Bitumen (Type 80/100) (kg)	1.0	kg
2. Bitumen (Type 80/100) (kg)	1.0	kg
3. Bitumen (Type 80/100) (kg)	1.0	kg
Grades		
4. Bitumen (Type 80/100) (kg)	1.0	kg
5. Bitumen (Type 80/100) (kg)	1.0	kg
Total	3.0	kg

510.1.3 Construction Operations

510.1.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

510.1.3.2 Preparation of Surface

The underlying surface on which the bituminous surfacing is to be laid shall be prepared and conditioned to the specified lines, grade and cross-section in accordance with Clause 501. A prime coat where needed shall be applied in accordance with Clause 502 as directed by the Engineer.

510.1.3.3 Tack Coat

A tack coat complying with Clause 503, shall be applied over the base preparatory to laying of the surfacing.

510.1.3.4 Preparation of Premix

Hot mix plant of appropriate capacity and type shall be used for the preparation of the mix material. The hot mix plant shall have separate dryer arrangement for heating aggregate.

The temperature of the binder and aggregate at the time of mixing, laying and compaction shall be in conformity with the temperature given in Table 500-3. The difference in temperature between the binder and aggregate shall at no time exceed 14 0 C. Mixing shall be thorough to ensure that a homogeneous mix is obtained in which all particles of the aggregates are coated uniformly.

The mix shall be immediately transported from the mixer to the point of use in suitable vehicles or hand barrows. The vehicles employed for transport shall be clean and the mix being transported covered in transit if so directed by the Engineer.

510.1.3.5 Spreading and Rolling

The pre mixed material shall be spread on a previously prepared base to Clause 501 by a paver unless specified otherwise in the Contract to the desired thickness, grades and crossfall (camber). The cross-fall should be checked by means of camber boards and irregularities levelled out. Excessive use of blades or rakes should be avoided. As soon as sufficient length of bituminous material has been laid, rolling shall commence with 8—10 tonne rollers, smooth wheel tandem type or other approved equipment. Rolling shall begin at the edge and progress towards the centre longitudinally, except that on superelevated and uni-directional cambered portions, it shall progress from the lower to upper edge parallel to the centre line of the pavement.

When the roller has passed over the whole area once, any high spots or depressions, which apparent, shall be corrected by removing or adding premixed materials. Rolling shall continued until the entire surface has been rolled and all the roller marks eliminated. pass of the roller the preceding track shall be overlapped uniformly by at least one third width. The roller wheels shall be kept damp to prevent the premix from adhering to the wheels. In no case shall fuel/lubricating oil be used for this purpose. Excess use of water for tiis purpose shall also be avoided.

Rollers shall not stand on newly laid material. Rolling operations shall be completed in every respect before the temperature of the mix falls below the rolling temperature indicated in Table 500-3.

510.1.3.6 Seal Coat

A seal coat conforming to Clause 511 of the type specified in the Contract shall be applied to the surface immediately after laying the surfacing.

510.1.4 Opening to Traffic

No traffic shall be allowed on the road until the seal coat has been laid. After the seal coat is laid, the road may be opened to traffic according to Clause 511.4.

510.1.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. For are control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

510.1.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

510.1.7 Measurement for Payment

Open graded premix surfacing shall be measured as finished work, for the area instructed to be covered, in square metres.

510.1.8 Rate

The contract unit rate for open-graded premix surfacing shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

510.2 Open Graded Premix Surfacing Using Cationic Bitumen Emulsion

510.2.1 Scope

This work shall consist of the preparation, laying and compaction of an open graded premixacc surfacing of 20 mm thickness composed of small-sized aggregate premixed with a cationic bitumen emulsion on a previously prepared surface, in accordance with the requirements of these Specifications to serve as a wearing course.

510.2.2 Material

510.2.2.1 Binder

The binder for Premix wearing course shall be Cationic Bitumen emulsion of Medium Setting (MS) grade complying with IS:8887 or as specified in the Contract.

510.2.2.2 Aggregate

The requirements of Clause 511.1.2.2 shall apply.

510.2.2.3 Proportioning of Materials

The materials shall be proportioned as per quantities given in Tables 500-24.

Table 500-24 : Quantities of Aggregate for 10 m² Area

Material	Quantity (m ³)
Small-sized aggregate (7.5 mm to 20 mm)	0.15
Cationic Bitumen Emulsion (Medium Setting)	0.015
Water	0.005
Total	0.165

510.2.3 Construction Operations

510.2.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply except that the minimum air temperature for laying shall be 10°C. Cationic bitumen emulsions shall not normally be stored below 0°C.

510.2.3.2 Preparation of Surface

The underlying surface on which the premix surfacing is to be laid shall be prepared, in accordance with the requirements of Clause 504.3.2 for a newly primed surface, and in accordance with Clause 505.4.2 where an existing bituminous surface is to be overlaid.

510.2.3.3 Preparation of Binder

Before opening, the cationic bitumen emulsion drums shall be rolled at a slow speed, to and fro at least 5 times, for a distance of about 10 metres, to distribute any storage sedimentation.

510.2.3.4 Tack Coat

A tack coat complying with Clause 503, shall be applied over the surface preparatory to laying of the surfacing where specified in the Contract, as directed by the Engineer.

510.2.3.5 Preparation of Premix

Premixing of cationic bitumen emulsion and aggregates can be carried out in a suitable mixer such as cold mixing plant as per IS:5435 (Revised) or concrete mixer or by pay loaders in exceptional cases where approved by the Engineer. Where specified in the Contract, continuous mixing operation shall be done either in batch or continuous hot mix plant suitable for emulsion mixes.

When using concrete mixer for preparing the premix, 0.135 cu.m (0.09 cu.m of 13.2 mm size and 0.045 cu.m of 11.2 mm size) of aggregates per batch shall be used. This quantity will be for 5 sq.m of road surface with 20 mm average thickness.

The aggregates required for one batch shall be prepared adjacent to the mixer.

The coarse aggregate of 13.2 mm size shall be placed into the mixer followed by 5 to 6.5 kg of Cationic bitumen emulsion and then the 11.2 mm size aggregate shall be added, followed by 5 to 6.5 kg of Cationic bitumen emulsion. After the materials have been mixed thoroughly, the mix shall be immediately transported to the laying site in suitable vehicles. Too much mixing shall be avoided.

510.2.3.6 Spreading and Rolling

The premixed cationic bitumen emulsion and aggregates shall be spread uniformly by a paver pc. within 10 minutes of applying the tack coat. All levelling, raking etc. should be completed within 20 minutes of the time of mixing.

The mix shall be spread uniformly to the desired thickness, grades and crossfall (camber).

The crossfall shall be checked by means of camber boards and irregularities levelled out. Too much raking is to be avoided.

The rolling shall start immediately after laying the premix. A smooth wheeled tandem roller of 8-10 tonnes shall be used, unless other compaction methods are approved by the Engineer, to be based on the results of laying trials, if necessary. While rolling, wheels of roller should be clean and kept moist to prevent the premix from adhering to the wheels. In no case shall fuel/ 51 lubricating oil be used for this purpose. Use of water for this purpose shall be strictly limited to an absolute minimum.

Rolling shall commence at the edges and progress towards the centre longitudinally except in the case of superelevated and uni-directionally cambered sections where rolling shall be carried out from the lower edge towards the higher edge parallel to the centre line of the road.

After one pass of roller over the whole area, depressions or uncovered spots should be corrected by adding premix material. Rolling shall be continued until the entire surface has been rolled, to maximum compaction and all the roller marks eliminated. In each pass of the roller, the preceding track shall be overlapped uniformly by at least one-third width. Roller(s) shall not stand on newly laid material. Joints, both longitudinal and transverse to the road sections laid and compacted earlier, shall be cut vertically to their full depth so as to expose fresh surface which shall be painted with a thin coat of binder before the new mix is laid.

510.2.4 Seal Coat

A seal coat, conforming to Clause 511, as specified in the Contract, shall be applied 5 immediately after laying the premix carpet.

510.2.5 Opening to Traffic

Traffic should not be allowed over the premix surface till seal coat is laid. After the seal coat is laid, traffic may be allowed in accordance with Clause 511.4.

510.2.6 Surface Finish and Quality Control

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials and work carried out, relevant provision of Section 900 shall apply.

510.2.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

510.2.8 Measurement for Payment

Open graded premix surfacing shall be measured as finished work, for the area instructed to be covered, in square metres. All allowances for wastage in cutting of joints shall be deemed to be included in the rate.

510.2.9 Rate

The contract unit rate for premix carpet shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

511 SEAL COAT

511.1 Scope

This work shall consist of the application of a seal coat for sealing the voids in a bituminous surface laid to the specified levels, grade and cross fall (camber).

The Seal coat shall be of either of the two types specified below:

- A) Liquid seal coat comprising of an application of a layer of bituminous binder followed by a cover of stone chips.
- B) Premixed seal coat comprising of a thin application of fine aggregate premixed with bituminous binder.

511.2 Materials

511.2.1 Binder

The requirements of Clauses 510.1.2.1 and 510.2.2.1 shall apply.

The quantity of bitumen per 10 square metres, shall be 9.8 kg for Type A, and 6.8 kg for Type B seal coat. Where bituminous emulsion is used as a binder, the quantities for Type A and Type B seal coats shall be 15 kg and 10.5 kg respectively.

511.2.2 Stone Chips for Type A Seal Coat

The stone chips shall consist of angular fragments of clean, hard, tough and durable rock of uniform quality throughout. They shall be free of soft or disintegrated stone, organic or other deleterious matter. Stone chips shall be of 6.7 mm size defined as 100 percent passing through 11.2 mm sieve and retained on 2.36 mm sieve. The quantity used for spreading shall be 0.09 cubic metre per 10 square metre area. The chips shall satisfy the quality requirements given in Table 500-8 except that the upper limit for water absorption value shall be 1 percent.

511.2.3 Aggregate for Type B Seal Coat

The aggregate shall be sand or grit and shall consist of clean, hard, durable, uncoated dry particles, and shall be free from dust, soft or flaky/elongated material, organic matter or other deleterious substances. The aggregate shall pass 2.36 mm sieve and be retained on 180 micron sieve. The quantity used for premixing shall be 0.06 cum per 10 sqm area.

511.3 Construction Operations

511.3.1 Weather and Seasonal Limitations

The requirements of Clause 501.5.1 shall apply.

511.3.2 Preparation of Surface

The seal coat shall be applied immediately after laying the bituminous course which is required to be sealed. Before application of seal coat materials, the surface shall be cleaned free of any dust or other extraneous matter.

511.3.3 Construction of Type A Seal Coat

The construction operations shall be the same as described in Clause 509.3.3 to 509.3.5.

511.3.4 Construction Type B Seal Coat

511.3.4.1 Using Paving Bitumen

The construction operations shall be the same as in Clause 510.1.3.

511.3.4.2 Using Emulsion

The construction operations shall be the same as in Clause 510.2.4.

511.4 Opening to Traffic

In the case of Type B seal coat, traffic may be allowed soon after final rolling when the premixed material has cooled down to the surrounding temperature. In the case of Type A seal coat, traffic shall not be permitted to run on any newly sealed area until the following day.

In special circumstances, however, the Engineer may open the road to traffic immediately after rolling, but in such cases traffic shall be rigorously limited to 20 km per hour until the following day.

511.5 Surface Finish and Quality Control Work

The surface of construction shall conform to the requirements of Clause 902.

For control on the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

511.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

511.7 Measurement for Payment

Seal coat, Type A or B shall be measured as finished work, over the area specified to be covered, in square metres at the thickness specified in the Contract.

511.8 Rate

The contract unit rate for seal coat Type A or B shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2.

512 SLURRY SEAL

512.1 Scope

The work consists of design and laying a mixture of mineral aggregate, slow setting cationic bitumen emulsion, water and additives, if needed, proportioned, mixed and uniformly spread over a previously prepared surface. The finally laid slurry seal shall have a homogenous mat, adhere firmly to the prepared surface and provide friction resistant surface texture throughout its surface life.

512.2 Type of Slurry Seals and Applications

Different types of slurry seal and their applications are given in Table 500-25. The type and application of the slurry seal shall be specified in the Contract.

Table 500-25: Different Types of Slurry Seals

Slurry Seal Type	Typical Bitumen Emulsion Content (%)	Typical Aggregate Content (%)	Typical Water Content (%)	Typical Additive Content (%)
Seal Coat Type A	10-15	85-90	5-10	0-5
Seal Coat Type B	15-20	80-85	5-10	0-5
Seal Coat Type C	20-25	75-80	5-10	0-5
Seal Coat Type D	25-30	70-75	5-10	0-5
Seal Coat Type E	30-35	65-70	5-10	0-5
Seal Coat Type F	35-40	60-65	5-10	0-5
Seal Coat Type G	40-45	55-60	5-10	0-5
Seal Coat Type H	45-50	50-55	5-10	0-5
Seal Coat Type I	50-55	45-50	5-10	0-5
Seal Coat Type J	55-60	40-45	5-10	0-5
Seal Coat Type K	60-65	35-40	5-10	0-5
Seal Coat Type L	65-70	30-35	5-10	0-5
Seal Coat Type M	70-75	25-30	5-10	0-5
Seal Coat Type N	75-80	20-25	5-10	0-5
Seal Coat Type O	80-85	15-20	5-10	0-5
Seal Coat Type P	85-90	10-15	5-10	0-5
Seal Coat Type Q	90-95	5-10	5-10	0-5

*In terms by weight of dry aggregate

**Indicative only

***CVPD : Commercial Vehicles per day

512.3 Materials

The materials for slurry seal shall conform to the following requirements.

512.3.1 Bitumen Emulsion

The bitumen emulsion shall be a cationic slow setting type SS 2, conforming to the requirements of IS:8887.

512.3.2 Aggregates

The mineral aggregates shall be crushed stone dust, clean, sharp, hard, durable and uncoated dry particles and shall be free from soft pieces and organic and other deleterious

substances. The aggregate shall satisfy the requirement given in Table 500-26. The target grading shall conform to one of the three types given in Table 500-27.

Table 500-26 : Properties of Aggregates

Aggregate	Test Method	Requirement
1. Specific Gravity	ASTM D 155	2.65
2. Moisture Content	ASTM D 155	1.0%
3. Bulk Density	ASTM D 155	1.45
4. Bulk Density	ASTM D 155	1.45
5. Bulk Density	ASTM D 155	1.45

1. The aggregate shall be tested in accordance with the test methods given in Table 500-26.

Table 500-27 : Targeting Grading

Sieve Size (mm)	Percentage by Mass Passing Different Types of Grading		
	Type I (mm)	Type II (mm)	Type III (mm)
75	100	100	100
150	100	100	100
300	100	100	100
475	100	100	100
750	100	100	100
1180	100	100	100
1900	100	100	100
2500	100	100	100
3750	100	100	100
5000	100	100	100

1. The aggregate shall be tested in accordance with the test methods given in Table 500-26.

Table 500-28 : Bulk Density of Aggregate

Aggregate	Test Method	Requirement
1. Bulk Density	ASTM D 155	1.45
2. Bulk Density	ASTM D 155	1.45
3. Bulk Density	ASTM D 155	1.45
4. Bulk Density	ASTM D 155	1.45
5. Bulk Density	ASTM D 155	1.45

If more than one nominal size aggregate is used to produce the required grading, the correct amount of each type of aggregate used shall be proportioned separately to meet the requirements of grading as per Table 500-27, prior to adding other materials in the mixture. After target gradation has been submitted, the percent passing each sieve shall not vary by more than the tolerance limits given in Table 500-29, and shall remain within

the gradation band. The aggregate will be acceptable based on average of five gradation tests at the job location.

512.3.3 Filler

Mineral filler shall be Ordinary Portland Cement. The quantity of filler shall be in the range of 0.5 to 2 percent by weight of dry aggregate.

512.3.4 Water

Water shall be potable, free from harmful salt and contaminants. The pH of the water shall be in the range of 6 to 7.

512.3.5 Additives

Chemical additives may be used to accelerate or retard the break-set time of the slurry or to improve the resulting surface finish. The quantity of additive, if used, shall be decided by mix design and to be adjusted as per the site/climate conditions. The specifications for additive shall be supplied by the supplier of the emulsion. The additive and emulsion shall be compatible with each other.

512.4 Mix Design

The compatibility of aggregate, emulsion, filler and additive(if needed) shall be verified by mix design for a selected type and grading of aggregate as specified in Tables 500-27 and 500-28. the design criteria for slurry seal mixture is specified in Table 500-29. The proposed slurry seal mix shall conform to the specified requirements, when tested in accordance with tests specified in Table 500-30. The mix design report shall clearly show the proportions of aggregate, filler, water and residual bitumen content based on the dry weight of the aggregates, additive usage (if any).

Table 500-29: Design Criteria for Slurry Seal Mixture

Property	Requirement
Slurry Seal Mixture	Shall be designed to meet the requirements of Table 500-29.
Aggregate	Shall be designed to meet the requirements of Table 500-27 and 500-28.
Emulsion	Shall be designed to meet the requirements of Table 500-29.
Water	Shall be designed to meet the requirements of Table 500-29.
Additive	Shall be designed to meet the requirements of Table 500-29.
Residual Bitumen Content	Shall be designed to meet the requirements of Table 500-29.

Aggregate, bitumen emulsion, water and additive including set control additive (if needed), shall be proportioned by weight utilizing the mix design approved by the Engineer. The final mixture, after addition of water and additive (if used) shall be such that the slurry seal mixture has proper workability and permit traffic within four hours (without leading to ravelling after placement). Trial mix shall be prepared and laid at site for the designed mix and observed for breaking and setting time. Indicative limits of various ingredients for job mix of slurry seal shall be as given in Table 500-30.



512.5 Construction

512.5.1 Weather and Seasonal Limitations

Laying of slurry seal shall not be undertaken, if either the pavement temperature or air temperature is below 10°C. However during a dry spell, slurry seal may be laid in rainy season also, even if the surface is wet but there is no stagnant water on the pavement surface.

512.5.2 Surface Preparation

The underlying surface on which the slurry seal is to be applied shall be cleaned of all loose material, mud spots, vegetation and extraneous matter and shall be prepared and shaped to the needed profile. It is essential to pre-treat cracks on the pavement surface with an appropriate crack sealing material prior to application of slurry seal, if it is used for preventive/ renewal treatment. The surface should be swept clean by removing caked earth and other foreign matter with wire brushes, sweeping with mechanical brooms and finally dusting with air jet or other means approved by the Engineer

512.5.3 Application of Tack Coat

Tack coat is not required normally for flexible pavements, unless surface is extremely hungry and dry. In case it is needed, Clause 503 shall apply..

512.5.4 Machine

The machine shall be specially designed and manufactured to lay slurry seal. It shall be self propelled equipment, truck mounted, consisting of following sub-assemblies used to manufacture and simultaneously spread these mixes on the surface:

- i. Aggregate bin.
- ii. Filler Bin
- iii. Water and Emulsion Tanks.
- iv. Additive Tanks.
- v. Aggregates and filler conveyors to supply the mixer box.
- vi. Pump or compressed air system to supply the emulsion/water.
- vii. Mixer Box.

- viii. Spreader box to place the mixed slurry on the job.

512.5.5 Calibration of Machine

Slurry seal laying machine shall be calibrated for flow of all the constituents as per the job mix in presence of Engineer. No machine shall be allowed to work on the project until the calibration has been completed and accepted by the engineer. 2 kg samples of slurry seal mix will be taken and verified for proportioning and mix consistency. The verification for application rate shall also be carried out in presence of the Engineer. The procedure for calibration and verification is as given in Appendix 7 of IRC:SP:81.

512.5.6 Application of Slurry Seal

A calibrated slurry seal machine, as per requirements of job mix, shall be used to spread the material. The surface shall be pre-wetted by fogging ahead of the spreader box (if required under hot weather conditions). The rate of application shall be adjusted during the day to suit temperature, surface texture and humidity. The mixture shall be agitated and mixed uniformly in the spreader box by means of twin shafted paddles or spiral augurs fixed in spreader box. A front seal shall be provided to ensure no loss of the mixture at the road contact point. The rear seal shall act as final strike off and shall be adjustable. The spreader box and rear strike off shall be so designed and operated that a uniform consistency is achieved to produce free flow of material to the rear strike off. A secondary strike off shall have the same adjustment as the spreader box. The spreader box shall have the suitable means provided to side shift the box to compensate for variation in pavement geometry. Sufficient amount of material shall be carried in all parts of spreader box at all times so that a complete coverage is obtained. Overloading of the spreader box shall be avoided. No lumping, balling and unmixed aggregates shall be permitted. No streak, caused by oversized aggregates shall be left on the finished surface. Longitudinal joints shall correspond with the edges of existing traffic lanes. Other patterns of longitudinal joints may be permitted, if pattern will not adversely affect the quality of finished surface. In case streak is formed, it shall be corrected immediately by fresh material and with use of squeeze. Longitudinal joints, common to two traffic lanes shall be butt joints with overlap not exceeding an average of 60-100 mm. The mixture shall be uniform and homogeneous after spreading on existing surfaces and shall not show separation of the emulsion and aggregates after setting.

512.5.7 Rate of Application

The rate of application shall be as per Table 500-26 (by weight of dry aggregates).

512.5.8 Rolling

Generally rolling is not required. Where rolling is felt necessary due to inadequate cohesion, a pneumatic tyred roller having individual wheel load between 0.75 to 1.5 tonne shall be used. Rolling shall commence as soon as the slurry has set.

512.6 Surface Finish and Quality Control

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials and work carried out, relevant provision of Section 900 shall apply.

512.7 Opening to Traffic

Surface shall be opened to traffic after slurry is in a completely set condition. The maximum setting time shall be 4 hours. Speed of traffic shall be restricted to 20 km per hour for next 12 hours.

512.8 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

512.9 Measurement for Payment

Slurry seal shall be measured as finished work as specified, in square metres.

512.10 Rate

The contract unit rate for slurry seal shall be payment in full for carrying out the required operations including full compensation for the specified rate of application of the mix and the quantity of residual binder. The variation in rates of actual application shall be suitably adjusted plus or minus as provided in the Contract. The contract unit rate shall cover all operations listed in Clause 501.8.8.2.

513 FOG SPRAY

513.1 Scope

The work covers a very light application of low viscosity bitumen emulsion for purposes of sealing cracks less than 3 mm wide or incipient fretting or disintegration in an existing bituminous surfacing, and to help reduce loosening of chips by traffic on newly finished surface dressing.

513.2 Material

The bitumen emulsion shall be as specified in the Contract or as instructed by the Engineer. The emulsion shall be SS-I complying with the requirements of IS:8887.

513.3 Weather and Seasonal Limitations

Spraying shall not take place when the temperature is below 10°C, nor in windy or dusty conditions, nor when it is raining or the surface to be sprayed is wet (a damp surface is acceptable but refer to Clause 513.4.2.)

513.4 Construction Operations

513.4.1 Equipment

The fog spray shall be applied by means of a self-propelled or towed bitumen pressure sprayer complying with the requirements of the Manual for Construction and Supervision of Bituminous Works. The spray bar should be protected from gusts of wind by means of a hood.

513.4.2 Preparation of Surface

The surface on which the fog spray is to be applied shall be thoroughly cleaned with compressed air, scrubbers etc. The cracks shall be cleaned with a pressure air jet to remove all dirt, dust etc.

513.4.3 Application

The fog seal shall be applied at a rate of 0.5-1.0 litres/m², using equipment such as pressure tank, flexible hose and spray bar or lance.

513.5 Blinding

If specified in the Contract or ordered by the Engineer, the fog spray shall be blinded with graded grit of 3 mm size and under, coated with about 2 percent of the emulsion by weight. The pre coated grit shall be allowed to be cured for at least one week or until they become non-sticky and can be spread easily.

513.6 Quality Control of Work

For control of quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

513.7 Arrangements for Traffic

During the spraying operations, arrangements for traffic shall be made in accordance with Clause 112. The surface should not be opened to traffic for 24 hours after does occur a light blinding of crusher dust or sand should be applied.

513.8 Measurement of Payment

Fog spray and blinding (if used) shall be measured in terms of surface area of application, for in square metres.

513.9 Rate

The contract unit rate for fog spray and blinding (if used) shall be payment in full for required operations including full compensation for all components listed in Clause 501.8.8.2 (i) to (xi) as applicable to the work specified in these Specifications.

514 MICRO-SURFACING

514.1 Scope

The work shall consist of design, testing and construction of micro-surfacing composed of modified bitumen emulsion, mineral aggregate, water and necessary additives (if needed), proportioned, mixed and uniformly spread over a properly prepared surface for surface treatment of pavements in accordance with these Specifications.

514.2 Type of Mirco-Surfacing

Micro-surfacing is applied on an existing pavement surface which is structurally sound but the surface shows signs of premature ageing, aggregate loss, cracking, high degree of polishing etc, It may be used as surface sealing treatment to improve skid resistance, surface fine and medium cracks and for preventive maintenance and periodic on low and medium traffic roads. Types of micro-surfacing and rates of in Table 500-31.

Table 500-31 : Types of Micro-Surfacing and Rate of Application

Sl. No.	Description of Work	Unit	Rate (Rs./sq.m)
1	Micro-surfacing on existing pavement surface	Sq.m	1500
2	Micro-surfacing on new pavement surface	Sq.m	1800

514.3 Material

514.3.1 Binder

The bitumen emulsion shall be a modified bitumen emulsion conforming to requirements specified in Table 500-32. The modifier shall be polymer/rubber, preferably synthetic or natural rubber latex.

Table 500-32: Requirement of Modified Bitumen Emulsion for Micro-Surfacing

Sl. No.	Requirement	Unit	Rate (Rs./kg)
1	Modified Bitumen Emulsion	kg	120
2	Mineral Aggregate	kg	100
3	Water	kg	50
4	Additives	kg	10

514.3.2 Aggregates

As per Clause 512.3.2 (Type II and Type Grading, Table 500-27).

514.3.3 Filler

As per Clause 512.3.3.

514.3.4 Water

As per Clause 512.3.4.

514.3.5 Additives

As per Clause 512.3.5.

514.4 Design and Proportioning of Micro-Surfacing Mix

514.4.1 The design criteria for micro-surfacing mixture is specified in Table 500-33. The mix design report shall clearly show the proportions of aggregate, filler, water and residual bitumen content based on the dry weight of aggregates and additives used (if any). The set time shall be determined by the method given in Appendix-2 of IRC:SP:81.

Table 500-33 : Mix Design Criteria for Micro-Surfacing Mix

Designation of Mix	Designation of Mix	Designation of Mix
1. Bitumen Content (%)	2. Water Content (%)	3. Residual Bitumen Content (%)
4. Aggregate Content (%)	5. Filler Content (%)	6. Additive Content (%)
7. Set Time (min)	8. Wet Track Abrasion (mm)	9. Bleeding (mm)
10. Shrinkage (%)	11. Density (kg/m³)	12. Bulk Density (kg/m³)
13. Voids in Aggregate (%)	14. Voids in Filler (%)	15. Voids in Mix (%)
16. Air Content (%)	17. Water Absorption (%)	18. Solubility (%)
19. Hardness (N/mm²)	20. Modulus of Elasticity (N/mm²)	21. Poisson's Ratio
22. Tensile Strength (N/mm²)	23. Compressive Strength (N/mm²)	24. Flexural Strength (N/mm²)
25. Impact Resistance (J/m²)	26. Fatigue Life (cycles)	27. Creep Resistance (%)
28. Thermal Stability (%)	29. Oxidation Resistance (%)	30. Aging Resistance (%)
31. Resistance to Water Damage (%)	32. Resistance to Salt Crystallization (%)	33. Resistance to Acid Attack (%)
34. Resistance to Fuel Spills (%)	35. Resistance to Oil Spills (%)	36. Resistance to Deicing Salts (%)
37. Resistance to Abrasion (%)	38. Resistance to Scuffing (%)	39. Resistance to Skidding (%)
40. Resistance to Raveling (%)	41. Resistance to Bleeding (%)	42. Resistance to Staining (%)
43. Resistance to Discoloration (%)	44. Resistance to Cracking (%)	45. Resistance to Spalling (%)
46. Resistance to Delamination (%)	47. Resistance to Frost Damage (%)	48. Resistance to Freeze-Thaw Cycles (%)
49. Resistance to Chloride Ion Penetration (%)	50. Resistance to Sulfate Ion Penetration (%)	51. Resistance to Acid Rain (%)
52. Resistance to Air Pollution (%)	53. Resistance to Noise Reduction (%)	54. Resistance to Heat Reflection (%)
55. Resistance to UV Radiation (%)	56. Resistance to Microbial Growth (%)	57. Resistance to Insect Damage (%)
58. Resistance to Rodent Damage (%)	59. Resistance to Fire Retardancy (%)	60. Resistance to Smoke Development (%)
61. Resistance to Flammability (%)	62. Resistance to Ignition (%)	63. Resistance to Self-Healing (%)
64. Resistance to Healing (%)	65. Resistance to Repairability (%)	66. Resistance to Maintenance (%)
67. Resistance to Longevity (%)	68. Resistance to Sustainability (%)	69. Resistance to Environmental Impact (%)
70. Resistance to Social Acceptance (%)	71. Resistance to Cultural Heritage (%)	72. Resistance to Historical Preservation (%)
73. Resistance to Archaeological Excavation (%)	74. Resistance to Paleontological Research (%)	75. Resistance to Geological Studies (%)
76. Resistance to Anthropological Research (%)	77. Resistance to Linguistic Studies (%)	78. Resistance to Ethnographic Research (%)
79. Resistance to Historical Linguistics (%)	80. Resistance to Archaeological Linguistics (%)	81. Resistance to Paleontological Linguistics (%)
82. Resistance to Geological Linguistics (%)	83. Resistance to Anthropological Linguistics (%)	84. Resistance to Linguistic Linguistics (%)
85. Resistance to Ethnographic Linguistics (%)	86. Resistance to Historical Linguistics (%)	87. Resistance to Archaeological Linguistics (%)
88. Resistance to Paleontological Linguistics (%)	89. Resistance to Geological Linguistics (%)	90. Resistance to Anthropological Linguistics (%)
91. Resistance to Linguistic Linguistics (%)	92. Resistance to Ethnographic Linguistics (%)	93. Resistance to Historical Linguistics (%)
94. Resistance to Archaeological Linguistics (%)	95. Resistance to Paleontological Linguistics (%)	96. Resistance to Geological Linguistics (%)
97. Resistance to Anthropological Linguistics (%)	98. Resistance to Linguistic Linguistics (%)	99. Resistance to Ethnographic Linguistics (%)
100. Resistance to Historical Linguistics (%)	101. Resistance to Archaeological Linguistics (%)	102. Resistance to Paleontological Linguistics (%)
103. Resistance to Geological Linguistics (%)	104. Resistance to Anthropological Linguistics (%)	105. Resistance to Linguistic Linguistics (%)
106. Resistance to Ethnographic Linguistics (%)	107. Resistance to Historical Linguistics (%)	108. Resistance to Archaeological Linguistics (%)
109. Resistance to Paleontological Linguistics (%)	110. Resistance to Geological Linguistics (%)	111. Resistance to Anthropological Linguistics (%)
112. Resistance to Linguistic Linguistics (%)	113. Resistance to Ethnographic Linguistics (%)	114. Resistance to Historical Linguistics (%)
115. Resistance to Archaeological Linguistics (%)	116. Resistance to Paleontological Linguistics (%)	117. Resistance to Geological Linguistics (%)
118. Resistance to Anthropological Linguistics (%)	119. Resistance to Linguistic Linguistics (%)	120. Resistance to Ethnographic Linguistics (%)
121. Resistance to Historical Linguistics (%)	122. Resistance to Archaeological Linguistics (%)	123. Resistance to Paleontological Linguistics (%)
124. Resistance to Geological Linguistics (%)	125. Resistance to Anthropological Linguistics (%)	126. Resistance to Linguistic Linguistics (%)
127. Resistance to Ethnographic Linguistics (%)	128. Resistance to Historical Linguistics (%)	129. Resistance to Archaeological Linguistics (%)
130. Resistance to Paleontological Linguistics (%)	131. Resistance to Geological Linguistics (%)	132. Resistance to Anthropological Linguistics (%)
133. Resistance to Linguistic Linguistics (%)	134. Resistance to Ethnographic Linguistics (%)	135. Resistance to Historical Linguistics (%)
136. Resistance to Archaeological Linguistics (%)	137. Resistance to Paleontological Linguistics (%)	138. Resistance to Geological Linguistics (%)
139. Resistance to Anthropological Linguistics (%)	140. Resistance to Linguistic Linguistics (%)	141. Resistance to Ethnographic Linguistics (%)
142. Resistance to Historical Linguistics (%)	143. Resistance to Archaeological Linguistics (%)	144. Resistance to Paleontological Linguistics (%)
145. Resistance to Geological Linguistics (%)	146. Resistance to Anthropological Linguistics (%)	147. Resistance to Linguistic Linguistics (%)
148. Resistance to Ethnographic Linguistics (%)	149. Resistance to Historical Linguistics (%)	150. Resistance to Archaeological Linguistics (%)
151. Resistance to Paleontological Linguistics (%)	152. Resistance to Geological Linguistics (%)	153. Resistance to Anthropological Linguistics (%)
154. Resistance to Linguistic Linguistics (%)	155. Resistance to Ethnographic Linguistics (%)	156. Resistance to Historical Linguistics (%)
157. Resistance to Archaeological Linguistics (%)	158. Resistance to Paleontological Linguistics (%)	159. Resistance to Geological Linguistics (%)
160. Resistance to Anthropological Linguistics (%)	161. Resistance to Linguistic Linguistics (%)	162. Resistance to Ethnographic Linguistics (%)
163. Resistance to Historical Linguistics (%)	164. Resistance to Archaeological Linguistics (%)	165. Resistance to Paleontological Linguistics (%)
166. Resistance to Geological Linguistics (%)	167. Resistance to Anthropological Linguistics (%)	168. Resistance to Linguistic Linguistics (%)
169. Resistance to Ethnographic Linguistics (%)	170. Resistance to Historical Linguistics (%)	171. Resistance to Archaeological Linguistics (%)
172. Resistance to Paleontological Linguistics (%)	173. Resistance to Geological Linguistics (%)	174. Resistance to Anthropological Linguistics (%)
175. Resistance to Linguistic Linguistics (%)	176. Resistance to Ethnographic Linguistics (%)	177. Resistance to Historical Linguistics (%)
178. Resistance to Archaeological Linguistics (%)	179. Resistance to Paleontological Linguistics (%)	180. Resistance to Geological Linguistics (%)
181. Resistance to Anthropological Linguistics (%)	182. Resistance to Linguistic Linguistics (%)	183. Resistance to Ethnographic Linguistics (%)
184. Resistance to Historical Linguistics (%)	185. Resistance to Archaeological Linguistics (%)	186. Resistance to Paleontological Linguistics (%)
187. Resistance to Geological Linguistics (%)	188. Resistance to Anthropological Linguistics (%)	189. Resistance to Linguistic Linguistics (%)
190. Resistance to Ethnographic Linguistics (%)	191. Resistance to Historical Linguistics (%)	192. Resistance to Archaeological Linguistics (%)
193. Resistance to Paleontological Linguistics (%)	194. Resistance to Geological Linguistics (%)	195. Resistance to Anthropological Linguistics (%)
196. Resistance to Linguistic Linguistics (%)	197. Resistance to Ethnographic Linguistics (%)	198. Resistance to Historical Linguistics (%)
199. Resistance to Archaeological Linguistics (%)	200. Resistance to Paleontological Linguistics (%)	201. Resistance to Geological Linguistics (%)
202. Resistance to Anthropological Linguistics (%)	203. Resistance to Linguistic Linguistics (%)	204. Resistance to Ethnographic Linguistics (%)
205. Resistance to Historical Linguistics (%)	206. Resistance to Archaeological Linguistics (%)	207. Resistance to Paleontological Linguistics (%)
208. Resistance to Geological Linguistics (%)	209. Resistance to Anthropological Linguistics (%)	210. Resistance to Linguistic Linguistics (%)
211. Resistance to Ethnographic Linguistics (%)	212. Resistance to Historical Linguistics (%)	213. Resistance to Archaeological Linguistics (%)
214. Resistance to Paleontological Linguistics (%)	215. Resistance to Geological Linguistics (%)	216. Resistance to Anthropological Linguistics (%)
217. Resistance to Linguistic Linguistics (%)	218. Resistance to Ethnographic Linguistics (%)	219. Resistance to Historical Linguistics (%)
220. Resistance to Archaeological Linguistics (%)	221. Resistance to Paleontological Linguistics (%)	222. Resistance to Geological Linguistics (%)
223. Resistance to Anthropological Linguistics (%)	224. Resistance to Linguistic Linguistics (%)	225. Resistance to Ethnographic Linguistics (%)
226. Resistance to Historical Linguistics (%)	227. Resistance to Archaeological Linguistics (%)	228. Resistance to Paleontological Linguistics (%)
229. Resistance to Geological Linguistics (%)	230. Resistance to Anthropological Linguistics (%)	231. Resistance to Linguistic Linguistics (%)
232. Resistance to Ethnographic Linguistics (%)	233. Resistance to Historical Linguistics (%)	234. Resistance to Archaeological Linguistics (%)
235. Resistance to Paleontological Linguistics (%)	236. Resistance to Geological Linguistics (%)	237. Resistance to Anthropological Linguistics (%)
238. Resistance to Linguistic Linguistics (%)	239. Resistance to Ethnographic Linguistics (%)	240. Resistance to Historical Linguistics (%)
241. Resistance to Archaeological Linguistics (%)	242. Resistance to Paleontological Linguistics (%)	243. Resistance to Geological Linguistics (%)
244. Resistance to Anthropological Linguistics (%)	245. Resistance to Linguistic Linguistics (%)	246. Resistance to Ethnographic Linguistics (%)
247. Resistance to Historical Linguistics (%)	248. Resistance to Archaeological Linguistics (%)	249. Resistance to Paleontological Linguistics (%)
250. Resistance to Geological Linguistics (%)	251. Resistance to Anthropological Linguistics (%)	252. Resistance to Linguistic Linguistics (%)
253. Resistance to Ethnographic Linguistics (%)	254. Resistance to Historical Linguistics (%)	255. Resistance to Archaeological Linguistics (%)
256. Resistance to Paleontological Linguistics (%)	257. Resistance to Geological Linguistics (%)	258. Resistance to Anthropological Linguistics (%)
259. Resistance to Linguistic Linguistics (%)	260. Resistance to Ethnographic Linguistics (%)	261. Resistance to Historical Linguistics (%)
262. Resistance to Archaeological Linguistics (%)	263. Resistance to Paleontological Linguistics (%)	264. Resistance to Geological Linguistics (%)
265. Resistance to Anthropological Linguistics (%)	266. Resistance to Linguistic Linguistics (%)	267. Resistance to Ethnographic Linguistics (%)
268. Resistance to Historical Linguistics (%)	269. Resistance to Archaeological Linguistics (%)	270. Resistance to Paleontological Linguistics (%)
271. Resistance to Geological Linguistics (%)	272. Resistance to Anthropological Linguistics (%)	273. Resistance to Linguistic Linguistics (%)
274. Resistance to Ethnographic Linguistics (%)	275. Resistance to Historical Linguistics (%)	276. Resistance to Archaeological Linguistics (%)
277. Resistance to Paleontological Linguistics (%)	278. Resistance to Geological Linguistics (%)	279. Resistance to Anthropological Linguistics (%)
280. Resistance to Linguistic Linguistics (%)	281. Resistance to Ethnographic Linguistics (%)	282. Resistance to Historical Linguistics (%)
283. Resistance to Archaeological Linguistics (%)	284. Resistance to Paleontological Linguistics (%)	285. Resistance to Geological Linguistics (%)
286. Resistance to Anthropological Linguistics (%)	287. Resistance to Linguistic Linguistics (%)	288. Resistance to Ethnographic Linguistics (%)
289. Resistance to Historical Linguistics (%)	290. Resistance to Archaeological Linguistics (%)	291. Resistance to Paleontological Linguistics (%)
292. Resistance to Geological Linguistics (%)	293. Resistance to Anthropological Linguistics (%)	294. Resistance to Linguistic Linguistics (%)
295. Resistance to Ethnographic Linguistics (%)	296. Resistance to Historical Linguistics (%)	297. Resistance to Archaeological Linguistics (%)
298. Resistance to Paleontological Linguistics (%)	299. Resistance to Geological Linguistics (%)	300. Resistance to Anthropological Linguistics (%)

514.4.2 Aggregate, modified bitumen emulsion, water and additive (if used), shall be proportioned by weight of aggregate utilizing the mix design approved by the Engineer. If more than one type of aggregates is used, the correct amount of each type of aggregate used to produce the required grading shall be proportioned separately prior to adding other materials of the mixture, in a manner that will result in a uniform and homogenous blend. of Final completed mixture, after addition of water and any additive, if used shall be such that the micro-surfacing mixture has proper workability and permit traffic within a short period depending upon the weather conditions without occurrence of raveling and bleeding. Trial mixes shall be prepared and laid for the designed mix and observed for breaking time and setting time. The wet track abrasion test is used to determine the

minimum residual bitumen . content. Indicative limits of various ingredients for job mix of micro-surfacing shall be as given in Table 500-34.

Table 500-34 : Indicative ingredients in mix

Sl. No.	Ingredients	Indicative Limits (%)
1	Bitumen	5.0 to 6.0
2	Filler	1.0 to 2.0
3	Gravel	85.0 to 93.0

514.5 Construction

As per Clause 512.5.

514.5.1 Weather and Seasonal Limitations

As per Clause 512.5.1.

514.5.2 Surface Preparation

As per Clause 512.5.2.

514.5.3 Application of Tack Coat

As per Clause 512.5.3.

514.5.4 Machine

As per Clause 512.5.4.

514.5.5 Calibration of Machine

As per Clause 512.5.5.

514.5.6 Application of Micro-Surfacing

A calibrated micro-surfacing machine as per requirements of job mix shall be used to spread the material. The surface shall be pre-wetted (if required under extreme hot weather conditions) by spraying water ahead of the spreader box. The rate of application of spray shall be adjusted during the day to suit temperature, surface texture and humidity. The application of micro-surfacing shall be as per Clause 512.5.6.

514.5.7 Rate of Application

The micro-surfacing mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition. The quantities of micro-surfacing mix (by weight of dry aggregate) to be used shall be as given in Table 500-31.

514.5.8 Rolling

As per Clause 512.5.8.

514.5.9 Quality Control and Surface Finish

finish of construction shall conform to the requirements of Clause 902. For quality of materials and work carried out, relevant provision of Section 900

514.6 Control of Traffic

Micro-surfacing mix requires -about 2 hours to set. Traffic may be opened only after 2 hours restricting the speed to 20 km/h till 12 hours thereafter.

514.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

514.8 Measurement for Payment

Micro-surfacing shall be measured as finished work as specified, in square metres.

514.9 Rate

The contract unit rate for micro-surfacing shall be payment in full for carrying out the required operations including full compensation for the specified rate of application of the mix and the quantity of residual binder. The variation in rates of actual application shall be suitably adjusted plus or minus as provided in the Contract. The contract unit rate shall include full compensation for all operations listed in Clause 501.8.8.2.

515 STONE MATRIX ASPHALT (SMA)

515.1 Scope

This work shall consist of construction in a single or multiple layer of fibre-stabilized SMA for all use as wearing course/ binder course on a previously prepared bituminous bound surface. The 13 mm SMA in this Specification shall be used for wearing course with nominal layer thickness of 40 to 50 mm. The 19 mm SMA shall be used for binder (or intermediate) course with nominal layer thickness of 45 to 75 mm.

515.2 Materials

515.2.1 Bitumen

The bitumen for fibre-stabilized SMA shall be viscosity grade paving bitumen conforming to Indian Standard Specification IS:73 or Modified Bitumen complying with IS: 15462 and TRC: SP:53 of appropriate type and grade capable of yielding the design mix requirements, and as per Table 500-2.

515.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed rock retained on 2.36 mm sieve. It shall be clean, hard, durable, of cubical shape and free from dust and soft organic and

Table 500-35: Physical Requirements for Coarse Aggregates for Stone Matrix Asphalt

515.2.3 Fine Aggregates

515.2.4 Mineral Filler

Table 500-36 : Grading Requirement of Mineral Filler

The filler shall be inert material free from organic impurities and shall have plasticity index not greater than 4. Plasticity index requirement will not apply if filler is hydrated lime. Where

the complete SMA mixture fails to satisfy the requirement of Moisture Susceptibility Test (AASHTO T 283), at least 2 percent by total weight of aggregate of hydrated lime shall be used as filler and the percentage of fine aggregate reduced accordingly.

515.2.5 Stabilizer Additive

Only pelletized cellulose fibres shall be utilized. The dosage rate for cellulose fibres is 0.3 percent minimum by weight (on loose fibre basis) of the total mix. The dosage rate shall be confirmed so that the bitumen draindown does not exceed 0.3 percent when the designed mix is tested in accordance with ASTM D 6390.

515.2.6 The cellulose fibres to be used in pellets shall meet the following requirements:

Maximum fibre length	-	8 mm
Ash content	-	maximum of 20 percent nonvolatile
Oil absorption	-	more than 4 times of the fibre weight
Moisture content	-	less than 5 percent by weight

When the Contractor submits the proposed job-mix formula for SMA for approval, it shall include the fibre manufacturer's most recently dated actual test data showing that the fibres meet the above requirements. The contractor shall protect the cellulose from moisture and contamination prior to incorporating it into the SMA.

515.3 SMA Mix Design

515.3.1 The combined grading of the coarse aggregate, fine aggregate and mineral filler (including hydrated lime if used) shall be within the limits shown in Table 500-37.

[illegible]

515.4 SMA Production

The SMA mix shall be prepared in a hot mix plant of adequate capacity and capable of yielding a mix of proper and uniform quality with thoroughly coated aggregate.

When viscosity grade bitumen is used, the mix temperature shall range from 150°C to 165°C. In case of modified bitumen, the temperature of mixing and compaction shall be higher than the mix with viscosity grade bitumen. The exact temperature depends upon the type and amount of modifier used and shall be adopted as per the recommendations of the manufacturer. In order to ensure uniform quality of mix, the plant shall be calibrated from time to time.

515.4.2 Handling Mineral Filler

Adequate dry storage will be provided for the mineral filler and provisions shall be made for proportioning the filler into the mixture uniformly and in the desired quantities. This is necessary because relatively large amounts of mineral filler are required in SMA mixes.

515.4.3 Fibre Additive

For batch plant, the fibre will be added directly into the weigh hopper above the pugmill. Adequate dry mixing time is required to disperse the fiber uniformly throughout the hot aggregate. Dry mixing time will be increased by 5 to 10 seconds. Wet mixing time shall be increased by at least 5 seconds. For drum mix plant, a separate fibre feeding system shall be utilized that can accurately and uniformly introduce fibre into the drum at such a rate as not to limit the normal production of mix through the drum. At no time shall there be any evidence of fibre in the baghouse/wasted baghouse fines

515.5 SMA Placement and Compaction

515.5.1 Preparation of Existing Bituminous Surface

The existing bituminous surface shall be cleaned of all loose extraneous matter by means Of mechanical broom and high-pressure air jet from compressor or any other approved equipment method. Any potholes and/or cracks shall be repaired and sealed.

515.5.2 Tack Coat

Clause 503 shall apply.

515.5.3 Transportation

Clause 501.4 shall apply.

515.5.4 Laying

515.5.4.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

515.5.4.2 Spreading

Clause 501.5.3 shall apply.

515.5.5 Compaction

Clause 501.6. shall apply, except that the use of pneumatic roller shall not be permitted if there is a possibility of pick-up.

The density of the finished paving layer shall be determined by taking 150 mm diameter cores. The density of finished paving layer shall not be less than 94 percent of the average (sample size N=2) theoretical maximum specific gravity of the loose mix (G) obtained on that day in accordance with ASTM D2041. That is, no more than 6 percent air voids shall be allowed in the compacted SMA mat.

515.5.6 Joints

Clause 501.7 shall apply.

515.6 Quality Control and Surface Finish

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials supplied and work carried out, relevant portion of Section 900 shall apply.

515.7 Control of Traffic

It shall be ensured that traffic is not allowed on the SMA surface until the paved mat has cooled to ambient temperature in its entire depth.

515.8 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

515.9 Measurement for Payment

SMA shall be measured as finished work in sq.m at this specified thickness or in cu.m as specified in the Contract.

515.10 Rate

The contract unit rate for SMA shall be payment in full for carrying out the required operations . including full compensation for all components listed in Clause 501.8.8.2.

516 MASTIC ASPHALT

516.1 Scope

This work shall consist of constructing a single layer of mastic asphalt wearing course for road pavements and bridge decks.

Mastic asphalt is an intimate homogenous mixture of selected well-graded aggregates, filler and bitumen in such proportions as to yield a plastic and void less mass, which when applied ter hot can be trowelled and floated to form a very dense impermeable surfacing.

516.2 Materials

516.2.1 Binder

Subject to the approval of the Engineer, the binder shall be a paving/ Industrial grade bitumen meeting the requirements given in Table 500-39.

Table 500-39 : Requirements for Physical Properties of Binder

Property	Requirement	Test Method
Penetration at 25°C	60-80	IP 35
Softening Point	48-54	IP 34
Flash Point	Not less than 260°C	IP 39
Viscosity at 135°C	0.17-0.28 Pa.s	IP 350
Residue after 5% Solvent Extraction	Not less than 98%	IP 35

516.2.2 Coarse Aggregates

The coarse aggregates shall consist of crushed stone, crushed gravel/shingle or other stones. They shall be clean, hard, durable, of fairly cubical shape, uncoated and free from soft, organic or other deleterious substances. They shall satisfy the physical requirements given in Table 500-6.

The percentage and grading of the coarse aggregates to be incorporated in the mastic . asphalt depending upon the thickness of the finished course should be as specified in Table 500-40.

Table 500-40 : Grade and Thickness of Mastic Asphalt Paving and Grading of Coarse Aggregates

Grade	Thickness of Course (mm)	Coarse Aggregate (mm)	Fine Aggregate (mm)
Super Course	25-30	10-15	0-75
Base Course	30-40	15-20	0-75
Sub-base Course	40-50	20-25	0-75
Grading	50-60	25-30	0-75

Fine Aggregates : The fine aggregates shall be the fraction passing the 2.36 mm and retained on the 0.075 mm sieve consisting of crusher run screening, natural sand or a mixture of both. These shall be clean, hard, durable, uncoated, dry, and free from soft or flaky pieces and organic or other deleterious substances.

Filler : The filler shall be limestone powder passing the 0.075 mm sieve and shall have a calcium carbonate content of not less than 80 percent by weight when determined in accordance with IS: 1514.

The grading of the fine aggregate inclusive of filler shall be as given in Table 500-41.

Table 500-41 : Grading of Fine Aggregate (Inclusive of Filler)

sieve size	Percentage passing
75 microns	100
150 microns	100
300 microns	100
475 microns	100

516.3 Mix Design

516.3.1 Hardness Number

The mastic asphalt shall have a hardness number at the time of manufacture of 50 to 70 at prior to the addition of coarse aggregate and 10 to 20 at 250C at the time of laying after addition of coarse aggregate.

The hardness number shall be determined in accordance with the method specified in IS:1195-1978.

516.3.2 Binder Content

The binder content shall be so fixed as to achieve the requirements of the mix specified in Clause 516.3.1 and shall be in the range of 14 to 17 percent by weight of total mix as indicated in Table 500-42.

Table 500-42 : Composition of Mastic Asphalt Blocks without Coarse Aggregate

Property	Requirement
Hardness Number	50 to 70
Softening Point	10 to 20
Penetration	10 to 20
Viscosity	10 to 20

516.3.3 Job Mix Formula

The Contractor shall submit to the Engineer for approval at least one month before the start of the work the job mix formula proposed to be used by him for the work, indicating the source and location of all materials, proportions of all materials such as binder and aggregates, single definite percentage passing each sieve for the mixed aggregate and results of the tests recommended in the various Tables and Clauses of this Specification.

516.4 Construction Operations

516.4.1 Weather and Seasonal Limitations

The provisions of Clause 501.5.1 shall apply, except that laying shall not be carried out when the air temperature at the surface on which the Mastic Asphalt is to be laid is below 100 C.

516.4.2 Preparation of the Base

The base on which mastic asphalt is to be laid shall be prepared, shaped and conditioned to the profile required, in accordance with Clause 501 or 902 as appropriate or as directed by the Engineer. In the case of a cement concrete base, the surface shall be thoroughly power brushed clean and free of dust and other deleterious matter. Under no circumstances shall mastic asphalt be spread on a base containing a binder which might soften under high application temperatures. If such material exists, the same shall be cut out and repaired before the mastic asphalt is laid.

516.4.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied on the base or as directed by the Engineer.

516.4.4 Preparation of Mastic Asphalt

Preparation of mastic asphalt consists of two stages. The first stage shall be mixing of filler and fine aggregates and then heating the mixture to a temperature of 170 O C to 210 O C. Required quantity of bitumen shall be heated to 170 O C to 180 O C and added to the heated aggregated. They shall be mixed and cooked in an approved type of mechanically agitated mastic cooker for some time till the materials are thoroughly mixed. Initially the filler alone is to be heated in the cooker for an hour and then half the quantity of binder is added. After heating and mixing for some time, the fine aggregates and the balance of binder are to be added and further cooked for about one hour. The second stage is incorporation of coarse aggregates and cooking the mixtures for a total period of 3 hours. During cooking and mixing care shall be taken to ensure that the contents in the cooker are at no time heated to a temperature exceeding 210oc

Where the material is not required for immediate use it shall be cast into blocks consisting of filler, fine aggregates and binder, but without the addition of coarse aggregate, weighing about 25 kg each. Before use, these blocks shall be reheated to a temperature of not less than 175O C and not more than 210O C, thoroughly incorporated with the requisite

quantity of coarse aggregates and mixed continuously. Mixing shall be continued until laying operations are completed so as to maintain the coarse aggregates in suspension. At no stage during the process of mixing shall the temperature exceed 210°C.

The mastic asphalt blocks (without coarse aggregate) shall show on analysis a composition within the limits as given in Table 500-42.

The mix shall be transported to the laying site in a towed mixer transporter having arrangements for stirring and keeping the mix hot during transportation.

516.4.5 Spreading

The mastic asphalt shall be laid, normally in one coat, at a temperature between 175°C and spread uniformly by hand using wooden floats or by machine on the prepared thickness of the mastic asphalt and the percentage of added coarse aggregate accordance with Table 500-40 or as specified by the Engineer. Where necessary, of the requisite dimensions should be employed. Any blow holes that appear in the shall be punctured while the material is hot, and the surface made good by further floating.

Laying surface over existing bridge deck : Before laying bitumen over existing bridge the existing cross fall/camber, expansion joint members and water drainage spouts shall be carefully examined for their proper functioning in the bridge deck structure and any deficiency found shall be removed. Loose elements in the expansion joint shall be firmly existing wearing coat shall be removed, as per Clause 2809. The cracks in the surface, if any, shall be repaired and filled up properly or replaced by new concrete grade before laying the bitumen mastic over bridge deck.

Laying over new bridge deck : New concrete bridge deck which is not in camber/cross fall shall first be provided with required camber and cross fall by suitable concrete or bituminous treatment.

Treatment where mastic asphalt is laid over a concrete surface : In case of laying over concrete surface, following measures shall be taken :

- 1) For proper bond with new concrete deck, surface shall be roughened by means of stiff broom or wire brush and it shall be free from ridges and troughs.
- 2) A thin bituminous tack coat (with bitumen of grade VG 30) shall be applied on the concrete deck before pouring mastic. The deck shall be dry. The quantity of bitumen for tack coat shall be as per Table 500-6.
- 3) After applying tack coat, chicken-mesh reinforcement of 1.5 mm dia steel wire with hexagonal or rectangular openings of 20-25 mm shall be placed and held properly in position on the concrete surface before pouring mastic.

516.4.6 Joints

All construction joints shall be properly and truly made. These joints shall be made by warming existing mastic asphalt by the application of an excess quantity of the hot mastic

asphalt mix which afterwards shall be trimmed to leave it flush with the surfaces on either side.

516.4.7 Surface Finish

The mastic asphalt surface can have poor skid resistance after floating. In order to provide resistance to skidding, the mastic asphalt after spreading, while still hot and in a plastic condition, shall be covered with a layer of stone aggregate. This aggregate shall be 13.2 mm size (passing the 19.0 mm sieve and retained on the 6.7 mm sieve) or 9.5 mm size (passing the 13.2 mm sieve and retained on the 6.7 mm sieve) subject to the approval of the Engineer. Hard stone chips, complying with the quality requirements of Table 500-16, shall be precoated with bitumen at the rate of 2 ± 0.4 percent of VG 30 grade. The addition of 2 percent of filler complying with Table 500-9 may be required to enable this quantity of binder to be held without draining. The chips shall then be applied at the rate of 0.005 cu.m per 10 sq.m and rolled or otherwise pressed into the surface of the mastic layer when the temperature of the mastic asphalt is not less than 100°C.

516.5 Opening of Traffic

Traffic may be allowed after completion of the work when the mastic asphalt temperature of the completed layer has cooled to the daytime maximum ambient temperature.

516.6 Surface Finish and Quality Control of Work

The surface finish of the completed construction shall conform to the requirements of Clause 902.

For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

The surface of the mastic asphalt, tested with a straight edge 3 m long, placed parallel to the centre line of the carriageway, shall have no depression greater than 7 mm. The same shall also apply to the transverse profile when tested with a camber template.

516.7 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

516.8 Measurement for Payment

Mastic asphalt shall be measured as finished work in square metres at a specified thickness, or by weight in tonnes as stated in the Contract.

516.9 Rate

The contract unit rate for mastic asphalt shall be payment in full for carrying out the required operations including full compensation for all components listed under Clause 501.8.2.2.

517 CRACK PREVENTION COURSES

517.1 Scope

Work shall consist of providing one or two coats of an elastomeric rubber membrane as Stress Absorbing Membrane (SAM) over a cracked surface, followed by a covering chip, and a Stress Absorbing Membrane Interlayer (SAM), which is a material or which consists of a bitumen impregnated geotextile, as specified in the contract.

517.2 Materials

517.2.1 Binder

Binder shall be a modified binder complying with the requirements of IS: 15462 and RC: SP:53, according to the requirements of the Contract, except that viscosity grade VG 10 complying with the requirements of IS:73 shall be used in the case of a bitumen impregnated geotextile.

517.2.2 Aggregate

The requirements of Clause 510.2.2 apply except that the Polished Stone Value requirement does not apply in the case of SAMI. Where required by the contract, aggregates shall be pre-coated by mixing them with 0.75 to 1.0 percent of paving bitumen by weight of chips in a suitable mixer, the chips being heated to 160°C and the bitumen to its application temperature. The pre-coated chips shall be allowed to cure for at least one week or until they become non-stick and can be spread easily.

517.2.3 Rates of Spread of Binder and Aggregate

The rate of spread of binder and aggregate shall be as given in Table 500-43, as required by the contract.

517.2.4 Geotextile

The geotextile as prescribed shall conform to the requirements of Clause 703.3.

517.3 Construction Operations

517.3.1 Weather and Seasonal Limitations

Clause 501.5.1 shall apply.

517.3.2 Preparation of Base

The base on which the SAM, SAMI or bitumen impregnated geotextile is to be laid shall be prepared, in accordance with Clause 501 and as directed by the Engineer. The surface shall be thoroughly cleaned either by using a mechanical brush or any other equipment/method approved by the Engineer. Dust removed in the process shall be blown off with compressed air.

517.3.3 Application of Binder

517.3.3.1 The equipment and general procedures shall all be in accordance with the Manual for Construction and Supervision of Bituminous Works. The application temperature for modified binder shall be 1600-1700C. Binder for bitumen impregnated geotextile shall be applied according to Clause 703.4.4. The surface on which the binder is to be applied shall be dry.

Table 500-43 : Quantity of Materials Required for 10 sq.m of Road Surface for Stress Absorbing Membrane

Sl. No.	Material	Quantity (kg)	Quantity (kg)	Remarks
1	Modified Bitumen	1.0	1.0	For SAM
2	Gravel	10.0	10.0	For SAM
3	Gravel	10.0	10.0	For SAMI
4	Gravel	10.0	10.0	For SAMI
5	Gravel	10.0	10.0	For SAMI
6	Gravel	10.0	10.0	For SAMI
7	Gravel	10.0	10.0	For SAMI
8	Gravel	10.0	10.0	For SAMI
9	Gravel	10.0	10.0	For SAMI
10	Gravel	10.0	10.0	For SAMI

Notes: 1. The quantities are given in kg for 10 sq.m of road surface. 2. The quantities are given in kg for 10 sq.m of road surface. 3. The quantities are given in kg for 10 sq.m of road surface. 4. The quantities are given in kg for 10 sq.m of road surface. 5. The quantities are given in kg for 10 sq.m of road surface. 6. The quantities are given in kg for 10 sq.m of road surface. 7. The quantities are given in kg for 10 sq.m of road surface. 8. The quantities are given in kg for 10 sq.m of road surface. 9. The quantities are given in kg for 10 sq.m of road surface. 10. The quantities are given in kg for 10 sq.m of road surface.

517.3.4 Application of Aggregates

The equipment and general procedures shall all be in accordance with the Manual for construction and Supervision of Bituminous Works. Immediately after application of the modified binder, clean, dry aggregate shall be spread uniformly on the surface.

517.3.5 Sweeping

The surface of SAMs and SAMIs shall be swept to ensure uniform spread of aggregate and that there are no loose chips on the surface.

517.3.6 Two Coat SAM or SAMI

Where a two coat SAM or SAMI is required by the Contract, the second coat shall be applied within 90 days of the first coat.

517.3.7 Geotextile Placement

For bitumen impregnated geotextile, the requirements of Clause 703.4.4 shall apply.

517.4 Opening to Traffic

Traffic may be permitted over a SAM or SAMI 2 hours after rolling, but the speed shall be limited to 20 km/h, until the following day. Speed control measures are to be approved by the Engineer, prior to laying. Traffic shall not be allowed on the bitumen impregnated geotextile layer unless it is overlaid.

517.5 Surface Finish and Quality Control of Work

The surface finish shall conform to the requirements of Clause 902. For control on the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

517.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

517.7 Measurement for Payment

Each application of SAM, SAMI or bitumen impregnated geotextile shall be measured as finished work, for the area specified, in square metres

517.8 Rate

The contract unit rate for SAM, SAMI or bitumen impregnated geotextile shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.82.

518 BITUMINOUS COLD MIX (INCLUDING GRAVEL EMULSION)

518.1 The Design Mix

The work shall consist of providing a bituminous cold mix consisting of a mixture of unheated mineral aggregate and emulsified or cutback bitumen, laid in a single layer of 25-75 mm. The mix shall either be a design mix or a recipe mix.

518.2 Materials

518.2.1 Binder

The binder shall be a slow/ medium setting bitumen emulsion conforming to IS:8887 or a medium curing cut-back conforming to IS:217.

The binder with the highest residual viscosity at ambient temperatures that can reasonably be handled by the mixing and laying equipment proposed shall be used.

The aggregates shall comply with the requirements of Clauses 505.2.2. and 505.2.3. If the aggregates are not properly coated with the binder, a small amount of hydrated lime on an approved antistripping agent (see Appendix 4) shall be proposed by the Contractor, for the approval of the Engineer.

The combined aggregate grading for the particular mixture, when tested in accordance with IS:2386 Part I, (wet sieving method), shall fall within the limits shown in Table 500-44.

518.2.2.1 Requirements for the Mixture

[illegible]

Table 50045: Job Mix Formula for Road and Pavement		
Material	Percentage by Weight	Percentage by Volume
Coarse Aggregate (20mm and above)	55	55
Medium Aggregate (7.5mm to 20mm)	35	35
Fine Aggregate (0.075mm to 7.5mm)	10	10
Binder (Bitumen)	5	5
Filler (0.075mm and below)	5	5
Total		
100		
Notes: 1. The percentages are based on the dry weight of the materials. 2. The percentages are based on the volume of the materials. 3. The percentages are based on the weight of the materials. 4. The percentages are based on the volume of the materials. 5. The percentages are based on the weight of the materials. 6. The percentages are based on the volume of the materials. 7. The percentages are based on the weight of the materials. 8. The percentages are based on the volume of the materials. 9. The percentages are based on the weight of the materials. 10. The percentages are based on the volume of the materials.		
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518.2.2.2 Binder Content

The binder content shall be optimized by the Modified Marshall Test to achieve the requirements of the mix set out in Table 50045. The method adopted shall be that described in Appendix F and H of Asphalt Institute's Manual, MS-14.

518.2.2.3 Job Mix Formula

The Contractor shall submit to the Engineer for approval at least one month before the start of the work, the job mix formula proposed for use in the works together with the following details:

- i) Source and location of all materials;
- ii) Proportions of all materials expressed as follows where each is applicable:
 - a) Binder, as percentage by weight of total mix;
 - b) Coarse aggregate/fine aggregate as percentage by weight of total aggregate;

- iii) A single definite percentage passing each sieve for the mixed aggregate;
- iv) The results of tests enumerated in Table 50046 as obtained by the Contractor;
- v) Test results of the physical characteristics of the aggregates to be used;
- vi) Spraying temperature of binder if appropriate.

While working out the job mix formula, the Contractor shall ensure that it is based on a correct and truly representative sample of the materials that will actually be used in the work and that the mix and its different ingredients satisfy the physical and strength requirements of these Specifications.

Approval of the job mix formula shall be based on independent testing by the Engineer for which samples selected jointly with the Engineer of all ingredients of the mix shall be furnished by the Contractor as required by the former.

The approved job mix formula shall remain effective unless and until modified by the Engineer. Should a change in the source of materials be proposed, a new job mix formula shall be established by the Contractor and approved by the Engineer before actually using the materials.

518.2.2.4 Permissible Variation from the Job Mix Formula

it shall be the responsibility of the Contractor to produce a uniform mix conforming to the approved job mix formula, subject to the permissible variations of the individual percentages of the various ingredients in the actual mix from the job mix formula to be used, within the limits as specified in Tables 500-13 and 500-18. These variations are intended to apply to individual specimens taken for quality control tests in accordance with Section 900.

518.2.3 Construction operations

518.2.3.1 Weather and Seasonal Limitations

Construction with cold mix must not be undertaken when ambient temperatures below 10° C are expected, during rain, in standing water, or generally when poor weather is predicted. Bitumen emulsions and cutbacks depend on the evaporation of water and/or solvent for the development of their curing and adhesion characteristics. Cold weather, rain and high humidity slow down the rate of curing. Extra manipulation may be required to remove volatiles in cool and humid conditions. Wind increases the rate of evaporation.

518.2.3.2 Preparation of the Base

The base on which cold mix is to be laid shall be prepared, shaped and leveled to the required profile in accordance with Clauses 501 and 902 as appropriate, and a prime coat, where specified, shall be applied in accordance with Clause 502 or as directed by the Engineer.

518.2.3.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied over the base on which the cold mix is to be laid where specified in the Contract.

518.2.3.4 Preparation and Transportation of the Mix

Mixing can be carried out using one of the following types of mixer, which is provided with equipment for spraying the binder at a controlled rate and, if necessary, for heating the binder to a temperature at which it can be applied uniformly to the aggregate:

- a) rotary drum type concrete mixer for small jobs or asphalt cold mix plant;
- b) batch or continuous type mixer without dryer

A sufficient number of haul trucks with smooth, clean beds should be available to ensure continuous operation of the mixing plant. The type of truck used for transporting the mixture from the mixer to the road site shall suit to the Contractor's proposed laying procedure methodology.

518.2.3.5 Spreading

Designed cold mix shall be placed by a paver or grader as specified in the Contract. The mix shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

If spreading by motor grader, the grader shall have a blade that is straight and sharp and long enough to ensure finishing to close, straight, transverse tolerances and all joints and linkages . must be in good condition. The grader must be heavy enough to hold the blade firmly and uniformly on the surface while spreading the mix.

If climatic conditions and aggregate grading do not permit evaporation of moisture or volatiles without aeration by manipulation, a grader shall be used to place designed cold mix.

Other methods of spreading may be used as approved by the Engineer.

518.2.3.6 Compaction

Initial compaction of the laid material shall preferably be carried out using a pneumatic tyred roller of a weight appropriate to the layer thickness to be compacted with single layer thickness being 25-100 mm and all compaction being in accordance with Clauses 501.6 and 501.7. Smooth tyres shall be used. Final rolling and smoothening of the surface should be completed using steel wheel rollers. The Contractor shall demonstrate at laying trials that his proposed laying and compaction methods can achieve a satisfactory result.

518.2.4 Opening to Traffic

Traffic shall not be allowed to run on new work until all the water or volatiles in the mix have evaporated, as determined by the Engineer. The rate of evaporation will be influenced by the temperature, humidity and wind conditions.

518.2.5 Surface Finish and Quality Control of Work

The surface finish of construction shall conform to the requirements of Clause 902. For control of the quality of materials and the works carried out, the relevant provisions of Section 900 shall apply.

518.2.6 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

518.2.7 Measurement for Payment

Designed Cold Mix shall be measured as finished work, for the area covered, in cubic metres, by weight in metric tonnes, or by square metres at a specified thickness as specified in the Contract.

518.2.8 Rate

The contract unit rate for Designed Cold Mix shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. The rate shall cover the provision of the specified grade of cutback in the mix at 5 percent of the weight of the total mix or emulsion at 8 percent of the weight of the total mix. However, any variation in quantity of binder will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted, plus or minus, as per the rate for cutback or emulsion quoted in the Bill of Quantities.

518.3 Recipe Cold Mix

518.3.1 Scope

The work consists of construction of Recipe Cold Mixes composed of aggregate and emulsion binder which are laid immediately after mixing and while the emulsion is still substantially in an unbroken state. These mixes are considered suitable for emergency and repair work and temporary road surface improvement.

518.3.2 Materials

518.3.2.1 Binder

Emulsions of sufficient stability for mixing with the particular graded aggregate should be used. Bitumen emulsion shall be slow/ medium setting conforming to IS:8887.

518.3.2.2 Aggregates

Any normal, clean, but not necessarily dry, aggregate shall be used, conforming to Clauses 505.2.2 and 505.2.3 provided that it has sufficiently high crushing strength with regard to the traffic to be carried. Typical gradings are given in Table 500-47.

518.3.2.3 Aggregate Grading and Binder Content

When tested in accordance with IS:2386 Part 1 (wet sieving methods) the combined aggregate grading for the particular mix shall fall within the limits shown in Table 500-47. The actual quantity of emulsion to be used shall be approved by the Engineer after seeing the results of trial mixes made in the laboratory.

518.3.3 Construction Operations

518.3.3.1 Weather and Seasonal Limitations

As per Clause 518.2.3.1.

518.3.3.2 Preparation of Base

As per Clause 518.2.3.2.

518.3.3.3 Tack Coat

A tack coat in accordance with Clause 503 shall be applied over the base on which the cold mix is to be laid if specified in the Contract or required by the Engineer.

518.3.3.4 Preparation and Transportation of the Mix

As per Clause 518.2.3.4.

518.3.3.5 Spreading

As per Clause 518.2.3.5.

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518.3.7 Measurement for Payment

As per Clause 518.2.7.

518.3.8 Rate

The contract unit rate for Recipe Cold Mix shall be payment in full for carrying out the required operations including full compensation for all components listed in Clause 501.8.8.2. The rate shall cover the provision of the specified grade of emulsion at the lower quantity in the range for each type of mix indicated in Table 500-47. However, any variation of quantity in emulsion will be assessed on the basis of the amount agreed by the Engineer and the payment adjusted plus or minus, as per the rate for emulsion quoted in the Bill of Quantities.

519 RECYCLING OF BITUMINOUS PAVEMENT

519.1 Scope

This work covers the recycling of existing bituminous pavement materials to upgrade an existing bituminous pavement which has served its initially intended purpose. The work shall be performed on such widths and lengths as shall be directed by the Engineer and may consist of pavement removal, stockpiling of materials from the old pavement, addition of new bitumen and untreated aggregates in the requisite proportions, mixing, spreading and compaction of the blended materials.

These specifications cover the hot process.

519.2 Reclaimed Bituminous Materials for Central Plant Recycling

The reclaimed bituminous material shall be used in the production of bituminous macadam and dense bituminous macadam subject to the Clauses 519.2.3 to 519.2.8, and subject to satisfactory completion of full investigations in respect of all related materials entirely at the Contractor's cost and subject to the approval of the Engineer. For estimation purposes, an amount not greater than 60 per cent of reclaimed bituminous material shall be assumed.

519.2.1 Materials for Recycled Pavement

The recycled materials shall be a blend of reclaimed and new materials proportioned to achieve a paving mixture with the specified engineering properties. The reclaimed materials shall be tested and evaluated to find the optimum blend meeting the mixture requirements. Such testing and evaluation shall be carried out on representative sample, either cores sampled from the carriageway or samples taken from stockpiles in accordance with current practice. The sampling frequency should be sufficient to determine how consistent the reclaimed material is and to provide representative samples for composition analysis and measurement of properties of recovered binder. As an absolute minimum, one sample to represent 500 m two lane carriageway shall be taken.

519.2.2 Bitumen Extraction

The procedure described in ASTM D-2172 shall be used to quantitatively separate aggregates and bitumen from any representative sample of reclaimed bituminous pavement.

519.2.3 Aggregate Evaluation

Mechanical sieve analysis (IS:2386, Part I, wet sieving method) shall be performed on the aggregate portion of the reclaimed bituminous pavement sample to determine the grading. It is essential that the reclaimed materials to be recycled are consistent, as variable materials will cause problems with the control of quality and impede the efficiency of the recycling operation. Suitable sources of consistent material either in existing pavements, from stockpiled of known origin or from another suitable source shall be identified before a decision can be made on the optimum percentage of reclaimed material.

After selecting the proportion of reclaimed materials to be recycled, the grading of the mixture may need adjustment, to meet Specification requirements, by the addition of selected aggregate sizes.

519.2.4 Evaluation of Bitumen

When the amount of reclaimed bituminous materials to be used in the mixture exceeds 10 percent, the penetration value of the recovered binder from the reclaimed bituminous material, before mixing, shall exceed 15 pen, after recovery of binder in accordance with the requirements of BS:2000:Part 397, when tested in accordance with IS: 1203. Provided the above requirement is met, hardening of the old binder, during the original mixing process or through ageing, can be compensated for by adding softer bitumen, to obtain the appropriate final grade of binder.

The determination of the type and amount of binder required to be added in the final mix is essentially a trial and error procedure.

After mixing with recycled materials, the binder recovered from the mixture shall have a recovered penetration value not less than the value specified in Table 500-48.

Table 500-48 : Minimum Recovered Binder Penetration of Recycled Mixture

Reclaimed Bituminous Pavement (RBP) Content (%)	Minimum Recovered Binder Penetration (mm)
0 to 10	1.0
10 to 20	1.5
20 to 30	2.0
30 to 40	2.5
40 to 50	3.0
50 to 60	3.5
60 to 70	4.0
70 to 80	4.5
80 to 90	5.0
90 to 100	5.5

519.2.5 Rejuvenators

The use of rejuvenators, and a test to measure their effectiveness, is given in Clause 519.6.3.

519.2.6 Untreated Aggregates

If necessary, fresh untreated aggregates shall be added to the reclaimed bituminous pavement to produce a mix with the desired grading. The aggregate shall be checked for quality requirements in accordance with Table 500-7 or Table 500-10 as appropriate. Reclaimed aggregate, if any, or any aggregate normally used for the desired bituminous mix, or both, may be used for this purpose.

519.2.7 Combined Aggregate Grading

The blend reclaimed and new aggregate shall meet the grading criteria specified in the relevant parts of Clauses 505 or 506, as appropriate and as approved by the Engineer. The blend of aggregates shall be checked for resistance to stripping as specified in Tables 500-7 or 500-10 as appropriate.

519.3 Mixture Design

The combined aggregate grading and binder content shall comply with the relevant tables in Clauses 504 or 505 as appropriate. The mix design shall also comply with the requirements of Table 500-10. There may be a variation on three to four sieves with respect to percent passing, the permissible variation shall not exceed 3 to 4 percent per sieve.

519.4 Reclaiming Old Pavement Materials

The removal of pavement materials to the required depth shall be accomplished either at ambient temperature (cold process) or at an elevated temperature (hot process), as approved by the Engineer.

519.4.1 Cold Removal Process

In the cold process, the ripping and crushing operations shall be carried out using scarifiers, grid rollers, or rippers or by any other means as directed by the Engineer. The removed materials shall be loaded and hauled for crushing to the required size as directed by the Engineer. Alternatively, cold milling or planning machines can be used to reclaim bituminous pavement to controlled depths. Thereafter the bituminous layers are removed, any remaining aggregate materials that are to be incorporated in the recycled hot mix shall be scarified and removed. When the pavement material removal

is completed, any drainage deficiencies shall be corrected. After that, the base/sub-base, as the case may be, shall be cut, graded and compacted to the required profile and density.

519.4.2 Hot Removal Process

In the hot process, the road surface shall be heated, by infra-red/ hot-air heating system, before scarification. A self propelled plant fitted with suitable arrangement for heating the existing bituminous surface shall be used. A milling drum shall follow the planer for removing the heated soft bituminous layer. The depth, width and speed of travel shall be adjusted to suit specific requirements as directed by the Engineer. During the heating process, the surface temperature of the road shall not exceed 200 °C for more than 5 minutes.

519.4.3 Stockpiling

In the cold process, the reclaimed bituminous pavement material shall be stockpiled with height of stockpiles not exceeding 3 m. The reclaimed untreated aggregate base/sub-base material shall be stockpiled in the same manner as new aggregate. The number and location Of stockpiles shall be carefully planned for efficient operation of the hot-mix plant.

519.4.4 Mixing and Laying

the requirements of Clauses 504.3 or 505.4, as appropriate shall apply.

519.5 In Situ Recycling — The Remix and Repave Processes

519.5.1 Scope

In the process of repaving, the existing surface is preheated and scarified but the scarified material is not removed. A layer of fresh bituminous mix material prepared in the integrated mixing unit of the plant is then spread evenly on the scarified surface to give a uniform profile. The spread material should be compacted as soon as possible after laying. In the process, the total thickness of the pavement increased by up to 50 mm.

In the remix process, the scarified material should be taken from the mixing unit of the plant where it is recycled with fresh binder, aggregate and recycling agent. Then the recycled mixture is spread on the preheated surface and tamped and compacted to the required profile.

519.5.2 Heating and Scarifying

Surfaces to be treated shall be heated by plant with surfaces insulated and fully enclosed. The heated width of surfacing shall exceed the scarified width by at least 75 mm on each side, except against the edge of the carriageway or kerb face. When new surfacing material is spilled onto the road surface it shall be removed before the existing surface is heated and scarified. Areas of unscarified material shall not exceed 50 mm x 50 mm.

The depth of scarification shall be such that the bottom of the scarified layer is parallel to and below the finished road surface level by the thickness of wearing course material specified. A tolerance of ± 6 mm is permissible.

Where street furniture and other obstructions occur, these shall be suitably protected or removed and the void covered. Surface dressing and large areas of road markings shall be removed by milling, planning scarifying or by similar approved processes.

The heated surface shall be evenly scarified to comply with the requirements of this Clause. When street furniture is left in place or raised, the adjacent area shall be scarified by other means, with the material either left in place or removed, prior to passage of the machine. If furniture needs to be repositioned on completion of work, the new wearing course material shall be used to make good the road surface for a maximum width of 200 mm around the obstruction.

During the reheating process, the surface temperature of the road shall not exceed 200°C for more than 5 minutes.

519.5.3 Rejuvenator

For Remix, when required, rejuvenator shall be uniformly sprayed across the fullwidth of the processed material. The machine shall incorporate a metre for continuous verification of quantities which shall be within $\pm 5\%$ of the specified rate. The volume of rejuvenator shall vary in relation to the operating speed of the machine, which shall be related to the volume of material mixed or scarified.

The rejuvenator shall be a non-emulsified aromatic extract. Its properties shall be verified using the Rolling Thin Film Oven Test.

Rejuvenation of the existing pavement may also be performed by adding new hot mix bituminous material containing a soft binder for restoring the binder in the existing pavement to the required viscosity. Use of rejuvenating oil may be resorted to in case the target values of viscosity, penetration and softening are not met.

519.5.4 Mixing

When required, new hot-mix material shall be mixed with the heated and scarified road pavement material in a pugmill within the Remix machine, observing the mixing temperatures specified in Table 500-2.

After mixing, the recycled bituminous materials shall be automatically led to a finishing unit, which spreads and levels the mixture to the specified thickness and cross-section. The new bituminous concrete wearing course shall comply with Clause 507.

519.5.5 Additional Material (General)

The proportion of new hot-mix bituminous material, and the proportion of existing bituminous pavement material shall be as directed by the Engineer, together with the amount the road surface level is to be raised (if any).

The type and quantity of the new hot-mix material shall be determined by using the Marshall Mix Design procedure specified in the Asphalt Institute Manual MS-2, before work commences. Remix designs shall incorporate the stated proportion of material sampled from the existing road surface.

When additional coarse or fine aggregate or filler are required to be added, they shall comply with the requirements of Clause 508.2. The amount of additional coarse or fine aggregate or filler to be added to the existing bituminous pavement material shall be notified to the Engineer.

519.5.6 Additional Aggregate (Remix Process)

The coarse aggregate, fine aggregate and filler added to the Remixed material shall comply with the requirements of Clause 507.2.

519.5.7 New Surfacing (Repave and Remix/Repave Processes)

New surfacing material shall be bituminous concrete wearing course complying with Clause 508, or other wearing course material approved by the Engineer.

The new surfacing material shall be laid on, and compacted with, the reprofiled surfacing, which shall be at a temperature within the range of 100°C to 150°C.

519.5.8 Binder

The binder shall be recovered from samples taken from each layer of material laid. The method of recovery shall be in accordance with BS:2000: Part 397 or an equivalent test. The penetration of the binder shall be in the range 35-70 pen.

519.5.9 Mixture Design

The surfacing material shall be sampled from the paver hopper or augers. Care shall be taken that only the material forming the new surface layer is sampled. The sample shall be reduced at site by rifling or quartering to approximately 5 kg and placed loose in an air-tight container.

The sample shall only be reheated once whilst within the container. As soon as the sample reaches the required temperature, the reheated material shall be remixed and three Marshall test specimens prepared in accordance with the procedures specified in MS-2.

The bulk density of each specimen shall be measured before Marshall Stability testing. The mean stability and flow of the three specimen measured in accordance with the procedures specified in MS-2, shall comply with the requirements of Table 500-11.

The three Marshall specimens shall be combined and the maximum theoretical specific gravity (G_{mm}) of the mix shall be determined in accordance with ASTM D 2041. This maximum theoretical specific gravity (G_{mm}) corresponds to 0% air voids in the mix. The percent air voids (P_a) in the specimen of the compacted mixture given by $\frac{G - G_{mm}}{G_{mm}} \times 100$ shall meet the requirements of air voids laid down in Table 500-10, where

Gmb is the actual bulk specific gravity of a Marshall specimen determined in the Laboratory.

519.6 Opening to Traffic

For recycled material forming the base or binder course layer, Clauses 504.5 or 505.5 shall apply as appropriate. For recycled material forming the wearing course layer, Clause 508.4 shall apply.

519.7 Surface Finish and Quality Control

The surface finish of the completed construction shall conform to the requirements of Clause 902.

For control of the quality of materials and the works carried out the relevant provisions of Section 900 shall apply.

519.8 Arrangements for Traffic

During the period of construction, arrangements for traffic shall be made in accordance with the provisions of Clause 112.

519.9 Measurement for Payment

The recycled pavement work shall be measured in cubic metres or tonnes of finished work as stated in the Contract.

519.10 Rate

The contract unit rate for recycled pavement shall be payment in full for carrying out the required operations including full compensation for all items as Clause 501.8.8.2.

520 SUPPLY OF STONE AGGREGATES FOR PAVEMENT COURSES

520.1 Scope

This Clause shall apply to the supply of stone aggregates only. The work shall consist only of collection, transportation and stacking the stone aggregates and stone filler for subsequent use in pavement courses. The actual work of laying the pavement courses shall, however, be governed by the individual Specification Clause for the actual work, given elsewhere in these Specifications. The size and quantities of the aggregates to be supplied shall be so selected by the Engineer that the grading requirements set forth in the individual Specification Clauses for the pavement courses, for which the supply is intended, are satisfied.

All the materials shall be procured from approved sources and shall conform to the physical requirements, specified in the respective Specification Clauses for the individual items given elsewhere in these Specifications.

520.2 Sizes of Stone Aggregates

The stone aggregates shall be designated by their standard sizes in the Contract and shall conform to the requirements shown in Table 500-49.

520.3 Stacking

520.3.1 Coarse Aggregates

Only the aggregates satisfying the Specifications requirements shall be conveyed to the roadside and stacked. Each size of aggregate shall be stacked separately. Likewise, materials obtained from different quarry sources shall be stacked separately and in such a manner that there is no contamination of one source with another.

Table 50049 : Size Requirements for Coarse Stone Aggregates

Size	Maximum Permissible Percentage by Weight	Maximum Permissible Percentage by Weight	Maximum Permissible Percentage by Weight
75 mm	100	100	100
150 mm	100	100	100
300 mm	100	100	100
600 mm	100	100	100
1200 mm	100	100	100

520.3.2 Fine Aggregate

As stated in the individual relevant Specification Clauses.

The aggregates shall be stacked clear of the roadway on even clear hard ground, or on a platform prepared in advance for the purpose by the Contractor at his own cost and in a manner that allows correct and ready measurement. If the stockpile is placed on ground where the scraping action of the loader can contaminate the material with underlying soil, then the stockpile shall be rejected by the Engineer. Materials shall not be stacked in locations liable to inundation or flooding.

The dimensions of the stockpiles and their locations shall be approved by the Engineer. Where the material is improperly stacked, the Engineer shall direct complete re-stacking of the materials in an approved manner at the Contractor's cost.

Stone filler shall be supplied in a dry state in bags or other suitable containers approved by the Engineer and shall be protected from the environment, so as to prevent deterioration in quality.

520.4 Quality Control of Materials

Engineer shall exercise control over the quality of the materials so as to ascertain their conformity with the Specifications requirements, by carrying out tests for the specified properties in accordance with Section 900 of these Specifications.

Materials shall only be brought to site from a previously tested and approved source, and any materials not conforming to the requirements of the Specification shall be rejected by the Engineer and removed from the work site at the cost of the Contractor.

520.5 Measurement for Payment

Coarse and fine aggregates supplied to the site shall be paid for in cubic metres. The actual volume of the aggregates to be paid for shall be computed after deducting the specified percentages in Table 500-50, from the volume computed by stack measurements, to allow for bulking.

Table 500-50 : Percent Reduction In Volume of Aggregates

Material	Percent Reduction
Coarse aggregate	5
Fine aggregate	5
Stone filler	5

Unless otherwise directed by the Engineer, measurements shall not be taken until sufficient materials for use on the road have been collected and stacked. Immediately after measurement, the stacks shall be marked by white wash or other means as directed by the Engineer.

Stone filler as delivered to the site shall be measured in tonnes.

520.6 Rates

The contract unit rates for different sizes of coarse aggregate, fine aggregate and stone filler shall be payment in full for collecting, conveying and stacking or storing at the site including full compensation for:

- i. all royalties, fees, rents where necessary;
- ii. all leads and lifts; and
- iii. all labour, tools, equipment and incidentals to complete the work to the specifications.
- iv. All necessary testing of material, both initial, to approve the source, and regular control testing thereafter.

900 DRY LEAN CEMENT CONCRETE SUB-BASE

900.1 Scope

The work shall consist of construction of (zero slump) dry lean concrete sub-base for cement concrete pavement in accordance with the requirements of these specifications and in conformity with the lines, grades and cross-sections shown on the drawings or as directed by the Engineer. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations, in connection with the work, as approved by the Engineer.

900.1.1 The design parameters of dry lean concrete sub-base, viz., width, thickness, grade of concrete, details of joints, if any, etc. shall be as stipulated in the drawings.

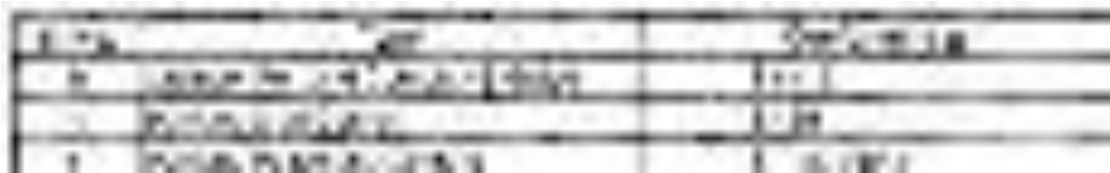
900.2 Materials

900.2.1 Sources of Materials

The Contractor shall indicate to the Engineer the source of all materials with relevant test data to be used in the dry lean concrete work sufficiently in advance and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work in trial length. If the Contractor later proposes to obtain the materials from a different source during the execution of main work, he shall notify the Engineer with relevant test data for his approval at least 45 days before such materials are to be used.

900.2.2 Cement

Any of the following types of cement may be used with prior approval of the Engineer:



OPC	43/53
OPC	53/59
OPC	62.5/67

If the subgrade soil contains soluble sulphates in a concentration more than 0.5 percent, sulphate resistant cement conforming to IS:6909 shall be used.

Cement to be used may preferably be obtained in bulk form. It shall be stored in accordance with stipulations contained in Clause 1014 and shall be subjected to acceptance test prior to its immediate use.

900.2.3 Fly-ash

Fly-ash upto 20 percent by weight of cementitious material (cement+flyash) may be used along with 43/53 grade cement may be used to replace OPC cement grade 43 upto 30 percent by weight of cement. Fly-ash shall conform to IS:3812 (Part 1) and its use shall be permitted only after ensuring that facilities exist for uniform blending through a proper mechanical facility with automated process control like batch mix plant conforming to IS:4925 and IS:4926.

900.2.4 Aggregates

900.2.4.1 Aggregates for lean concrete shall be natural material complying with IS:383. The aggregates shall not be alkali reactive. The limits of deleterious materials shall not exceed the requirements set forth in Table 600-2. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching, or as directed by the Engineer.

900.2.4.2 Coarse Aggregates

Coarse aggregates shall comply with Clause 602.2.6.2, except that the maximum size of the coarse aggregate shall be 26.5 mm, and aggregate gradation shall comply with Table 600-1.

900.2.4.3 Fine Aggregates

The fine aggregate shall comply with Clause 602.2.6.3.

900.2.4.4 The material after blending shall conform to the grading as indicated in Table 600-1.

Table 600-1 : Aggregate Gradation for Dry Lean Concrete

Size of Aggregate (mm)	Percentage by Weight (min. to max.)
75	100
4.75	75-100
7.5	85-100
15	90-100
30	95-100
4.75	75-100
7.5	85-100
15	90-100
30	95-100
4.75	75-100
7.5	85-100
15	90-100
30	95-100

900.2.5 Water

Water used for mixing and curing of concrete shall comply with Clause 602.2.7.

900.2.6 Storage of Materials

All materials shall be stored in accordance with the provisions of Clauses 602.2.12 of these specifications and other relevant IS Specifications.

900.3 Proportioning of Materials for the Mix

900.3.1

The mix shall be proportioned with a maximum aggregate cementitious material ratio of 15:1. The water content shall be adjusted to the optimum as per Clause 601.3.2 for facilitating compaction by rolling. The strength and density requirements of concrete shall be determined in accordance with Clauses 601.7 and 601.8 by making trial mixes. Care should be taken to prevent one size of aggregate falling into the other size of the hopper of the feeding bin while loading the individual size of aggregates into the bins.

900.3.2 Moisture Content

The optimum water content shall be determined and demonstrated by rolling during trial length construction and the optimum moisture content and degree of compaction shall be got approved from Engineer. While laying in the main work, the lean concrete shall have a moisture content between the optimum and optimum +2 percent, keeping in view the effectiveness of compaction achieved and to compensate for evaporation losses.

900.3.3 Cement Content

The cement content in the dry lean concrete shall be such that the strength specified in Clause 601.3.4 is achieved. The minimum cement content shall be 150 kg/cu.m of concrete. In case flyash is blended at site as part replacement of cement, the quantity of flyash shall not be more than 20 percent by weight of cementitious material and the content of OPC shall not be less than 120 kg/cu.m.

If this minimum is not sufficient to produce dry lean concrete of the specified strength, it shall be increased as necessary by the Contractor at his own cost.

900.3.4 Concrete Strength

The average compressive strength of each consecutive group of 5 cubes made in accordance with Clause 903.5.1.1 shall not be less than 10 MPa at 7 days. In addition, the minimum compressive strength of any individual cube shall not be less than 7.5 MPa at 7 days. The design mix complying with the above Clauses shall be got approved from the Engineer and demonstrated in the trial length construction.

900.4 Sub-grade

The sub-grade shall conform to the grades and cross-sections shown on the drawings and shall be laid and compacted in accordance with Clause 305. The subgrade strength shall correspond to the design strength specified in the Contract. As far as possible, the construction traffic shall be avoided on the prepared sub-grade.

900.5 Drainage Layer

A drainage layer conforming to Clause 401 shall be laid above the subgrade before laying the Dry Lean Concrete sub-base, as specified in the drawings and the Contract.

900.6 Construction

900.6.1 General

The Dry Lean Concrete shall be laid on the prepared granular drainage layer. The pace and programme of the Dry Lean Concrete sub-base construction shall be matching suitably with the programme of construction of the cement concrete pavement over it. The Dry Lean Concrete sub-base shall be overlaid with concrete pavement only after 7 days of sub-base construction.

900.6.2 Batching and Mixing

The batching plant shall be capable of proportioning the materials by weight, each type of material being weighed separately in accordance with Clauses 602.9.2, 602.9.3.1 and 602.9.3.2.

The design features of Batching Plant should be such that the plant can be shifted quickly.

900.6.3 Transporting

Plant mix lean concrete shall be discharged immediately from the mixer, transported directly to the point where it is to be laid and protected from the weather by covering the tipping trucks with tarpaulin during transit. The concrete shall be transported by tipping trucks, sufficient in number to ensure a continuous supply of material to feed the laying equipment to work at a uniform speed and in an uninterrupted manner. The lead of the batching plant to paving site shall be such that the travel time available from mixing to paving as specified in Clause 601.6.5.2 will be adhered to. Tipping truck shall not have old concrete sticking to it. Each tipping truck shall be washed with water jet before next loading as and when required after inspection.

900.6.4 Placing

Lean concrete shall be placed by a paver with electronic sensor on the drainage layer or as specified in the Contract. The equipment shall be capable of laying the material in one layer in an even manner without segregation, so that after compaction the total thickness is as specified. The paving machine shall have high amplitude tamping bars to give good initial compaction to the sub-base. One day before placing of the dry lean cement concrete subbase, the surface of the granular sub-base/drainage layer shall be given a fine spray of water and rolled with a smooth wheeled roller.

Preferably the lean concrete shall be placed and compacted across the full width of the two lane carriageway, by constructing it in one go. In roads with carriageway more than 2 lanes a longitudinal joint shall be provided. Transverse butt type joint shall be provided at the end of the construction in a day. Transverse joints in the concrete pavement shall not be coterminous with the transverse construction joint of the Dry Lean Concrete.

The Dry Lean Concrete shall be laid in such a way that it is at least 750 mm wider on each end side than the proposed width including paved shoulders of the concrete pavement. The by actual widening shall be decided based on the specifications of the paver, such that the an

crawler moves on the Dry Lean Concrete, and the cost of extra width shall be borne by the Contractor.

900.6.5 Compaction

- 900.6.5.1** The compaction shall be carried out immediately after the material is laid and levelled. In order to ensure thorough compaction, rolling shall be continued on the full width till there is no further visible movement under the roller and the surface is well closed. The minimum dry density obtained shall not be less than 98 percent of that achieved during the trial length construction in accordance with Clause 601.7. The densities achieved at the edges i.e. 0.5 m from the edge shall not be less than 96 percent of that achieved during the trial construction.
- 900.6.5.2** The spreading, compacting and finishing of the lean concrete shall be carried out as rapidly as possible and the operation shall be so arranged as to ensure that the time between the mixing of the first batch of concrete in any transverse section of the layer and the final finishing of the same shall not exceed 90 minutes when the temperature of concrete is between 25°C and 30°C, and 120 minutes if less than 25°C. This period may be reviewed by the Engineer in the light of the results of the trial run but in no case shall it exceed 120 minutes. Work shall not proceed when the temperature of the concrete exceeds 30°C. If necessary, chilled water or addition of ice may be resorted to for bringing down the temperature. It is desirable to stop concreting when the ambient temperature is above 35°C. After compaction has been completed, roller shall not stand on the compacted surface for the duration of the curing period except during commencement of next day's work near the location where work was terminated the previous day.
- 900.6.5.3** Double drum smooth-wheeled vibratory rollers of minimum 80 to 100 kN static weight are suitable for rolling dry lean concrete. In case any other roller is proposed, the same shall be got approved from the Engineer, after demonstrating its performance. The number of passes required to obtain maximum compaction depends on the thickness of the dry lean concrete, the compatibility of the mix and the weight and type of the roller and the same as well as the total requirement of rollers for the jobs shall be determined during trial run by measuring in-situ density and the scale of the work to be undertaken. Except on super elevated portions where rolling shall proceed from the inner edge to the outer, rolling shall begin from the edges gradually progressing towards the centre. First, the edge/edges shall be compacted with a roller running forward and backward. The roller shall then move inward parallel to the centerline of the road, in successive passes uniformly lapping preceding tracks by at least one half width.
- 900.6.5.4** A preliminary pass without vibration to bed the Dry Lean Concrete down shall be given followed by the required number of passes to achieve the desired density and, a final pass without vibration to remove roller with vibration marks and to smoothen the surface.

Special care and attention shall be exercised during compaction near joints, kerbs, channels, side forms and around gullies and manholes. In case adequate compaction is not achieved by the roller at these locations, use of plate vibrators shall be made, if so directed by the Engineer.

900.6.5.5 The final lean concrete surface on completion of compaction shall be well closed, free from movement under roller and free from ridges, low spots, cracks, loose material, pot holes, ruts or other defects, The final surface shall be inspected immediately on completion and all loose, segregated or defective areas shall be corrected by using fresh lean concrete material, laid and compacted. For repairing honeycombed/hungry surface, concrete with aggregates of size 10 mm and below shall be spread and compacted as per Specifications. It is necessary to check the level of the rolled surface for compliance. Any level/thickness deficiency shall be corrected after applying concrete with aggregates of size 10 mm and below after roughening the surface. Surface regularity also shall be checked with 3 m straight edge. Strength tests shall be carried out, and if deficiency in strength is noticed, at least three (evenly spread) cores of minimum 100 mm dia per km shall be cut to check deficiency in strength. The holes resulting from cores shall be restored by filling with concrete of the specified strength and compacted by adequate rodding.

900.6.5.6 Segregation of concrete in the tipping trucks shall be controlled by moving the dumper back and forth while discharging the mix into the same or by any appropriate means. Paving operation shall be such that the mix does not segregate.

900.6.6 Joints

Construction and longitudinal joints shall be provided as per the drawings.

Transverse butt type joint shall be provided at the end of the construction in a day. Longitudinal joint shall be provided only when full width paving is not possible. Transverse in Dry Lean concrete shall be staggered from the construction butt type joint in Concrete by 800-1000 mm.

Longitudinal joint in Dry Lean Concrete shall be staggered by 300/400 mm from the joint of concrete pavement.

Longitudinal or transverse construction joints, unless vertical forms are used, the edge of compacted material shall be cut back to a vertical plane where the correct thickness of the compacted material has been obtained.

900.6.7 Curing

As soon as the lean concrete surface is compacted, curing shall commence. One of the methods shall be adopted:

- a) Curing may be done by covering the surface by gunny bags/hessian, which shall be kept wet continuously for 7 days by sprinkling water.
- b) The curing shall be done by spraying with approved resin based aluminized reflective curing compound conforming to ASTM-C 309-81 in accordance with Clause 602.9.12. As soon as the

curing compound has lost its tackiness, the surface shall be covered with wet hessian for three days. The rate of application shall be as recommended by the supplier.

- c) Wax-based white pigmented curing compound with water retention index of not less than 90 percent shall be used to cure the dry lean concrete. The curing compound shall conform to BS:7542. The compound shall be applied uniformly with a mechanical sprayer and with a hood to protect the spray from the wind. The curing compound shall be applied over the entire exposed surface of the Dry Lean Concrete, including sides and edges, at the rate of 0.2 litres/sq.m, or as recommended by the supplier.
- d) The first application, referred to as curing application shall be applied immediately after the final rolling of Dry Lean Concrete is completed. As soon as the curing compound loses tackiness, the surface shall be covered with wet hessian for three days. The second application of curing compound also referred to as the debonding application, shall be applied 24 to 48 hours prior to the placement of the concrete pavement. Any damaged Dry Lean Concrete shall be corrected prior to the second application. Normally, the manufacturer's instructions shall be followed for its application.

900.7 Trial Mixes

The Contractor shall make trial mixes of dry lean concrete with moisture contents like 5.0 5.5, 6.0, 6.5 and 7.0 percent using specified cement content, specified aggregate grading and aggregate-cement ratio specified in Clause 601.3.1. Optimum and density shall be established by preparing cubes with varying moisture contents. Compaction of the mix shall be done in three layers with vibratory hammer fitted with a square or rectangular foot as described in Clause 903.5.1.1. After establishing the optimum moisture, a set of six cubes shall be cast at optimum moisture for the determination of compressive strength on the third and the seventh day. Trial mixes shall be repeated if the strength is not satisfactory by increasing cement content. After the mix design is approved, the Contractor shall construct a trial section in accordance with Clause 601.8.

If during the construction of the trial length, the optimum moisture content determined as above is found to be unsatisfactory, the Contractor may make suitable changes in the moisture content to achieve the satisfactory mix. The cube specimens prepared with the changed mix content should satisfy the strength requirement. Before production of the mix, natural moisture content of the aggregate should be determined on a day-to-day basis so that the moisture content could be adjusted. The mix finally designed should neither stick to the rollers nor become too dry resulting in ravelling of surface.

900.8 Trial Length

- 900.8.1** The trial length shall be constructed at least 14 days in advance of the proposed date of commencement of work. At least 30 days prior to the construction of the trial length, the Contractor shall submit for the Engineer's approval a "Method Statement" giving detailed description of the proposed materials, plant, equipment, mix proportions, and procedure for batching, mixing, laying, compaction and other construction procedures. The Engineer shall also approve the location and length of trial construction which shall be a minimum of 100 m length laid in two days and

for full width of the pavement. The trial length shall be outside the main works. The trial length shall contain the construction of at least one transverse construction joint involving hardened concrete and freshly laid Dry Lean Concrete sub-base. The construction of trial length shall be repeated till the Contractor proves his ability to satisfactorily construct the Dry Lean Concrete sub-base.

900.8.2 After the construction of the trial length, the in-situ density of the freshly laid material shall be determined by sand replacement method. Three density holes shall be made at locations equally spaced along a diagonal that bisects the trial length and average of these densities shall be determined. The density holes shall not be made in the strip 500 mm from the edges. The average density obtained from the three samples collected shall be the reference density and is considered as 100 percent. The field density of regular work will be compared with this reference density in accordance with Clauses 601.6.5.1 and 903.5.1.2.

900.8.3 The hardened concrete shall be cut over 3 m width and reversed to inspect the bottom surface for any segregation taking place. The trial length shall be constructed after making necessary changes in the gradation of the mix to eliminate segregation of the mix. The lower surface shall not have honey-combing and the aggregates shall not be held loosely at the edges.

900.8.4 The main work shall not start until the trial length has been approved by the Engineer. After approval has been given, the materials, mix proportions, moisture content, laying, compaction plant and construction procedures shall not be changed without approval of the Engineer.

900.9 Tolerances for Surface Regularity, Level, Thickness, Density and Strength

Control of quality of materials and works shall be exercised by the Engineer in accordance Section 900.

900.10 Traffic

No heavy commercial vehicles like trucks and buses shall be permitted on the dry lean concrete sub-base. Construction vehicles at slow speed may be permitted after 7 days of its construction with the prior approval of the Engineer.

900.11 Measurement for Payment

unit of measurement for dry lean concrete pavement shall be in cubic metre of concrete placed, based on the net plan area for the accepted thickness shown on the drawings or as directed by the Engineer.

900.12 Rate

The Contract unit rate payable for dry lean concrete sub-base shall be for carrying out the required operations including full compensation for all labour, materials and equipment, mixing, transport, placing, compacting, finishing, curing, rectification of defective surface or testing and incidentals such as trial length to complete the work as per Specifications, all royalties, fees, storage and rents where necessary and all leads and lifts.

901 CEMENT CONCRETE PAVEMENT

901.1 Scope

901.1.1 The work shall consist of construction of un-reinforced, dowel jointed, plain cement concrete pavement in accordance with the requirements of these Specifications and in conformity with the lines, grades and cross sections shown on the drawings. The work shall include furnishing of all plant and equipment, materials and labour and performing all operations in connection with the work, as approved by the Engineer.

901.1.2 The design parameters, viz., thickness of pavement slab, grade of concrete, joint details etc. shall be as stipulated in the drawings.

901.2 Materials

901.2.1 Source of Materials

The Contractor shall indicate to the Engineer the source of all materials to be used in the concrete work with relevant test data sufficiently in advance, and the approval of the Engineer for the same shall be obtained at least 45 days before the scheduled commencement of the work in trial length. If the Contractor subsequently proposes to obtain materials from a different source during the execution of main work, he shall notify the Engineer, with relevant test data, for his approval, at least 45 days before such materials are to be used.

901.2.2 Cement

Any of the following types of cement capable of achieving the design strength may be used with prior approval of the Engineer, but preference shall be to use at least the 43 grade or higher.



If the soil around concrete pavement has soluble salts like sulphates in excess of 0.5 percent, the cement used shall be sulphate resistant and shall conform to IS: 12330.

Cement to be used may preferably be obtained in bulk form. If cement in paper bags is proposed to be used, there shall be bag-splitters with the facility to separate pieces of paper bags and dispose them off suitably. No paper pieces shall enter the concrete mix. Bulk cement shall be stored in accordance with Clause 1014. The cement shall be subjected to acceptance test.

Fly-ash upto 20 percent by weight of cementitious material may be used in Ordinary Portland cement 43 and 53 Grade as part replacement of cement provided uniform blending with cement is ensured. The fly ash shall conform to IS:3812 (Part I).

Site mixing of fly ash shall be permitted only after ensuring availability of the equipment at site for uniform blending through a specific mechanised facility with automated process control like batch mix plants conforming to IS:4925 and IS:4926. Site mixing will not be allowed otherwise.

The Portland Pozzolana Cement produced in factory as per IS: 1489-Part I shall not have content more than 20 percent by weight of cementitious material. Certificate from the manufacturer to this effect shall be produced before use.

901.2.3 Chemical Admixtures

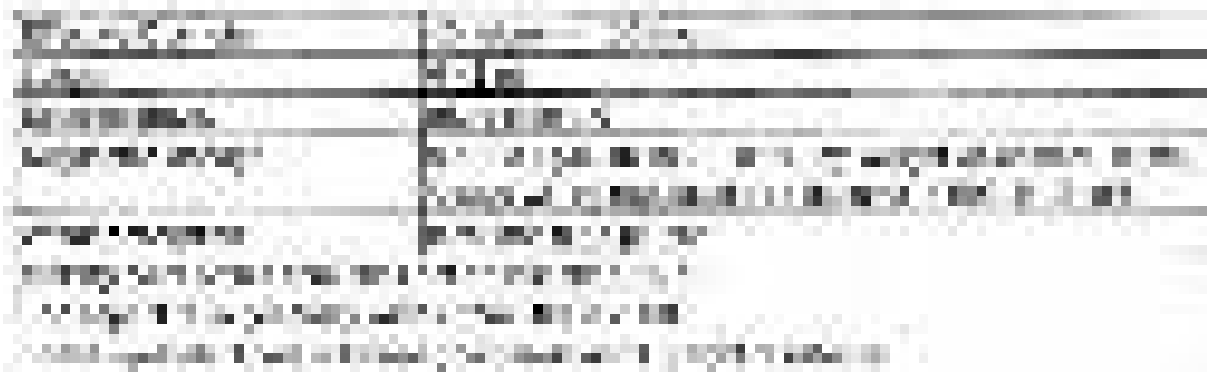
Admixtures conforming to IS:9103 and IS:6925 shall be permitted to improve workability of the concrete and/or extension of setting time, on satisfactory evidence that they will not have adverse effect on the properties of concrete with respect to strength, volume change, durability and have no deleterious effect on steel bars. The particulars of the admixture and the quantity to be used, must be furnished to the Engineer in advance to obtain his approval before use. Satisfactory performance of the admixtures should be proved both on laboratory concrete trial mixes and in the trial length paving. If air entraining admixture is used, the total quantity of air shall be 5±1.5 percent for 31.5 mm maximum nominal size aggregate (in air-entrained concrete as a percentage of the volume of the mix).

901.2.4 Silica Fumes

Silica fume conforming to a standard approved by the Engineer may be used as an admixture in the proportion of 3 to 10 percent of cement. Silica fume shall comply with the requirements given in IS-.15388-2003, IS:456-2000,  and IRC:44-2008.

901.2.5 Fibres

Fibres may be used subject to the provision in the design/approval by the Engineer to reduce the shrinkage cracking and post-cracking. The fibres may be steel fibre as per IRC:SP:46 or polymeric Synthetic fibres within the following range of specifications:



When fibres are used, the mix shall be so designed that the slump of concrete at paving site is 25±15 mm.

901.2.6 Aggregates

901.2.6.1 Aggregates for pavement concrete shall be natural material complying with IS:383 but with a Los Angeles Abrasion Test value not exceeding 35 percent. The limits of deleterious materials shall not exceed the requirements set out in Table 600-2.

Table 600-2 : Permissible Limits of Deleterious Substances in Fine and Coarse Aggregates

Sl. No.	Deleterious Substances	Method of Test	Fine Aggregate Percentage by Weight		Coarse Aggregate Percentage by Weight	
			Maximum	Minimum	Maximum	Minimum
1	Loss on Ignition	IS: 383 Part 1: 1997	10	15	10	15
2	Organic Impurities	IS: 383 Part 1: 1997	0.1	0.2	0.1	0.2
3	Free Chlorides	IS: 383 Part 1: 1997	0.06	0.06	0.06	0.06
4	Sulphate	IS: 383 Part 1: 1997	0.25	0.25	0.25	0.25
5	Crushed aggregate at least one face fractured	IS: 383 Part 1: 1997	100	100	100	100

*

Crushed aggregate at least one face fractured

Note: The presence of mica in the fine aggregate has been found to reduce considerably the durability and compressive strength of concrete and further investigations are underway to determine the extent of the deleterious effect of mica. It is advisable, therefore, to investigate the mica content of fine aggregate and make suitable allowances for the possible reduction in the strength of concrete or mortar; in cases where the stretch of the project road passes through micaceous belt.

The aggregates shall be free from chert, flint, chalcedony or other silica in a form that can react with the alkalis in the cement. In addition, the total chlorides content expressed as chloride ion content shall not exceed 0.06 percent by weight and the total sulphate content expressed as sulphuric anhydride (SOO shall not exceed 0.25 percent by weight. In case the Engineer considers that the aggregates are not free from dirt, the same may be washed and drained for at least 72 hours before batching, as directed by the Engineer.

901.2.6.2 Coarse Aggregates

Coarse aggregates shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone or crushed gravel and shall be devoid of pieces of disintegrated stone, soft, flaky, elongated, very angular or splintery pieces. The maximum size of coarse aggregate shall not exceed 31.5 mm for pavement concrete. No aggregate which has water absorption more than 2 percent shall be used in the concrete mix. The aggregates shall be tested for soundness in accordance with IS:2386 (Part-5). After 5 cycles of testing, the loss shall not be more than 12 percent if sodium sulphate solution is used or 18 percent if magnesium sulphate solution is used. The Los Angeles Abrasion value shall not exceed 35. The combined flakiness and elongation index of aggregate shall not be more than 35 percent.

901.2.6.3 Fine Aggregates

The fine aggregates shall consist of clean natural sand or crushed stone sand or a combination of the two and shall conform to IS:383. Fine aggregate shall be free from soft particles, clay, shale, loam, cemented particles, mica and organic and other foreign matter. The fine aggregates shall have a sand equivalent value of not less than 50 when tested in accordance with the requirement of IS:2720 (Part 37).

901.2.6.4 Combined Gradation of Fine and Coarse Aggregates

The combined gradation of fine and coarse aggregates shall be as per Table 600-3.

Table 600-3: Aggregate Gradation for Pavement Quality Concrete

Size (mm)	Percentage (%)
75	100
150	100
300	100
600	100
1200	100
2400	100
475	100
75	100
150	100
300	100
600	100
1200	100
2400	100

901.2.7 Water

Water used for mixing and curing of concrete shall be clean and free from injurious amount of oil, salt, acid, vegetable matter or other substances harmful to the finished concrete. It shall meet the requirements stipulated in IS:456.

901.2.8 Steel for Dowels and Tie Bars

Steel shall conform to the requirements of IS:432 and IS: 1786 as relevant. The dowel bars shall conform to IS:432 of Grade I. Tie bars shall be either High yield Strength Deformed bars

conforming to IS: 1786 and grade of Fe 500 or plain bars conforming to IS:432 of Grade I. The steel shall be coated with epoxy paint for protection against corrosion.

901.2.9 Joint Filler Board

Synthetic Joint filler board for expansion joints shall be used only at abutting structures like bridges and shall be of 20-25 mm thickness within a tolerance of ± 1.5 mm and of a firm compressible material and complying with the requirements of IS: 1838, with a compressibility more than 25 percent. It shall be 25 mm less in depth than the thickness of the slab within a tolerance of ± 3 mm and provided to the full width between the side forms. It shall be in suitable lengths which shall not be less than one lane width. If two pieces are joined to make up full width, the joint shall be taped such that no slurry escapes through the joint. Holes to accommodate dowel bars shall be accurately bored or punched out to give a sliding fit on the dowel bars.

901.2.10 Joint Sealing Compound

The joint sealing compound shall be of hot poured, elastomeric type or cold polysulphide/ polyurethane/ silicone type having flexibility, resistance to age hardening and durability as per IRC:57. Manufacturer's certificate shall be produced by the Contractor for establishing that the sealant is not more than six months old and stating that the sealant complies with the relevant standard mentioned below. The samples shall meet the requirements as mentioned in IRC:57.

If sealant is of hot poured type, it shall conform to

Hot applied sealant: IS: 1834 or ASTM : 3406-95, as applicable

Cold poured sealants shall be one of the following :

i)	polysulphide	IS:11433 (Part I), BS:5212 (Part II)
ii)	polyurethane	BS:5212
iii)	silicone	ASTM 5893-04

901.2.11 Preformed Seals

The pre-formed joint sealing material shall be a vulcanized elastomeric compound using polychloroprene (Neoprene) as the base polymer.

The joint seal shall conform to requirements of ASTM D 2628 as given in Table 600-4.

Table 600-4 : Requirement of Preformed Seals as per ASTM D 2628

Sl. No.	Description	Quantity	Unit
1	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
2	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
3	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
4	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
5	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
6	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
7	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
8	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
9	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
10	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
11	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
12	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
13	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
14	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
15	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
16	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
17	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
18	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
19	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²
20	Preformed Seal for Joints in Concrete Slabs	1.0000	m ²

901.2.12 Storage of Materials

All materials shall be stored in accordance with the provisions of Clause 1014 of the Specifications. All efforts shall be made to store the materials in proper places so as to prevent their deterioration or contamination by foreign matter and to ensure their satisfactory quality and fitness for the work. The platform where aggregates are stock piled shall be paved and elevated from the ground atleast by 150 mm. The area shall have slope to drain Off rain water. The storage space must also permit easy inspection, removal and storage of the materials. Aggregates of different sizes shall be stored in partitioned stack-yards. All such materials even though stored in approved godowns must be subjected to acceptance test as per Clause 903 of these Specifications prior to their use.

901.3 Proportioning of Concrete

901.3.1 After approval by the Engineer of all the materials to be used in the concrete, the Contractor shall submit the mix design based on weighed proportions of all ingredients for the approval of the Engineer vide Clause 602.3.4. The mix design shall be submitted at least 30 days prior to the paving of trial length and the design shall be based on laboratory trial mixes using the approved materials and methods as per IRC:44 or IS: 10262. The target . mean strength for the design mix shall be determined as indicated in Clause 602.3.3.1. The mix design shall be based on the flexural strength of concrete.

901.3.2 Cement Content

When Ordinary Portland Cement (OPC) is used the quantity of cement shall not be less than 360 kg/cu.m. In case fly ash grade I (as per IS:3812) is blended at site as part replacement of cement, the quantity of fly ash shall be upto 20 percent by weight of cementitious material and the quantity of OPC in such a blend shall not be less than 310 kg/cu.m. The minimum of OPC content, in case ground granulated blast furnace slag cement blended, shall also not be less than 310 kg/m³. If this minimum cement content is not sufficient to produce concrete of the specified strength, it shall be increased as necessary by the contractor at his own cost.

901.3.3 Concrete Strength

901.3.3.1 602.3.3.1 The characteristic flexural strength of concrete shall not be less than 4.5 MPa unless specified otherwise. Target mean flexural strength for mix design shall be more than $4.5 \text{ MPa} + 1.65s$, where s is standard deviation of flexural strength derived by conducting test on minimum 30 beams. While designing the mix in the laboratory, correlation between flexural and compressive strengths of concrete shall be established on the basis of at least thirty tests on specimens. However, quality control in the field shall be exercised on the basis of flexural strength. It may, however, be ensured that the materials and mix proportions remain substantially unaltered during the daily concrete production. The water content shall be the minimum required to provide the agreed workability for full compaction of the concrete to the required density as determined by the trial mixes or as approved by the Engineer and the maximum free water cement ratio shall be 0.45 when only OPC is used and 0.50 when blended cement (Portland Pozzolana Cement or Portland Slag Cement or OPC blended with fly ash or Ground Granulated Blast Furnance Slag, at site) is used.

901.3.3.2 The ratio between the 7 and 28 day strength shall be established for the mix to be used in the slab in advance, by testing pairs of beams and cubes at each stage on at least six batches of trial mix. The average strength of the 7 day cured specimens shall be divided by the average strength of the 28 day specimens for each batch, and the ratio 'R' shall be determined. The ratio 'R' shall be expressed to three decimal places.

901.3.3.3 If during the construction of the trial length or during some normal working, the average value of any four consecutive 7 day test results falls below the required 7 day strength as derived from the value of 'R' then the cement content of the concrete shall, without extra payment, be increased by 5 percent by weight or by an amount agreed by the Engineer. The increased cement content shall be maintained at least until the four corresponding 28 day strengths have been assessed for in conformity with the requirements as per Clause 6023.3.1. Whenever the cement content is increased, the concrete mix shall be adjusted to maintain the required workability.

901.3.4 Workability

901.3.4.1 The workability of the concrete at the point of placing shall be adequate for the concrete to be fully compacted and finished without undue flow. The optimum

workability for the mix to suit the paving plant being used shall be determined by the Contractor and approved by the Engineer. The control of workability in the field shall be exercised by the slump test as per IS: 1199.

- 901.3.4.2** The workability requirement at the batching and mixing plant and paving site shall be established by slump tests carried during trial paving. These requirements shall be established from season to season and also when the lead from batching and mixing plant site to the paving site changes. The workability shall be established for the type of paving equipment available. A slump value in the range of 25 ± 15 mm is reasonable for paving works but this may be modified depending upon the site requirement and got approved by the Engineer. These tests shall be carried out on every tipping truck/dumper at batching and mixing plant site and paving site initially when the work commences but subsequently the frequency can be reduced to alternate tipping trucks or as per the instructions of the Engineer.

901.3.5 Design Mix

- 901.3.5.1** The Contractor shall carry out laboratory trials of design mix with the materials from the approved sources to be used as per IRC:44. Trial mixes shall be made in presence of the Engineer or his representative and the design mix shall be subject to the approval of the Engineer. They shall be repeated, if necessary, until the proportions, that will produce a concrete which complies in all respects with these Specifications and conform to the requirements of the design/drawings.

- 901.3.5.2** The proportions determined as a result of the laboratory trial mixes may be adjusted, if necessary, during the construction of the trial length. Thereafter, neither the materials nor the mix proportions shall be varied in any way except with the written approval of the Engineer.

- 901.3.5.3** Any change in the source of materials or mix proportions proposed by the Contractor during the course of work shall be assessed by making laboratory trial mixes and the construction of a further trial length of length not less than 50 m unless approval is given by the Engineer for minor adjustments like compensation for moisture content in aggregates or minor fluctuations in the grading of aggregate.

901.4 Sub-base

The cement concrete pavement shall be laid over the sub-base constructed in accordance with the relevant drawings and Specifications. It shall be ensured that the sub-base is not damaged before laying the concrete pavement. If the dry lean concrete sub-base is found damaged at some places or it has cracks wider than 10 mm, it shall be repaired with fine cement concrete (aggregate size 10 mm and down) or bituminous concrete before laying separation membrane layer.

901.5 Separation Membrane

A separation membrane shall be used between the concrete slab and the sub-base. Separation membrane shall be impermeable PVC sheet 125 micron thick transparent or white in colour laid flat with minimum creases. Before placing the separation membrane, the sub-base shall be swept clean of all the extraneous materials using air compressor. Wherever overlap of plastic sheets is necessary, the same shall be at least 300 mm and any damaged sheathing shall be replaced at the Contractor's cost. The separation membrane may be nailed to the lower layer with concrete nails. The separation membrane shall be omitted when two layers of wax-based curing compound is used.

901.6 Joints

901.6.1 The locations and type of joints shall be as shown in the drawing. Joints shall be constructed depending upon their functional requirement. The location of the joints should be transferred accurately at the site and mechanical saw cutting of joints done as per stipulated dimensions. It shall be ensured that the required depth of cut is made from edge-to-edge of the pavement. Transverse and longitudinal joints in the pavement and Dry Lean Concrete sub-base shall be staggered so that they are not coincident vertically and are at least 800 to 1000 mm and 300 to 400 mm apart respectively. Sawing of joints shall be carried out with diamond studded blades soon after the concrete has hardened to take the load Of the sawing machine and crew members without damaging the texture of the pavement.

Sawing operation could start as early as 4-8 hours after laying of concrete pavement but not later than 8 to 12 hours depending upon the ambient temperature, wind velocity, relative humidity and required maturity of concrete achieved for this purpose.

When the kerb is cast integrally with the main pavement slab, the joint cutting shall also be extended to the kerb.

Where the use of maturity meter is specified, sawing should not be initiated when the compressive strength of the concrete is less than 2 MPa and should be completed before it attains the compressive strength of 7 MPa.

901.6.2 Transverse Joints

901.6.2.1 Transverse joints shall be contraction, construction and expansion joints constructed at the spacing described in the drawings. Transverse joints shall be straight within the following tolerances along the intended line of joints.

- i. Deviations of the performed filler board (IS: 1838) in the case of expansion joints from the intended line of the joint shall not be greater than ± 10 mm.
- ii. The best fit straight line through the joint grooves as constructed shall be not more than 25 mm from the intended line of the joint.
- iii. Deviations of the joint groove from the best fit straight line of the joint shall not be greater than 10 mm.

- iv. Transverse joints on each side of the longitudinal joint shall be in line with each other and of the same type and width. Transverse joints shall have a sealing groove which shall be sealed in compliance with Clause 602.10.

901.6.2.2 Contraction Joints

The contraction joints shall be placed transversely at pre-specified locations as per drawings/design using dowel bars. These joints shall be cut as soon as the concrete has undergone initial hardening and is hard enough to take the load of joint sawing machine without causing damage to the slab.

Contraction joints shall consist of a mechanical sawn joint groove, 3 to 5 mm wide and one-fourth to one-third depth of the slab $\pm$ 5 mm or as stipulated in the drawings and dowel bars complying with Clause 602.6.5.

Contraction joint shall be widened subsequently to accommodate the sealant as per Clause 602.10, to dimensions shown on drawings or as per IRC:57.

901.6.2.3 Expansion Joints

The expansion joint shall consist of a joint filler board complying with Clause 602.2.9 and dowel bars complying with Clause 602.6.5 and as detailed in the drawings. The filler board shall be positioned vertically with the prefabricated joint assemblies along the line of the joint within the tolerances given in Clause 602.6.2.1. The adjacent slabs shall be completely separated from each other by the joint filler board.

901.6.2.4 Transverse Construction Joint

Transverse construction joint shall be placed whenever concreting is completed after a day's work or is suspended for more than 30 minutes. These joints shall be provided at location of contraction joints using dowel bars. If sufficient concrete has not been mixed to form a slab extending up to a contraction joint, and if an interruption occurs, the concrete placed shall be removed up to the last preceding joint and disposed of. At all construction joints, steel bulk heads shall be used to retain the concrete. The surface of the concrete laid subsequently shall conform to the grade and cross sections of the previously laid pavement. When positioning of bulkhead/stop-end is not possible, concreting to an additional 1 or 2 m length may be carried out to enable the movement of joint cutting machine so that joint grooves may be cut and the extra 1 or 2 m length is cut out and removed subsequently after concrete has hardened.

After minimum 14 days of curing, in case OPC cement is used and 16 days of curing when fly ash or blended cement is used, the construction joint shall be widened to accommodate the sealant as per Clause 602.10 to dimensions shown on drawing or as per IRC:57.

901.6.3 Longitudinal Joint

- 901.6.3.1** The longitudinal joints shall be constructed by forming or by sawing as per details of the joints shown in the drawing. Sawed longitudinal joints shall be constructed when the concrete pavement placement width exceeds 4.5 m. The groove may be

cut after the final set of the concrete. Joints should be sawn to at least one-third the depth of the slab ± 5 mm as indicated in the drawing. The joint shall be widened subsequently to dimensions shown on the drawings.

Where adjacent lanes of pavement are constructed separately using slip form pavers or side forms, the tie bars may be bent at right angles against the vertical face/ side of the first lane constructed and straightened before placing concrete in the adjacent lane. Broken or damaged tie bars shall be repaired or replaced as required.

The groove for sealant shall be cut in the pavement lane placed later.

901.6.3.2 Tie Bars

Tie bars shall be provided at the longitudinal joints as per dimensions and spacing shown in the drawing and in accordance with Clause 602.6.6. The direction of the tie bars at curves shall be radial in the direction of the radius.

901.6.4 Dowel Bars

901.6.4.1 Dowel bars shall be mild steel rounds in accordance with Clause 602.2.8 with details/dimensions as indicated in the drawings and free from oil, dirt, loose rust or scale. They shall be straight, free of irregularities and burring restricting slippage in the concrete. The sliding ends shall be sawn or cropped cleanly with no protrusions outside the normal diameter of the bar. Any protrusions shall be removed by grinding the ends of the dowel bars. The dowel bar shall be supported on cradles/dowel chairs in pre-fabricated joint assemblies positioned prior to the construction of the slabs or mechanically inserted with vibration into the plastic concrete by a method which ensures correct placement of the bars besides full re-compaction of the concrete around the dowel bars.

901.6.4.2 Unless shown otherwise on the drawings, dowel bars shall be positioned at mid depth of the slab within a tolerance of ± 20 mm, and centered equally about intended lines of the joint within a tolerance of ± 25 mm. They shall be aligned parallel to the finished surface of the slab and to the centre line of the carriageway and to each other within tolerances given here-in-under, the compliance of which shall be checked as per Clause 602.11.7.

(i) For bars supported on cradles prior to the laying of the slab:

- a) All bars in a joint shall be within ± 2 mm per 300 mm length of bar
 - b) 2/3rd of the number of bars shall be within ± 3 mm per 500 mm length of bar
 - c) No bar shall differ in alignment from an adjoining bar by more than mm per 300 mm length of bar in either the horizontal or vertical plane
 - d) Cradles supporting dowel bar shall not extend across the line of joint i.e. no steel bar of the cradle assembly shall be continuous across the joint.
- (ii) For all bars inserted after laying of the slab except those inserted by a Dowel Bar Inserter the tolerance for alignment may be twice as indicated in (i) above.

The transverse joints at curves shall be radial in the direction of the radius

901.6.4.3 Dowel bars, supported on cradles in assemblies, when subject to a load of 110 N applied at either end and in either the vertical or horizontal direction (upwards and downwards and in both directions horizontally) shall conform to be within the limits given in Clause 602.6.5.2.

901.6.4.4 The assembly of dowel bars and supporting cradles, including the joint filler board in the case of expansion joints, shall have the following degree of rigidity when fixed in position: -

- i. For expansion joints, the deflection of the top edge of the filler board shall be not greater than 13 mm, when a load of 1.3 kN is applied perpendicular to the vertical face of the joint filler board and distributed over a length of 600 mm by means of a bar or timber packing, at mid depth and midway between individual fixings, or 300 mm from either end of any length of filler board, if a continuous fixing is used. The residual deflection after load shall be not more than 3 mm.
- ii. The fixings for joint assembly shall not fail under 1.3 kN load and shall fail before the load reaches 2.6 kN when applied over a length of 600 mm by means of a bar or timber packing placed as near to the level of the line of fixings as practicable.
- iii. Fixings shall be deemed to fail when there is displacement of the assemblies by more than 3 mm with any form of fixing, under the test load. The displacement shall be measured at the nearest part of the assembly to the centre of the bar or timber packing.

901.6.4.5 Dowel bars in the contraction joints, construction joints and expansion joints shall be covered by a thin plastic sheath. The thickness of the sheath shall not exceed 0.5 mm and shall be tightly fitted on the bar for at least two-thirds of the length from one end for dowel bars in contraction/construction joints and half the length plus 50 mm for expansion joints. The sheathed bar shall comply with the following pull-out tests:

Four bars shall be taken at random from stock and without any special preparation shall be covered by sheaths as required in this Clause. The ends of the dowel bars which have been sheathed shall be cast centrally into concrete specimens 150 mm x 150 mm x 600 mm, made of the same mix proportions to be used in the pavement, but with a maximum nominal aggregate size of 20 mm and cured in accordance with IS:516. At 7 days a tensile load shall be applied to achieve a movement of the bar of at least 0.25 mm. The average bond stress to achieve this movement shall not be greater than 0.14 MPa.

901.6.4.6 For expansion joints, a closely fitting cap 100 mm long consisting of waterproofed cardboard or an approved synthetic material like PVC or GI pipe shall be placed over the sheathed end of each dowel bar. An expansion space (about 25 mm) at least equal in length to the thickness of the joint filler board shall be formed between the end of the cap and the end of the dowel bar by using compressible sponge. To block the entry of cement slurry into the annular space between the sheathing and dowel bar shall be taped around its mouth.

901.6.5 Tie Bars

901.6.5.1 Tie bars in longitudinal joints shall be deformed steel bars of strength . 500 MPa complying with IS: 1786 and in accordance with the requirements given in this Clause. The bars shall be free from oil, dirt, loose rust and scale.

Bars projecting across the longitudinal joint shall be protected from corrosion for 75 mm on each side of the joint by a protective coating of bituminous paint with the approval of the Engineer. The coating shall be dry when the tie bars are used.

901.6.5.2 Tie bars in longitudinal joints shall be made up into rigid assemblies with adequate supports and fixings to remain firmly in position during the construction of the slab. Alternatively, tie bars at longitudinal joints may be mechanically or manually inserted into the plastic concrete from above by vibration using a method which ensures correct placements of the bars and recompaction of the concrete around the tie bars.

901.6.5.3 Tie bars shall be positioned to remain in the middle from the top or within the upper middle third of the slab depth as indicated in the drawings and approximately parallel to the surface and approximately perpendicular to the line of the joint, with the centre of each bar on the intended line of the joints within a tolerance of mm, and with a minimum cover of 30 mm below the joint groove. Spacing of tie bars on curves of radius less than 360 m shall not be less than 350 mm.

901.6.5.4 To check the position of the tie bars, one metre length, 0.5 m on either side of the longitudinal joint shall be opened when the concrete is green (within 20 to 30 minutes). The pit shall be refilled with the fresh concrete of same mix after checking.

901.7 Weather and Seasonal Limitations

901.7.1 Concreting during Monsoon Months

Concreting should be avoided during rainy season. However, when concrete is being placed during monsoon months and when it may be expected to rain, sufficient supply of tarpaulin or other waterproof cloth shall be provided along the line of the work. Any time when it rains, all freshly laid concrete which had not been covered for curing purposes shall be adequately protected. Any concrete damaged by rain shall be removed and replaced. If the damage is limited to texture, it shall be retextured in accordance with the directions of the Engineer.

901.7.2 Temperature Limitation

No concreting shall be done when the temperature of the concrete reaching the paving site is above 30°C. Besides, in adverse conditions like high temperature, low relative humidity, excessive wind velocity, imminence of rains etc., tents on mobile trusses may be provided over the freshly laid concrete for a minimum period of 3 hours as directed by the Engineer. To bring down the temperature, if necessary, chilled water or ice flakes should be made use of. When the ambient temperature is more than 35°C, no concreting shall be permitted. The ice flakes

should not be manufactured from chlorinated water. Generally the rate of evaporation of water shall not exceed 1 kg/sqm/hour as per IRC: 15.

No concreting shall be done when the concrete temperature is below 50C and the temperature is further falling.

901.8 Fixed Form Paving

901.8.1 Side Forms and Rails

These shall be provided in case of fixed form paving. All side forms shall be of mild steel of depth equal to the thickness of pavement or slightly less to accommodate the surface irregularity of the sub-base. The forms can be placed in series of steel packing plates or shims to take care of irregularity of sub-base. They shall be sufficiently robust and rigid to support the weight and pressure caused by a paving equipment. Side forms for use with wheeled paving machines shall incorporate metal rails firmly fixed at a constant height below the top of the forms. The forms and rails shall be firmly secured in position by not less than 3 stakes/pins for every 3 m length so as to prevent movement in any direction. Forms and rails shall be straight within a tolerance of 3 mm in 3 m and when in place shall not settle in excess of 1.5 mm in 3 m while paving is being done. Forms shall be cleaned and oiled immediately before each use. The forms shall be bedded on a continuous bed of low moisture content lean cement mortar or concrete and set to the line and levels shown on the drawings within tolerances mm and ± 3 mm respectively. The bedding shall not extend under the slab and there shall be no vertical step between adjacent forms of more than 3 mm. The forms shall be got inspected by the Engineer for his approval 12 hours before construction of the slab and shall not be removed until at least 12 hours afterwards. No concreting shall commence till formwork has been approved by the Engineer.

901.8.2 At all times sufficient forms shall be used and set to the required alignment for at least 300 m length of pavement immediately in advance of the paving operations, or the anticipated length of pavement to be laid within the next 24 hours whichever is more.

901.8.3 Slip Form Paving

901.8.3.1 Use of Guidewires

Where slip form paving is proposed, a guidewire shall be provided along both sides of the slab. Each guidewire shall be at a constant height above and parallel to the required edges of the slab as described in the contract drawing within a vertical tolerance of ± 3 mm. Additionally, one of the wires shall be kept at a constant horizontal distance from the required edge of the pavement as indicated in the contract drawing within a lateral tolerance of ± 10 mm.

901.8.3.2 The guidewires shall be supported on stakes 5—6 m apart by connectors capable of fine horizontal and vertical adjustment. The guidewire shall be tensioned on the stakes so that a 500 gm weight shall produce a deflection of not more than 20 mm when it is suspended at the mid point between any pair of stakes. The ends of the

guidewires shall be anchored to fixing point or winch and not on the stakes. On the curves, the stakes shall be fixed at not more than 3 m centre-to-centre.

- 901.8.3.3** The stakes shall be positioned and hammered into the ground and the connectors will be maintained at their correct height and alignment from 12 hours on the day before concreting takes place till after finishing of texturing and spraying of curing compound on the concrete.

However, the guidewire shall be erected and tensioned on the connectors at any section for or at least 2 hours before concreting that section.

- 901.8.3.4** The Contractor shall submit to the Engineer for his approval of line and level, the stakes and connectors which are ready for use in the length of road to be constructed 13 next day. Such approval shall be obtained atleast 12 hours before commencement of paving operation. Any deficiencies noted by the Engineer shall be rectified by the Contractor who shall then re-apply for approval of the affected stakes. Work shall not proceed until the Engineer has given his approval. It shall be ensured that the stakes and guidewires are not affected by the construction equipment when concreting is in progress.

901.9 Construction

901.9.1 General

A systems approach may be adopted for construction of the pavement, and the Method Statement for carrying out the work, detailing all the activities, indication of time-cycle, equipment, personnel etc., shall be got approved from the Engineer before the commencement of the work. This shall include the type, capacity and make of the batching and mixing plant besides the hauling arrangement and paving equipment. The capacity of paving equipment, batching plant as well as all the ancillary equipment shall be adequate for a paving rate of atleast 500 m in one day. The paving speed of slip-form paver shall not be less than 1.0 m per minute. The concreting should proceed continuously without stops and starts.

901.9.2 Batching and Mixing

Batching and mixing of the concrete shall be done at a central batching and mixing plant with automatic controls, located at a suitable place which takes into account sufficient space for stockpiling of cement, aggregates and stationary water tanks. This shall be located at an approved distance, duly considering the properties of the mix and the transporting arrangements available with the Contractor.

901.9.3 Equipment for Proportioning of Materials and Paving

- 901.9.3.1** Proportioning of materials shall be done in the batching plant by weight, each type of material being weighed separately. The cement from the bulk stock may be weighed separately from the aggregates. Water shall be measured by volume.

Specified percentage of plasticizer in volume will be added by weight of cement. Wherever properly graded aggregate of uniform quality cannot be maintained as envisaged in the mix design, the grading of aggregates shall be controlled by appropriate blending techniques. The capacity of batching and mixing plant shall be at least 25 percent higher than the proposed capacity of the laying/paving equipment.

901.9.3.2 Batching Plant and Equipment:

- 1) **General:** The batching plant shall include minimum four bins, weighing hoppers, and scales for the fine aggregates and for each size of coarse aggregate. If cement is used in bulk, a separate scale for cement shall be included. There shall be a separate bin for flyash, if this additive is specified. The weighing hoppers shall be properly sealed and vented to preclude dust during operation. Approved safety devices shall be provided and maintained for the protection of all personnel engaged in plant operation, inspection and testing. The batch plant shall be equipped with a suitable non-resettable batch counter which will correctly indicate the number of batches proportioned. A continuous type of mixing plant can also be used provided the ingredients are weighed through electronic sensors before feeding.
- 2) **Automatic weighing devices:** Batching plant shall be equipped to proportion aggregates and bulk cement by means of automatic weighing devices using load cells. The weighing devices shall have an accuracy within $\pm 1\%$ in respect of quantity of cement, admixtures and water and $\pm 2\%$ in respect of aggregates and the accuracy shall be checked at least once a month.
- 3) **Mixer:** Mixers shall be pan type, reversible type or any other mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period, and of discharging the mix, without segregation. Each stationary mixer shall be equipped with an approved timing device which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The device shall be equipped with a bell or other suitable warning device adjusted to give a clearly audible signal each time the lock is released. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed in 90 seconds or as per the manufacturer's recommendation. The mixer shall be equipped with a suitable non-resettable batch counter which shall correctly indicate the number of batches mixed.

The mixer shall be cleaned at suitable intervals. The pick-up and throw-over blades in the drum or drums shall be repaired or replaced when they are worn down 20 mm or more. The Contractor shall (1) have available at the job site a copy of the manufacturer's design, showing dimensions and arrangements of blades in reference to original height and depth, or (2) provide permanent marks on blade to show points of 20 mm wear from new conditions. Drilled holes of 5 mm diameter near each end and at midpoint of each blade are recommended. Batching Plant shall be calibrated in the beginning and thereafter at suitable interval not exceeding 1 month.
- 4) **Control 'cabin':** An air-conditioned centralized computer control cabin shall be provided for automatic operation of the equipment.
- 5) The design features of the batching plant should be such that it can be shifted quickly.

901.9.3.3 Paving Equipment

The concrete shall be placed with an approved fixed form or slip form paver with independent units designed to (i) spread, (ii) consolidate, screed and float-finish, (iii) texture and cure the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary and so as to provide a dense and homogeneous pavement in conformity with the plans and Specifications. The paver shall be equipped with electronic sensor controls to control the line and grade from either one side or both sides of the machine.

Vibrators shall operate at a frequency of 8000-10000 impulses per minute under load at a maximum spacing of 600 mm. The variable vibration setting shall be provided in the machine.

901.9.4 Concrete Saw

The Contractor shall provide adequate number of concrete saws with sufficient number of diamond-edge saw blades. The saw machine shall be either electric or petrol/diesel driven type. A water tank with flexible hose and pump shall be made available for this activity on priority basis. The Contractor shall have at least one standby saw in good working condition. The concreting work shall not commence if the saws are not in working condition.

901.9.5 Hauling and Placing of Concrete

901.9.5.1 Freshly mixed concrete from the central batching and mixing plant shall be transported to the paver site by means of tipping trucks or transit mixers of sufficient capacity and approved design in sufficient numbers to ensure a constant supply of concrete. Covers shall be used for protection of concrete against the weather. While loading the concrete truck shall be moved back and forth under the discharge chute to prevent segregation. The tipping trucks shall be capable of maintaining the mixed concrete in a homogeneous state and discharging the same without segregation and loss of cement slurry. The feeding to the paver is to be regulated in such a way that the paving is done in an uninterrupted manner with a uniform speed throughout the day's work. Tipping trucks shall be washed at a regular frequency as prescribed by the Engineer to ensure that no left-over mix of previous loading remains stuck.

901.9.5.2 Placing of Concrete

The total time taken from the addition of the water to the mix, until the completion of the surface finishing and texturing shall not exceed 120 minutes when concrete temperature is less than 25°C and 90 minutes when the concrete temperature is between 25°C and 30°C. When the time between mixing and laying exceeds these values, the concrete shall be rejected and removed from the site. Tipping trucks delivering concrete shall normally not run on plastic sheathing nor shall they run on completed slabs until after 28 days of placing the concrete.

The placing of concrete in front of the PQC paver should preferably be from the side placer to avoid damage to DLC by concrete tipping trucks. In case of unavoidable situation, truck supplying concrete to the paver may be allowed to ply on the DLC with the approval of the

Engineer. The paver shall be capable of paving the carriageway as shown in the drawings, in a single pass and lift.

901.9.5.3 Where fixed form pavers are to be used, forms shall be fixed in advance as per Clause 602.8. Before any paving is done, the site shall be shown to the Engineer, in order to verify the arrangement for paving besides placing of dowels, tie-bars etc., as per the relevant Clauses of these Specifications. The mixing and placing of concrete shall progress only at such a rate as to permit proper finishing, protecting and curing of the concrete in the pavement.

901.9.5.4 In areas inaccessible to paving equipment, the pavement shall be constructed using side forms, as per Clause 602.9.7.

901.9.5.5 In all cases, the temperature of the concrete shall be measured at the point of discharge from the delivery vehicle.

901.9.5.6 The addition of water to the surface of the concrete to facilitate the finishing operations will not be permitted except with the approval of the Engineer when it shall be applied as a mist by means of approved equipment.

901.9.5.7 If considered necessary by the Engineer, the paving machine shall be provided with approved covers to protect the surface of the slab under construction direct sunlight and rain or hot wind.

901.9.5.8 While the concrete is still plastic, its surface shall be textured by brush or tines as per the instructions of the engineer in compliance with Clause 602.9.11. The surface and edges of the slab shall be cured by the application of a sprayed liquid curing membrane in compliance with Clause 602.9.12. After the surface texturing, but before the curing compound is applied, the concrete slab shall be marked with the chainage at every 100 m interval by embossing.

901.9.5.9 As soon as the side forms are removed, edges of the slabs shall be corrected wherever irregularities have occurred by using fine concrete composed of 1:1:2, cement: sand: coarse agg (10 mm down) with water cement ratio not more than 0.4 under the supervision of the Engineer.

901.9.5.10 If the requirement of Clause 902.4. for surface regularity fails to be achieved on two consecutive working days, then normal working shall cease until the cause of the excessive irregularity has been identified and remedied.

901.9.6 Construction by Slip Form Paver

901.9.6.1 The slip form paving train shall consist of a power machine which spreads, compacts and finishes the concrete in a continuous operation. The slip form paving machine shall compact the concrete by internal vibration and shape it between the side forms with either a conforming plate or by vibrating and oscillating finishing beams. The concrete shall be provided with approved covers to protect the surface of

the slab under construction from be deposited without segregation in front of slip form paver across the whole width and to a height which at all times is in excess of the required surcharge. The deposited concrete shall be struck off to the necessary average and differential surcharge by means of the strike off plate or a screw auger device extending across the whole width of the slab. The equipment for striking-off the concrete shall be capable of being rapidly adjusted for changes of the average and differential surcharge necessitated by change in slab thickness or crossfall.

- 901.9.6.2** The level of the conforming plate and finishing beams shall be controlled automatically from the guide wires installed as per Clause 602.8 by sensors attached at the four corners of the slip form paving machine. The alignment of the paver shall be controlled automatically from the guide wire by at least one set of sensors attached to the paver. The alignment and level of ancillary machines for finishing, texturing and curing of the concrete shall be automatically controlled relative to the guide wire or to the surface and edge of the slab.
- 901.9.6.3** Slip-form paving machines shall have vibrators of variable output, with a maximum energy output of not less than 2.5 KW per metre width of slab per 300 mm depth of slab for a laying speed upto 1.5 m per minute. The machines shall be of sufficient mass to provide adequate reaction during spreading and paving operations on the traction units to maintain forward movements during the placing of concrete in all situations. Normal paving speed shall be maintained as per Clause 602.9.1.
- 901.9.6.4** If the edges of the slip formed slab slump to the extent that the surface of the top edge of the slab does not comply with the requirements of Clause 902.3, the work shall be stopped until such time as the Contractor can demonstrate his ability to slip form the edges to the required levels. The deficient edge shall be temporarily supported by a side form and the thickness deficiency shall be made good by adding fresh concrete to the newly formed edge and compacting.
- 901.9.6.5** Slip-form pavers with adequate width to pave the entire carriageway width in one go shall be employed unless specified in the Contract. In situations where full-width paving is not possible, paving in part widths may be permitted by the Engineer. Paving in part will be avoided, except in unavoidable circumstances. In case of part width paving, care shall be taken to ensure that while laying the next lane, bond between the remaining half length of tie bar or subsequently inserted tie bars and the newly laid concrete is adequately developed. Care shall be taken to avoid damage to the previous lane.
- 901.9.6.6** In case paving in separate lanes is allowed, work on the adjacent lane shall be permitted when the previously paved lane is cured for at least 14 days and is in a position to bear the weight of paving machine. When the wheels or crawler tracks are to ply on the already paved surface, necessary precautions shall be taken by placing protective pads of rubber or similar material so that texture is not damaged. The wheel or track shall be reasonably away from the edge to avoid damage to the previously laid slab.

901.9.6.7 Tube Floating

Upon the instructions of the Engineer, Contractor shall scrape the concrete surface when in plastic state with a 3 m long tube float fixed with a long and stable handle before texturing. Tube float shall be of an alloy steel tube of 50 to 60 mm diameter with a long and stable handle. The length of tube float shall preferably be longer than half the length of slab i.e., half the distance between two transverse contraction joints. This operation shall be done to 6 minimise surface irregularity caused due to varied causes like frequent stoppages of work, surface deformation due to plastic flow etc. The tube float shall be placed at the centre of the slab parallel to longitudinal joint and pulled slowly and uniformly towards the edges. After the use of float tube, it shall be frequently cleaned before further use. The slurry removed shall be discarded. This activity shall be advanced laterally by providing an overlap of half the length of tube float. The removal of the cement slurry from the surface shall be sufficient enough such that the texture is formed on a firm surface and is more durable. This operation, however, shall be carried out after removing bleeding water.

901.9.7 Construction by Fixed Form Paver

901.9.7.1 The fixed form paving train shall consist of separate powered machines which spread, compact and finish the concrete in a continuous operation.

901.9.7.2 The concrete shall be discharged without segregation into a hopper spreader which is equipped with means for controlling its rate of deposition on to the sub-base. The spreader shall be operated to strike off concrete upto a level requiring a small amount of cutting down by the distributor of the spreader. The distributor of spreader shall strike off the concrete to the surcharge adequate to ensure that the vibratory compactor thoroughly compacts the layer. If necessary, poker vibrators shall be used adjacent to the side forms and edges of the previously constructed slab. The vibratory compactor shall be set to strike off the surface slightly high so that it is cut down to the required level by the oscillating beam. The machine shall be capable of being rapidly adjusted for changes in average and differential surcharge necessitated by changes in slab thickness or crossfall. The final finisher shall be able to finish the surface to the required level and smoothness as specified, care being taken to avoid bringing up of excessive mortar to the surface by over working.

901.9.8 Semi-mechanised Construction

Areas in which hand-guided methods of construction become indispensable shall be got approved by the Engineer in writing in advance. Such work may be permitted only in restricted areas in small lengths. Work shall be carried out by skilled personnel as per methods approved by the Engineer. The acceptance criteria regarding level, thickness, surface regularity, texture, finish, strength, of concrete and all other quality control measures shall be the same as in the case of machine laid work. Guidelines on the use of plants, equipment, tools, hauling of mix, compaction floating, straight edging, texturing, edging etc. shall be as per IRC: 15.

901.9.9 Transition Slab

At the interface of rigid and flexible pavement, at least 3 m long reinforced buried slab shall be provided to give a long lasting joint at the interface. The details shall be as given in IRC: 15.

901.9.10 Anchor Beam and Terminal Slab Beam Adjoining Bridge Structures

RCC anchor beams shall be provided in the terminal slab adjoining bridge structures as per drawings and IRC:15.

901.9.11 The Treatment of Concrete Pavement on Culverts

The concrete pavement shall be taken over the culverts. At both ends of the culvert slab, a contraction joint shall be provided in the concrete pavement. Nominal reinforcement of 10 mm dia bars at 150 mm spacing in both directions shall be provided at 50 mm below the top of the slab. The reinforcement shall be stopped 50 mm short of the contraction joint. Such reinforcement shall also be provided in the next slab panel on either side.

901.9.12 Surface Texture

901.9.12.1 Tining

After final floating and finishing of the slab and before application of the liquid curing membrane, the surface of concrete slabs shall be textured either in the transverse direction (i.e., at right angles to the longitudinal axis of the road) or in longitudinal direction (i.e., parallel to the centreline of the roadway). The texturing shall be done by tining the finished concrete surface by using rectangular steel tines. A beam or a bridge mounted with steel tines shall be equipped and operated with automatic sensing and control devices from main paver or auxiliary unit. The tining unit shall have facility for adjustment of the download pressure on the tines as necessary to produce the desired finish. The tining rakes shall be cleaned often to remove snots of slurry. The tines shall be inspected daily and all the damaged and bent tines shall be replaced before commencing texturing. Tined grooves shall be 3 mm wide and 3 to 4 mm deep. Before commencing texturing, the bleeding water, if any, shall be removed and texturing shall be done on a firm surface. The measurement of texture depth shall be done as per Clause 602.12.

- a) **Transverse tining** : When the texturing is specified in transverse direction, a beam of at least 3 m length mounted with tines shall be moved in transverse direction to produce the texture. The grooves produced shall be at random spacing of grooves but uniform in width and depth. The spacing shall conform to a pattern shown below:

Random spacing in mm



The above pattern shall be repeated. Texturing shall be done at the right time such that the grooves after forming shall not close and they shall not get roughened. Swerving of groove patterns will not be permitted. The completed textured surface shall be uniform in appearance.

- b) **Longitudinal tining:** Longitudinal tining shall be done, if specified in the Contract. The texturing bridge shall be wide enough to cover the entire width of the carriageway but within 75 mm from the pavement edge. The centre to centre spacing between the tines shall be 18 to 21 mm. The width of tine texture shall be 3 mm and depth shall be 3 to be 4 mm.

901.9.12.2 Brush Texturing

Alternatively, the instructions of the Engineer, the brush texturing shall be applied. The Alternatively brushed surface texture shall be applied evenly across the slab in one direction by the use of a wire brush not less than 450 mm wide but wider brushes normally of 3 m length are preferred. The brush shall be made of 32 gauge tape wires grouped together in tufts placed at 10 mm centres. The tufts shall contain an average of 14 wires and initially be 1 00 mm long. The brush shall have two rows of tufts. The rows shall be 20 mm apart and the tufts in one row shall be opposite the centre of the gap between tufts in the other row. The brush shall be replaced when the shortest tuft wears down to 90 mm long.

The texture depth shall be determined by the Sand Patch Test as described in the Clause 602.12. This test shall be performed at least once for each day's paving and wherever the Engineer considers it necessary at times after construction as under:

Five individual measurements of the texture depth shall be taken at least 2 m apart anywhere along a diagonal line across a lane width between points 50 m apart along the pavement. No measurement shall be taken within 300 mm of the longitudinal edges of a concrete slab constructed in one pass.

Texture depths shall not be less than the minimum required depth when measurements are taken as given in Table 600-5 nor greater than an average of 1.25 mm.

Table 600-5: Texture Depth

Sl. No.	Texture Depth (mm)	Texture Depth (mm)	Texture Depth (mm)	Texture Depth (mm)
1	1.0	1.0	1.0	1.0
2	1.0	1.0	1.0	1.0
3	1.0	1.0	1.0	1.0
4	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0
6	1.0	1.0	1.0	1.0
7	1.0	1.0	1.0	1.0
8	1.0	1.0	1.0	1.0
9	1.0	1.0	1.0	1.0
10	1.0	1.0	1.0	1.0

After the application of the brushed texture, the surface of the slab shall have a uniform appearance.

Where the texture depth requirements are found to be deficient, the Contractor shall make good the texture across the full lane width over the length directed by the Engineer, by retexturing the hardened concrete surface in an approved manner.

901.9.13 Curing

901.9.13.1 Immediately after the surface texturing, the surface and sides of the slab shall be cured by the application of approved resin-based aluminized reflective curing compound which hardens into an impervious film or membrane with the help of mechanical sprayer.

901.9.13.2 The curing compound shall not react chemically with the concrete and the film or membrane shall not crack, peel or disintegrate within three weeks of application. Immediately prior to use, the curing compound shall be thoroughly agitated in its containers. The rate of spread shall be in accordance with the manufacturer's instructions checked during the construction of the trial length and subsequently whenever required by the Engineer. The mechanical sprayer shall incorporate an efficient mechanical device for continuous agitation and mixing of the compound during spraying. The curing compound shall be sprayed in two applications to ensure uniform spread.

Curing compounds shall contain sufficient flake aluminium in finely divided dispersion to produce a complete coverage of the sprayed surface with a metallic finish. The compound shall become stable and impervious to evaporation of water from the surface of the concrete within 60 minutes of application and shall be of approved type. The curing compounds shall have a water retention efficiency index not less than 90 percent in accordance with BS Specification No. 7542 or as per ASTM C-309-81 Type 2.

901.9.13.3 In addition to spraying of curing compound, the fresh concrete surface shall be protected for at least 3 hours by covering the finished concrete pavement with tents mounted on mobile trusses as described in Clause 602.7.2, during adverse weather conditions as directed by the Engineer. After three hours, the pavement shall be covered by moist hessian laid in two layers and the same shall then be kept damp for a minimum period of 14 days after which time the hessian may be removed. The hessian shall be kept continuously moist. All damaged/torn hessian shall be removed and replaced by new hessian on a regular basis.

901.9.13.4 The Contractor shall be liable at his cost to replace any concrete damaged as a result of incomplete curing or cracked on a line other than that of a joint as per procedure in IRC:SP:83.

901.10 Preparation and Sealing of Joint Grooves

901.10.1 General

All joints shall be sealed using sealants described in Clause 602.2.10.

901.10.2 Preparation of Joint Grooves for Sealing

901.10.2.1 Grooves are saw cut in the first instance just to provide minimum width (3-5 mm) to facilitate development of crack at joint locations, as shown in the drawing.

Subsequently before sealing, grooves are widened by sawing as per the dimensions in the drawing. Dimension of the grooves shall be controlled by depth/width gauge.

901.10.2.2 If rough arrises develop when grooves are made, they shall be ground to provide a chamfer approximately 5 mm wide. If the groove is at an angle upto 10^0 from the perpendicular to the surface, the overhanging edge of the groove shall be sawn or ground perpendicular. If spalling occurs or the angle of the former is greater than 10 degree, the joint sealing groove shall be sawn wider and perpendicular to the surface to encompass on. the defects upto a maximum width, including any chamfer, of 20 mm for transverse joints and 10 mm for longitudinal joints. If the spalling cannot be so eliminated then the arises shall be repaired by an approved thin bonded arises repair using cementitious/epoxy mortar materials.

901.10.2.3 All grooves shall be cleaned of any dirt or loose material by air blasting with filtered, oil-free compressed air. The Engineer shall instruct cleaning by pressurized water jets. Depending upon the requirement of the sealant manufacturer, the sides of the grooves to shall be sand blasted to increase the bondage between sealant and concrete.

901.10.2.4 The groove shall be cleaned and dried at the time of priming and sealing. If sand blasting is recommended by the supplier, the same shall be carried out.

901.10.2.5 Before sealing the temporary seal provided for blocking the ingress of dirt, soil etc., shall be removed. A highly compressible heat resistant paper-backed debonding be strip as per drawing shall be inserted in the groove to serve the purpose of breaking the ed bond between sealant and the bottom of the groove and to plug the joint groove so that the as sealant may not leak through the cracks. The width of debonding strip shall be more than the an joint groove width so that it is held tightly in the groove. In the case of longitudinal joints, heat ter resistant tapes may be inserted to block the leakage through bottom of the joint where hot All poured sealant is used. When cold poured sealant is used a debonding tape of 1.0-2.0 mm thickness and 6 to 8 mm width shall be inserted to plug the groove so that the sealant does not enter in the initially cut groove.

901.10.3 Sealing with Sealants

901.10.3.1 When sealants are applied, an appropriate primer shall also be used if recommended by the manufacturer and it shall be applied in accordance with his instructions. The sealant shall be applied within the minimum and maximum drying times of the primer recommended by the manufacturer. Priming and sealing with applied sealants shall not be carried out when the naturally occurring temperature in the joint groove to be sealed, is below 7oc.

- 901.10.3.2** If hot applied sealant is used it shall be heated and applied from a thermostatically controlled, indirectly heated preferably with oil jacketed melter and pourer th having recirculating pump and extruder. For large road projects, sealant shall be applied with extruder having flexible hose and nozzle. The sealant shall not be heated to temperature higher than the safe heating temperature and not for a period longer than the safe heating period, as specified by the manufacturer. The dispenser shall be cleaned out at the end of each day in accordance with the manufacturer's recommendations and reheated material shall not be used. The Movement Accomodation Factor of the sealant shall be more than 10 percent.
- 901.10.3.3** Cold applied sealants with chemical formulation like polysulphide/ Polyurethane/ silicone as per IRC:57 shall be used These shall be mixed and applied within the time limit specified by the manufacturer. If primers are recommended they Shali be applied neatly with an appropriate brush. The Movement Accomodation Factor shall be more than 25 percent.
- 901.10.3.4** The sealants applied at contraction phase of the slabs would result in bulging of the sealant over and above the slab. Therefore, the Contractor in consultation with the Engineer, shall establish the right temperature and time for applying the sealant. Thermometer shall be hung on a pole at the site for facilitating control during the sealing operation.
- 901.10.3.5** Sealant shall be applied, slightly to a lower level than the slab with a tolerance of 3 ± 1 mm.
- 901.10.3.6** During sealing operation, it shall be seen that no air bubbles are introduced in the sealant either by vapours or by the seating process. The sealant after pouring, shall be allowed to cure for 7 days or for a period as per instructions of manufacturers.

901.11 Trial Length

- 901.11.1** The trial shall be constructed at least one month in advance of the proposed start of concrete paving work. At least one month prior to the construction of the trial length, the Contractor shall submit for the Engineer's approval a detailed method statement giving description of the proposed materials, plant, equipment and construction methods. All the major equipments like paving train, batching plant, tipping trucks etc., proposed in the construction are to be approved by the Engineer before their procurement. No trials of new materials, plant, equipment or construction methods, nor any development of them shall be permitted either during the construction of trial length or in any subsequent paving work, unless they form part of further trials. The trial lengths shall be constructed away from the carriageway.
- 901.11.2** The Contractor shall demonstrate the materials, plant, equipment and methods of construction that are proposed for concrete paving, by first constructing a trial length of slab, at least 100 m long for mechanised construction and at least 50 m long for hand 6 guided methods. The width of the trial section shall be the full carriageway width as shown in the drawings. If the first trial is unsatisfactory, the Contractor shall

have to demonstrate his capability to satisfactorily construct the pavement in subsequent trials.

901.11.3 The trial length shall be constructed in two parts over a period comprising at least part of two separate working days, with a minimum of 50 m constructed each day for mechanised construction and a minimum of 25 m on each day for hand guided construction. The trial length shall be constructed at a paving rate which is proposed for the main work.

901.11.4 Transverse joints including expansion joint and longitudinal joint that are proposed in the main work shall be constructed and assessed in the trial length.

901.11.5 The trial length shall comply with the Specifications in all respects including the test requirement of Table 900-6 with the following additions.

901.11.5.1 Surface Levels and Regularity

- a) In checking for compliance with Clause 902.3 the levels shall be taken at intervals at the locations specified in this Clause along any line or lines parallel to the longitudinal centre line of the trial length.
- b) The maximum number of permitted irregularities of pavement surface shall comply with the requirements of Clause 902.4. Shorter trial lengths shall be assessed pro-rata based on values for a 300 m length.

901.11.5.2 Joints

- a) Alignment of dowel bars shall be inspected in any two consecutive transverse joints in a trial length construction by removing the fresh concrete in a width of 0.5 m on either side of the joint. The joint pit shall be refilled with freshly prepared concrete, after inspection. Alternatively, it can be tested by suitable device like MIT SCAN with the permission of the Engineer. If the position or alignment of the dowel bars at one of these joints does not comply with the requirements and if that joint remains the only one that does not comply after the next 3 consecutive joints of the same type have been inspected, then the method of placing dowels shall be deemed to be satisfactory. In order to check sufficient joints for dowel bar alignment without extending the trial length unduly joints may be constructed at more frequent joint intervals than the normal spacing required in trial slabs.
- b) If there are deficiencies in the first expansion joint that is constructed as a trial, the next expansion joint shall be a trial joint. Should this also be deficient, further trial of expansion joints shall be made as part of the trial length which shall not form part of the permanent works, unless agreed by the Engineer.

901.11.5.3 Density

In-situ density in trial length shall be assessed as described in Clause 903.5.2.2 from at least 3 cores drilled from each part of the trial length when the concrete is not less than 7 days Old. Should any of the cores show honey-combing in the concrete, the trial length shall be rejected and the construction in the main carriageway shall not be permitted until further trials have shown that modification has been made which would result in adequate compaction.

901.11.5.4 Strength

Minimum of thirty (30) beams for flexural strength and thirty (30) cubes for compressive strength shall be prepared from the concrete delivered in front of the paving plant. Each pair of beams and cubes shall be from the same location/batch but different sets of beams and cubes shall be from different locations/batches. Compressive and flexural strength shall be tested after 28 days water curing in the laboratory.

At the age of 28 days, thirty (30) cores with diameter 150 mm shall be cut from the slab when the thickness of concrete pavement is more than 300 mm. In case the concrete pavement thickness is less than 300 mm, the dia of core shall be 100 mm. The cores shall be suitably cut at both ends to provide a specimen of plain surface on both ends. The dia to height ratio of core shall be 1 to 2. For cylindrical specimen of PQC of dia 150 mm, the variation in dia shall be ± 0.5 mm, a tolerance on height shall be ± 1 mm for a specimen of height 300 mm or more. For cylindrical specimen of dia 100 mm, the variation in dia shall be ± 0.3 mm, and a tolerance on height shall be ± 1 mm for a specimen height of 200 mm. The compressive strength test shall be conducted as per IS-516.

Concrete in the member represented by a core test shall be considered acceptable, if the average equivalent cube strength of the cores is equal to at least 85 percent of the cube strength (characteristic strength) of the grade of the concrete specified for the corresponding age of 28 days and no individual core has a strength less than 75 percent.

901.11.5.5 Approval and Acceptance

901.11.5.6 Approval of the materials, plant, equipment and construction methods shall be given when the trial length complies with the Specifications. The Contractor shall not proceed with normal working until the trial length has been approved. If the Engineer does not notify the Contractor of any deficiencies in any trial length within 7 days after the completion of that trial length, the Contractor may assume that the trial length, and the materials, plant, equipment and construction methods adopted are acceptable, provided that the 28 days strength of cubes and cores extracted from trial length meet the requirement of the Specified strength.

901.11.5.7 When approval has been given, the materials, plant, equipment and construction methods shall not thereafter be changed, except for normal adjustments and maintenance of plant, without the approval of the Engineer. Any changes in materials, plant, equipment, and construction methods shall entitle the Engineer to require the Contractor to lay a further trial length as described in this Clause to demonstrate that the changes will not adversely affect the permanent works.

901.11.5.8 Trial lengths which do not comply with the Specifications, with the exception of areas which are deficient only in surface texture and which can be remedied in accordance with Clause 602.9.11.6 shall be removed immediately upon notification of deficiencies by the Engineer and the Contractor shall construct a further trial length.

901.11.6 Inspection of Dowel Bars

901.11.6.1 Compliance with Clause 602.6.5. for the position and alignment of dowel bars at contraction and expansion joints shall be checked by measurements relative to the side forms or guide wires.

901.11.6.2 When the slab has been constructed, the position and alignment of dowel bars and any filler board shall be measured after carefully exposing them in the plastic concrete across the whole width of the slab. When the joint is an expansion joint, the top of the filler board shall be exposed sufficiently in the plastic concrete to permit measurement of any lateral or vertical displacement of the board. During the course of normal working, these measurements shall be carried out in the pavement section at the end of days work by extending slab length by 2 m. After sawing the transverse joint groove, the extended 2 m shall be removed carefully soon after concrete has set to expose dowels over half the length. These dowels can be tested for tolerances. This joint shall be treated as construction joint. The position of dowel bars in any type of transverse joint ie, contraction, construction or expansion can alternatively be tested by suitable device like MIT SCAN with the permission of the Engineer.

901.11.6.3 If the position and alignment of the bars in a single joint in the slab is unsatisfactory then the next two joints shall be inspected. If only one joint of the three is defective, the rate of checking shall be increased to one joint per day until the Engineer is satisfied that compliance is being achieved.

901.11.6.4 After the dowel bars have been examined, the remainder of the concrete shall be removed over a width of 500 mm on each side of the line of the joint and reinstated to the satisfaction of the Engineer. The dowels shall be inserted on both sides of the 1 m wide slab by drilling holes and grouting with epoxy mortar. Plastic sheath as per Clause 602.6.5.5 shall be provided on dowels on one of the joints. The joint groove shall be widened and sealed as per Clause 602.10.

901.11.7 Inspection of Tie Bars

To check the position of the tie bars, one metre length 0.5 m on either side of the longitudinal joint shall be opened when the concrete is green (within 20 to 30 minutes of its laying). The pit shall be refilled with the fresh concrete of same mix after checking.

901.12 Measurement of Texture Depth — Sand Patch Method

901.12.1 The following Apparatus shall be used:

- i. A cylindrical container of 25 ml internal capacity;
- ii. A flat wooden disc 64 mm diameter with a hard rubber disc, 1.5 mm thick, next to one face, the reverse face being provided with a handle;
- iii. Dry natural sand with a rounded particle shape passing a 300 micron IS sieve and retained on a 150 micron IS sieve.

901.12.2 Method

The surface to be measured shall be dried, any extraneous mortar and loose material removed and the surface swept clean using a wire brush both at right angles and parallel to the carriageway. The cylindrical container shall be filled with the sand, tapping the base 3 times on the surface to ensure compaction, and striking off the sand level with the top of the cylinder. The sand shall be poured into a heap on the surface to be treated.

901.12.3 The diameter of the patch shall be measured to the nearest 5 mm. The texture depth of concrete surface shall be calculated from $31000/(D \times D)$ mm where D is the diameter of the patch in mm.

901.12.4 Measurement of Texture Depth – Tining

901.12.4.1 The following apparatus shall be used:

- i. Tire Tread Depth Gauge
A stainless-steel tire tread depth gauge with graduations with least count of 1.0 mm. The gauge end may be modified to measure depth of tine texture.
- ii. A stainless steel calliper to measure spacing of tines. If necessary the calliper may be modified to measure the spacing and width of tine texture. The gauge shall be used after making necessary calibration.
- iii. Wire brush
- iv. Carborundum stone
- v. Steel straight edge to remove snots etc. sticking to the surface. The straight edge may be of 6 x 25 x 300 mm size.

901.12.4.2 Test Section

A unit of testing shall be 75 m per lane. If the length of construction is less than 75 m it shall be taken as one unit.

901.12.4.3 Test Procedure

In each 75 m section, along the diagonal line, 10 points shall be selected for making checks of depth, width and spacing of tine grooves. The surface where tests are to be conducted shall be cleared carefully with a wire brush or a steel straight edge or using a carborundum plate to remove any upward projection of concrete. When the base plate of the gauge is in contact with the concrete surface, the gauge shall be pressed to the bottom of groove, and the depth shall be measured and recorded at this location. At the same location, the spacing of tines shall be measured to verify whether the pattern recommended in Clause 602.9.11.1 is complied or not.

The average of depth and width at 10 locations shall be calculated and recorded to the nearest 1 mm. The spacing of spectrum measured at 10 locations shall be recorded separately.

901.12.5 The average depth shall be 3 to 4 mm. When the depth is less than 2.5 mm and in excess of 4.5 mm, the Contractor shall stop concreting till he corrects his trowel brush or replaces it. The sensors associated with work shall be again calibrated to achieve the required texture. The textured groove less than 2.5 mm shall be re-grooved using concrete saw at the cost of Contractor. Variation in texture width in the range of 3+1 mm and 3 - 0.5 mm will be acceptable. If the variation of width is in excess of this range, the Contractor They shall stop work and correct the brush and technique. When the spacing of spectrum is not satisfactory, the Contractor shall replace the entire brush.

901.13 Opening to Traffic

No vehicular traffic shall be allowed to ply on the finished surface of a concrete pavement within a period of 28 days of its construction and until the joints are permanently sealed and cured. The road may be opened to regular traffic after completion of the curing period of 28 days and after sealing of joints is completed including the construction of shoulder.

901.14 Acceptance Criteria in Quality and Distress

- i. **Tolerances for Surface Regularity, Level, Thickness and Strength:**
The tolerances for surface regularity, level, thickness and strength shall conform to the requirements given in Clause 903.5. Control of quality of materials and works shall be exercised by the Engineer in accordance with Section 900.
- ii. **Tolerances in Distress :** The acceptance criteria with regard to the types of distresses in rigid pavement shall be as per IRC:SP-83. "Guidelines for Maintenance, Repair and Rehabilitation of Cement Concrete Pavements". The cracks (of severity rating not more than 2) which may appear during construction or before completion of Defect Liability Period shall be acceptable with suggested treatments as given in IRC:SP-83.

Cement Concrete Pavement slabs having cracks of severity rating more than 2 i.e. cracks of width more than 0.5 mm for single discrete cracks, multiple and transverse cracks and cracks of width more than 3 mm in case of longitudinal cracks and of depth more than half of the concrete pavement slabs, shall be removed and replaced as per IRC:SP-83.

901.15 Measurements for Payment

901.15.1 Cement Concrete pavement shall be measured as a finished work in cubic metres of concrete placed based on the net plan area and thickness as measured in accordance with Clause 602.15.2.

901.15.2 The finished thickness of concrete for payment on volume basis shall be computed in the manner described in Clause 113.3 with the following modifications:

- i. The levels shall be taken before and after construction at grid points 5 m centre to centre longitudinally in straight as well as at curves.
- ii. A day's work is considered as a 'lot' for calculating the average thickness of the slab. In calculating the average thickness, individual measurements which are in excess of the specified thickness by more than 10 mm shall be considered as the specified thickness plus 10 mm.

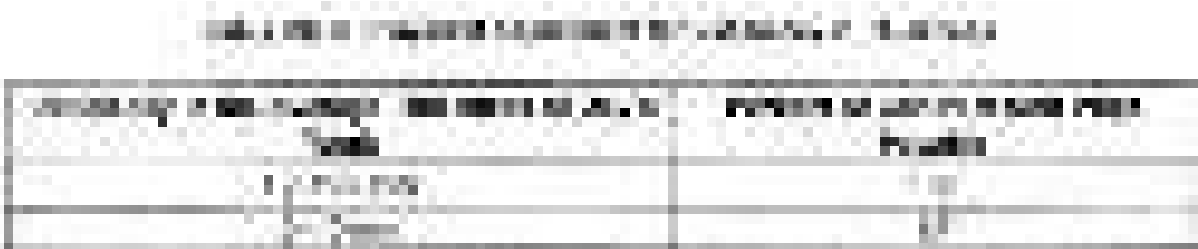
901.15.3 Individual areas deficient by more than 10 mm shall be verified by the Engineer by ordering core cutting and if in his opinion the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness shown on the plans.

901.16 Rate

901.16.1 The Contract unit rate for the construction of the cement concrete pavement shall be payment in full for carrying out the operations required for the different items of the work as per these Specifications including full compensation for all labour, tools, plant, equipment, providing all materials i.e. aggregates, dowel bars, tie bars, PVC membrane, cement, stabilizers (lime, cements or any other stabilizers approved by the Engineer), storing, mixing, transportation, placing, compacting, finishing, curing, testing, all royalties, fees, rents where necessary, all leads and lifts and incidentals to complete the work as per Specifications.

The unit rate shall all include the full costs of construction, expansion, contraction and longitudinal joints including joint filler, sealant, primer, debonding strip and all other operations for completing the work. The construction and testing of trial length shall be included in the contract unit rate for the pavement and shall not be paid separately.

901.16.2 Where the average thickness for the lot is deficient by the extent shown in Table 600-6, payment for cement concrete pavement shall be made at a price determined by adjusting the contract unit price as per Table 600-6.



Deficiency in thickness (mm)	Percentage of contract unit price to be deducted
0 to 10	0%
10 to 20	5%
20 to 30	10%
30 to 40	15%
40 to 50	20%
50 to 60	25%
60 to 70	30%
70 to 80	35%
80 to 90	40%
90 to 100	45%

901.16.3 No additional payment shall be made for the extra thickness of the slab than shown on the drawings.

801 TRAFFIC SIGNS

801.1 Scope

The work shall consist of the fabrication, supply and installation of ground mounted traffic signs on roads. The details of the signs shall be as shown in the drawings and in conformity with the Code of Practice for Road Signs, IRC:67-2010.

801.2 Materials

The various materials and fabrication of the traffic signs shall conform to the following requirements:

801.2.1 Concrete

Concrete for foundation shall be of M 15 Grade as per Section 1700 or the grade shown on the drawings or otherwise as directed by the Engineer.

801.2.2 Reinforcing Steel

Reinforcing steel shall conform to the requirement of IS: 1786 unless otherwise shown on the drawing.

801.2.3 Bolts, Nuts, Washers

High strength bolts shall conform to IS: 1367 whereas precision bolts, nuts, etc., shall conform to IS:1364.

801.2.4 Plates and Supports

Plates and support sections for the signposts shall conform to IS:226 and IS:2062 or any other relevant IS Specifications.

801.2.5 Substrate

Sign panels shall be fabricated on aluminium sheet, aluminium composite panel, fibre glass sheeting, or sheet moulding compound. Aluminum sheets used for sign boards shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS:736-Material Designation 24345 or 1900. Aluminum Composite Material (ACM) sheets shall be sandwiched construction with a thermoplastic core of Low-Density Polyethylene (LDPE) between two thick skins/sheets of aluminium with overall thickness and 3 mm or 4 mm (as specified in the Contract), and aluminium skin of thickness 0.5 mm and 0.3 mm respectively on both sides.

The mechanical proportion of ACM and that of aluminium skin shall conform to the requirements given in Table 800-1, when tested in accordance with the test methods mentioned against each of them.

TABLE 1.1.1: MINIMUM REQUIREMENTS FOR SIGN SHEETS			
Sl. No.	Description of Sign	Minimum Thickness (mm)	
		Aluminum	Aluminum Composite Material
1	Shoulder mounted ground signs	1.5	3
2	Other signs	2	4
3	Signs for traffic signals	2	4
4	Signs for pedestrian crossings	2	4
5	Signs for school crossings	2	4
6	Signs for railway crossings	2	4
7	Signs for narrow gauge crossings	2	4
8	Signs for level crossings	2	4
9	Signs for road works	2	4
10	Signs for construction sites	2	4
11	Signs for temporary traffic control	2	4
12	Signs for emergency services	2	4
13	Signs for public information	2	4
14	Signs for directional information	2	4
15	Signs for regulatory information	2	4
16	Signs for warning information	2	4
17	Signs for advance warning	2	4
18	Signs for priority	2	4
19	Signs for yield	2	4
20	Signs for stop	2	4
21	Signs for no entry	2	4
22	Signs for no parking	2	4
23	Signs for no overtaking	2	4
24	Signs for no U-turn	2	4
25	Signs for no left turn	2	4
26	Signs for no right turn	2	4
27	Signs for no through traffic	2	4
28	Signs for no heavy vehicles	2	4
29	Signs for no trucks	2	4
30	Signs for no motor vehicles	2	4
31	Signs for no bicycles	2	4
32	Signs for no pedestrians	2	4
33	Signs for no animals	2	4
34	Signs for no fire	2	4
35	Signs for no smoking	2	4
36	Signs for no alcohol	2	4
37	Signs for no drugs	2	4
38	Signs for no weapons	2	4
39	Signs for no explosives	2	4
40	Signs for no radioactive materials	2	4
41	Signs for no hazardous materials	2	4
42	Signs for no toxic materials	2	4
43	Signs for no corrosive materials	2	4
44	Signs for no flammable materials	2	4
45	Signs for no oxidizing materials	2	4
46	Signs for no reactive materials	2	4
47	Signs for no environmental hazards	2	4
48	Signs for no cultural heritage	2	4
49	Signs for no archaeological sites	2	4
50	Signs for no historical sites	2	4
51	Signs for no religious sites	2	4
52	Signs for no educational sites	2	4
53	Signs for no medical sites	2	4
54	Signs for no government buildings	2	4
55	Signs for no public buildings	2	4
56	Signs for no commercial buildings	2	4
57	Signs for no industrial buildings	2	4
58	Signs for no utility buildings	2	4
59	Signs for no other buildings	2	4
60	Signs for no other structures	2	4
61	Signs for no other objects	2	4
62	Signs for no other features	2	4
63	Signs for no other elements	2	4
64	Signs for no other components	2	4
65	Signs for no other parts	2	4
66	Signs for no other accessories	2	4
67	Signs for no other hardware	2	4
68	Signs for no other software	2	4
69	Signs for no other data	2	4
70	Signs for no other information	2	4
71	Signs for no other communication	2	4
72	Signs for no other interaction	2	4
73	Signs for no other behavior	2	4
74	Signs for no other actions	2	4
75	Signs for no other reactions	2	4
76	Signs for no other responses	2	4
77	Signs for no other outputs	2	4
78	Signs for no other results	2	4
79	Signs for no other effects	2	4
80	Signs for no other consequences	2	4
81	Signs for no other impacts	2	4
82	Signs for no other influences	2	4
83	Signs for no other forces	2	4
84	Signs for no other pressures	2	4
85	Signs for no other stresses	2	4
86	Signs for no other strains	2	4
87	Signs for no other deformations	2	4
88	Signs for no other displacements	2	4
89	Signs for no other movements	2	4
90	Signs for no other vibrations	2	4
91	Signs for no other oscillations	2	4
92	Signs for no other fluctuations	2	4
93	Signs for no other variations	2	4
94	Signs for no other changes	2	4
95	Signs for no other differences	2	4
96	Signs for no other similarities	2	4
97	Signs for no other commonalities	2	4
98	Signs for no other consistencies	2	4
99	Signs for no other uniformities	2	4
100	Signs for no other regularities	2	4

801.2.6 Plate Thickness

Shoulder mounted ground signs with a maximum side dimension not exceeding 900 mm shall not be less than 1.5 mm thick with Aluminum and 3 mm thick with Aluminum Composite Material. All other signs be at least 2 mm thick with Aluminum and 4 mm thick with Aluminum Composite Material. The thickness of the sheet shall be related to the size of the sign and its support and shall be such that it does not bend or deform under prevailing wind and other loads.

801.2.7 In respect of sign sizes not covered by IRC:67, the structural details (thickness, etc.) shall be as per the approved drawings or as directed by the Engineer.

801.3 Traffic Signs having Retro-Reflective Sheeting

801.3.1 General Requirements

The retro-reflective sheeting used on the sign shall consist of the white or coloured sheeting having a smooth outer surface which has the property of retro-reflection over its entire surface. It shall be weather-resistant and show colour fastness. It shall be new and unused and shall show no evidence of cracking, scaling, pitting, blistering, edge lifting or curling and shall have negligible shrinkage or expansion. A certificate of having tested the sheeting for co-efficient of retro-reflection, day/nighttime colour luminous, shrinkage, flexibility, linear removal, adhesion, impact resistance, specular gloss and fungus resistance and its having passed these tests shall be obtained from a Government Laboratory/institute, by the manufacturer of the sheeting. The retro-reflective sheeting shall be either of Engineering Grade material with enclosed lens, High Intensity Grade with encapsulated lens or Micro-prismatic Grade retro-reflective element

material as given in Clauses 801.3.2 to 801.3.7. Guidance on the recommended application of each class of sheeting may be taken from IRC:67.

801.3.2 High Intensity Grade Sheeting

801.3.2.1 High Intensity Grade (Type III)

This high intensity retro reflective sheeting shall be of encapsulated lens type consisting of spherical glass lens, elements adhered to a synthetic resin and encapsulated by a flexible, transparent waterproof plastic having a smooth surface or as an unmetallized micro prismatic reflective material element. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in Table 800-2.

Table 800-2 : Acceptable Minimum Co-efficient of Retro-Reflection for High Intensity Grade Sheeting (Type III) (Encapsulated Lens Type)
(Candelas Per Lux Per Square Metre)

View angle	Minimum retro reflectance	Minimum retro reflectance	Minimum retro reflectance	Minimum retro reflectance	Minimum retro reflectance	Minimum retro reflectance	Minimum retro reflectance
0.1°	100	100	100	100	100	100	100
0.2°	100	100	100	100	100	100	100
0.3°	100	100	100	100	100	100	100
0.4°	100	100	100	100	100	100	100
0.5°	100	100	100	100	100	100	100
0.6°	100	100	100	100	100	100	100
0.7°	100	100	100	100	100	100	100
0.8°	100	100	100	100	100	100	100
0.9°	100	100	100	100	100	100	100
1.0°	100	100	100	100	100	100	100
1.1°	100	100	100	100	100	100	100
1.2°	100	100	100	100	100	100	100
1.3°	100	100	100	100	100	100	100
1.4°	100	100	100	100	100	100	100
1.5°	100	100	100	100	100	100	100
1.6°	100	100	100	100	100	100	100
1.7°	100	100	100	100	100	100	100
1.8°	100	100	100	100	100	100	100
1.9°	100	100	100	100	100	100	100
2.0°	100	100	100	100	100	100	100
2.1°	100	100	100	100	100	100	100
2.2°	100	100	100	100	100	100	100
2.3°	100	100	100	100	100	100	100
2.4°	100	100	100	100	100	100	100
2.5°	100	100	100	100	100	100	100
2.6°	100	100	100	100	100	100	100
2.7°	100	100	100	100	100	100	100
2.8°	100	100	100	100	100	100	100
2.9°	100	100	100	100	100	100	100
3.0°	100	100	100	100	100	100	100
3.1°	100	100	100	100	100	100	100
3.2°	100	100	100	100	100	100	100
3.3°	100	100	100	100	100	100	100
3.4°	100	100	100	100	100	100	100
3.5°	100	100	100	100	100	100	100
3.6°	100	100	100	100	100	100	100
3.7°	100	100	100	100	100	100	100
3.8°	100	100	100	100	100	100	100
3.9°	100	100	100	100	100	100	100
4.0°	100	100	100	100	100	100	100
4.1°	100	100	100	100	100	100	100
4.2°	100	100	100	100	100	100	100
4.3°	100	100	100	100	100	100	100
4.4°	100	100	100	100	100	100	100
4.5°	100	100	100	100	100	100	100
4.6°	100	100	100	100	100	100	100
4.7°	100	100	100	100	100	100	100
4.8°	100	100	100	100	100	100	100
4.9°	100	100	100	100	100	100	100
5.0°	100	100	100	100	100	100	100
5.1°	100	100	100	100	100	100	100
5.2°	100	100	100	100	100	100	100
5.3°	100	100	100	100	100	100	100
5.4°	100	100	100	100	100	100	100
5.5°	100	100	100	100	100	100	100
5.6°	100	100	100	100	100	100	100
5.7°	100	100	100	100	100	100	100
5.8°	100	100	100	100	100	100	100
5.9°	100	100	100	100	100	100	100
6.0°	100	100	100	100	100	100	100
6.1°	100	100	100	100	100	100	100
6.2°	100	100	100	100	100	100	100
6.3°	100	100	100	100	100	100	100
6.4°	100	100	100	100	100	100	100
6.5°	100	100	100	100	100	100	100
6.6°	100	100	100	100	100	100	100
6.7°	100	100	100	100	100	100	100
6.8°	100	100	100	100	100	100	100
6.9°	100	100	100	100	100	100	100
7.0°	100	100	100	100	100	100	100
7.1°	100	100	100	100	100	100	100
7.2°	100	100	100	100	100	100	100
7.3°	100	100	100	100	100	100	100
7.4°	100	100	100	100	100	100	100
7.5°	100	100	100	100	100	100	100
7.6°	100	100	100	100	100	100	100
7.7°	100	100	100	100	100	100	100
7.8°	100	100	100	100	100	100	100
7.9°	100	100	100	100	100	100	100
8.0°	100	100	100	100	100	100	100
8.1°	100	100	100	100	100	100	100
8.2°	100	100	100	100	100	100	100
8.3°	100	100	100	100	100	100	100
8.4°	100	100	100	100	100	100	100
8.5°	100	100	100	100	100	100	100
8.6°	100	100	100	100	100	100	100
8.7°	100	100	100	100	100	100	100
8.8°	100	100	100	100	100	100	100
8.9°	100	100	100	100	100	100	100
9.0°	100	100	100	100	100	100	100
9.1°	100	100	100	100	100	100	100
9.2°	100	100	100	100	100	100	100
9.3°	100	100	100	100	100	100	100
9.4°	100	100	100	100	100	100	100
9.5°	100	100	100	100	100	100	100
9.6°	100	100	100	100	100	100	100
9.7°	100	100	100	100	100	100	100
9.8°	100	100	100	100	100	100	100
9.9°	100	100	100	100	100	100	100
10.0°	100	100	100	100	100	100	100

- A. minimum of Coefficient of Retro-reflection (RA) cd/fc/ft² (cd-lx-l m²).
- B. Values for 0.1 ° observation angles are supplementary requirements that shall apply only when specified by the purchaser in the Contract or order. When totally wet, the sheeting shall show not less than 90 percent, of the values of retro reflectance indicated in above Table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

801.3.3 High Intensity Micro-Prismatic Grade Sheeting (HIP) (Type IV)

This sheeting shall be of high intensity retro-reflective sheeting made of micro-prismatic retro-reflective element material coated with pressure sensitive adhesive. The retro-reflective surface after cleaning with soap and water and in dry condition shall have the minimum coefficient of retro-reflection (determined in accordance with ASTM D:4956-09) as indicated in Table 800-3.

**Table 800-3 : Acceptable Minimum Co-efficient of Retro-Reflection for High Intensity Micro-Prismatic Grade Sheeting (Type IV)
(Candelas Per Lux Per Square Metre)**

Observation Angle	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²	Minimum Co-efficient of Retro-Reflection (RA) cd/lx/m ²
0.1°	100	100	100	100	100	100	100	100
0.2°	100	100	100	100	100	100	100	100
0.3°	100	100	100	100	100	100	100	100
0.4°	100	100	100	100	100	100	100	100
0.5°	100	100	100	100	100	100	100	100
0.6°	100	100	100	100	100	100	100	100
0.7°	100	100	100	100	100	100	100	100
0.8°	100	100	100	100	100	100	100	100
0.9°	100	100	100	100	100	100	100	100
1.0°	100	100	100	100	100	100	100	100
1.1°	100	100	100	100	100	100	100	100
1.2°	100	100	100	100	100	100	100	100
1.3°	100	100	100	100	100	100	100	100
1.4°	100	100	100	100	100	100	100	100
1.5°	100	100	100	100	100	100	100	100
1.6°	100	100	100	100	100	100	100	100
1.7°	100	100	100	100	100	100	100	100
1.8°	100	100	100	100	100	100	100	100
1.9°	100	100	100	100	100	100	100	100
2.0°	100	100	100	100	100	100	100	100
2.1°	100	100	100	100	100	100	100	100
2.2°	100	100	100	100	100	100	100	100
2.3°	100	100	100	100	100	100	100	100
2.4°	100	100	100	100	100	100	100	100
2.5°	100	100	100	100	100	100	100	100
2.6°	100	100	100	100	100	100	100	100
2.7°	100	100	100	100	100	100	100	100
2.8°	100	100	100	100	100	100	100	100
2.9°	100	100	100	100	100	100	100	100
3.0°	100	100	100	100	100	100	100	100
3.1°	100	100	100	100	100	100	100	100
3.2°	100	100	100	100	100	100	100	100
3.3°	100	100	100	100	100	100	100	100
3.4°	100	100	100	100	100	100	100	100
3.5°	100	100	100	100	100	100	100	100
3.6°	100	100	100	100	100	100	100	100
3.7°	100	100	100	100	100	100	100	100
3.8°	100	100	100	100	100	100	100	100
3.9°	100	100	100	100	100	100	100	100
4.0°	100	100	100	100	100	100	100	100
4.1°	100	100	100	100	100	100	100	100
4.2°	100	100	100	100	100	100	100	100
4.3°	100	100	100	100	100	100	100	100
4.4°	100	100	100	100	100	100	100	100
4.5°	100	100	100	100	100	100	100	100
4.6°	100	100	100	100	100	100	100	100
4.7°	100	100	100	100	100	100	100	100
4.8°	100	100	100	100	100	100	100	100
4.9°	100	100	100	100	100	100	100	100
5.0°	100	100	100	100	100	100	100	100
5.1°	100	100	100	100	100	100	100	100
5.2°	100	100	100	100	100	100	100	100
5.3°	100	100	100	100	100	100	100	100
5.4°	100	100	100	100	100	100	100	100
5.5°	100	100	100	100	100	100	100	100
5.6°	100	100	100	100	100	100	100	100
5.7°	100	100	100	100	100	100	100	100
5.8°	100	100	100	100	100	100	100	100
5.9°	100	100	100	100	100	100	100	100
6.0°	100	100	100	100	100	100	100	100
6.1°	100	100	100	100	100	100	100	100
6.2°	100	100	100	100	100	100	100	100
6.3°	100	100	100	100	100	100	100	100
6.4°	100	100	100	100	100	100	100	100
6.5°	100	100	100	100	100	100	100	100
6.6°	100	100	100	100	100	100	100	100
6.7°	100	100	100	100	100	100	100	100
6.8°	100	100	100	100	100	100	100	100
6.9°	100	100	100	100	100	100	100	100
7.0°	100	100	100	100	100	100	100	100
7.1°	100	100	100	100	100	100	100	100
7.2°	100	100	100	100	100	100	100	100
7.3°	100	100	100	100	100	100	100	100
7.4°	100	100	100	100	100	100	100	100
7.5°	100	100	100	100	100	100	100	100
7.6°	100	100	100	100	100	100	100	100
7.7°	100	100	100	100	100	100	100	100
7.8°	100	100	100	100	100	100	100	100
7.9°	100	100	100	100	100	100	100	100
8.0°	100	100	100	100	100	100	100	100
8.1°	100	100	100	100	100	100	100	100
8.2°	100	100	100	100	100	100	100	100
8.3°	100	100	100	100	100	100	100	100
8.4°	100	100	100	100	100	100	100	100
8.5°	100	100	100	100	100	100	100	100
8.6°	100	100	100	100	100	100	100	100
8.7°	100	100	100	100	100	100	100	100
8.8°	100	100	100	100	100	100	100	100
8.9°	100	100	100	100	100	100	100	100
9.0°	100	100	100	100	100	100	100	100
9.1°	100	100	100	100	100	100	100	100
9.2°	100	100	100	100	100	100	100	100
9.3°	100	100	100	100	100	100	100	100
9.4°	100	100	100	100	100	100	100	100
9.5°	100	100	100	100	100	100	100	100
9.6°	100	100	100	100	100	100	100	100
9.7°	100	100	100	100	100	100	100	100
9.8°	100	100	100	100	100	100	100	100
9.9°	100	100	100	100	100	100	100	100
10.0°	100	100	100	100	100	100	100	100

- A. Minimum Coefficient of Retro reflection (RA) cd/lx/m² (cd-lx-l m²).
- B. Values for 0.1 0 observation angles are supplementary requirements that shall apply only when specified by the purchaser in the contract or order. When totally wet, the sheeting shall show not less than 90 percent of the values of retro reflection indicated in above Table. At the end of 7 years, the sheeting shall retain at least 80 percent of its original retro-reflectance.

801.3.4 Prismatic Grade Sheeting

801.3.4.1 Prismatic Grade Sheeting (Type VIII)

The reflective sheeting shall be retro reflective sheeting made of micro prismatic retro reflective material. The retro reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro reflection (determined in accordance with ASTM E 810) as indicated in Table 800-4.

801.3.4.2 Prismatic Grade Sheeting (Type IX)

The reflective sheeting shall be retro-reflective sheeting made of micro prismatic retro-reflective material. The retro-reflective surface, after cleaning with soap and water and in dry condition shall have the minimum co-efficient of retro-reflection (determined in accordance with ASTM E 810) as indicated in Table 800-5.

Project Overview					Financials		Timeline		Risk		Status	
Project Name	Manager	Start Date	End Date	Current Phase	Budget (k\$)	Actual (k\$)	Planned Start	Planned End	Probability	Impact	Current Status	Last Update
P001	J. Doe	2023-01-15	2023-06-30	Phase 2	120	115	2023-01-15	2023-06-30	High	Severe	On Track	2023-07-01
P002	A. Smith	2023-02-01	2023-08-15	Phase 1	80	82	2023-02-01	2023-08-15	Medium	Moderate	Minor Delay	2023-07-01
P003	M. Lee	2023-03-10	2023-09-30	Phase 3	150	148	2023-03-10	2023-09-30	Low	Minor	Ahead of Schedule	2023-07-01
P004	S. Kim	2023-04-01	2023-10-31	Phase 1	90	95	2023-04-01	2023-10-31	Medium	Moderate	At Risk	2023-07-01
P005	L. Brown	2023-05-01	2023-11-30	Phase 2	110	112	2023-05-01	2023-11-30	Low	Minor	On Track	2023-07-01
P006	K. Green	2023-06-01	2023-12-31	Phase 1	70	71	2023-06-01	2023-12-31	Medium	Moderate	Minor Delay	2023-07-01

Year	Country	Population (millions)	Urban population (millions)	Urban population (%)	Population (millions)	Urban population (millions)	Urban population (%)	Population (millions)	Urban population (millions)	Urban population (%)
1950	USA	150	80	53	150	80	53	150	80	53
1950	USSR	160	40	25	160	40	25	160	40	25
1950	China	550	100	18	550	100	18	550	100	18
1950	India	360	50	14	360	50	14	360	50	14
1950	Japan	90	40	44	90	40	44	90	40	44
1950	France	45	25	56	45	25	56	45	25	56
1950	Germany	50	30	60	50	30	60	50	30	60
1950	Italy	45	20	44	45	20	44	45	20	44
1950	UK	50	30	60	50	30	60	50	30	60
1950	Canada	20	10	50	20	10	50	20	10	50
1950	Australia	10	5	50	10	5	50	10	5	50
1950	South Africa	10	5	50	10	5	50	10	5	50
1950	Argentina	15	8	53	15	8	53	15	8	53
1950	Brazil	70	20	29	70	20	29	70	20	29
1950	Mexico	25	10	40	25	10	40	25	10	40
1950	Colombia	10	5	50	10	5	50	10	5	50
1950	Venezuela	10	5	50	10	5	50	10	5	50
1950	Peru	15	8	53	15	8	53	15	8	53
1950	Ecuador	5	2	40	5	2	40	5	2	40
1950	Guatemala	5	2	40	5	2	40	5	2	40
1950	Honduras	3	1	33	3	1	33	3	1	33
1950	El Salvador	3	1	33	3	1	33	3	1	33
1950	Nicaragua	2	1	50	2	1	50	2	1	50
1950	Panama	1	0.5	50	1	0.5	50	1	0.5	50
1950	Cuba	7	3	43	7	3	43	7	3	43
1950	Dominican Republic	2	1	50	2	1	50	2	1	50
1950	Haiti	2	1	50	2	1	50	2	1	50
1950	Jamaica	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Trinidad and Tobago	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Guyana	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Suriname	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	French Guiana	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Guadeloupe	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Martinique	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Reunion	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Mayotte	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	French Polynesia	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	New Caledonia	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	Wallis and Futuna	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	French Southern Territories	0.5	0.2	40	0.5	0.2	40	0.5	0.2	40
1950	British Virgin Islands	0.5	0.2	40	0.5	0.				

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Order Number	Product Name	Unit Price	Quantity	Discount	Net Price	Net Total	Tax	Total	Payment Method	Invoice Number	Invoice Date
1001	Apple iPhone 12	800	1	5%	760	760	0	760	Credit Card	INV-001	2023-01-01
1002	Samsung Galaxy S21	700	2	10%	1260	1260	0	1260	Bank Transfer	INV-002	2023-01-02
1003	Google Pixel 5	600	1	0%	600	600	0	600	Credit Card	INV-003	2023-01-03
1004	Microsoft Surface Pro	900	1	15%	765	765	0	765	Bank Transfer	INV-004	2023-01-04
1005	Amazon Echo Dot	50	10	5%	475	475	0	475	Credit Card	INV-005	2023-01-05
1006	Apple Watch Series 7	300	2	10%	540	540	0	540	Bank Transfer	INV-006	2023-01-06
1007	Sony WH-1000XM4	350	1	0%	350	350	0	350	Credit Card	INV-007	2023-01-07
1008	Logitech MX Master 3	120	1	5%	114	114	0	114	Bank Transfer	INV-008	2023-01-08
1009	Canon EOS R5	1200	1	0%	1200	1200	0	1200	Credit Card	INV-009	2023-01-09
1010	Fitbit Versa 4	150	1	10%	135	135	0	135	Bank Transfer	INV-010	2023-01-10

- ### 801.3.5 Adhesives

801.3.6 Fabrication

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shall be free from twists, cracks and folds. Cut-outs to produce legends and borders shall be bonded with the sheeting in the manner specified by the manufacturer.

801.3.7 Messages/Borders

The messages (legends, letters, numerals etc.) and borders shall either be screen-printed or of cut out from durable transparent overlay or cut out from the same type of reflective sheeting for the cautionary/mandatory sign boards. Screen printing shall be processed and finished with materials and in a manner specified by the sheeting manufacturer. For the informatory and other sign boards, the messages (legends, letters, numerals etc.) and borders shall be cut out from durable transparent overlay film or cut-out from the same reflective sheeting only. Cut-outs shall be from durable transparent overlay materials as specified by the sheeting manufacturer and shall be bonded with the sheeting in the manner specified by the manufacturer. For screen-printed transparent coloured areas on white sheeting, the coefficient of retro-reflection shall not be less than 50 percent of the values of corresponding colour in Tables 800-2 to 800-8 as applicable. Cut-out messages and borders, wherever used, shall be either made out of retro-reflective sheeting or made out of durable transparent overlay except those in black which shall be of non-reflective sheeting or opaque in case of durable transparent overlay.

801.3.8 Colour for Signs

- 801.3.8.1** Signs shall be provided with retro-reflective sheeting and/or overlay film/ screening ink. The reverse side of all signs shall be painted grey.
- 801.3.8.2** Except in the case of railway level crossing signs the sign posts shall be painted in 250 mm side bands, alternately black and white. The lowest band next to be ground shall be in black.
- 801.3.8.3** The colour of the material shall be located within the area defined by the chromaticity coordinates in Table 800-7 and comply with the luminance factor when measured as per ASTM D4956.

[illegible]

801.3.8.4 801.3.8.4 The Regulatory/ Prohibitory and warning signs shall be provided with white background and red border. The legend/ symbol for these signs shall be in black colour. The Mandatory sign shall be provided with Blue background and white Symbol/letter.

801.3.9 Refurbishment

801.3.10 Sizes of Letters

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being too large or obtrusive. The size of the letter, in terms of x-height, to be chosen as per the design speed is given in Table 800-8.

Table 800-8 : Acceptable Limits for Sizes of Letters

Design Speed (km/h)	Minimum Letter Height (mm)	Minimum Letter Width (mm)	Minimum Letter Thickness (mm)
100	150	100	10
80	120	80	8
60	100	60	6
40	80	40	4
20	60	30	3

The thickness of the letters and their relation to the x-height, the width, the heights are indicated in Table IV (a) of the Annexure-4 of IRC:67 to facilitate the design of the informatory signs and definition plates.

801.3.10.2 For advance direction signs on non-urban roads, the letter size ('x' height) should be minimum of 150 mm for Expressway, National and State Highways and 100 mm for other roads. In case of overhead signs, the size ('X' height) of letters may be minimum 300 mm. Thickness of the letter could be varied from 1/6 to 1/5 of the letter 'x' size. The size of the initial uppercase letter shall be 1-1/3 times x-height. In urban areas, letter size shall be 100 mm on all directional signs. For easy and better comprehension, the word messages shall be written in upper case letters only.

801.3.10.3 Letter size on definition plates attached with normal sized signs should be 100 mm or 150 mm. In the case of small signs, it should be 100 mm. Where the message is long, as for instance in "NO PARKING" and "NO STOPPING" signs, the message may be broken into two lines and size of letters may be varied in the lines so that the definition plate is not too large. The lettering on definition plates will be all in upper case letters.

801.3.11 Warranty and Durability

The Contractor shall obtain from the manufacturer a ten year warranty for satisfactory field performance including stipulated retro-reflectance of the retro-reflective sheeting of micro prismatic sheeting and a seven-year warranty for high intensity grade and submit the same to the Engineer. The warranty shall be inclusive of the screen printed or cut out letters/legends and their bonding to the retro-reflective sheeting. The Contractor/supplier shall also furnish the LOT numbers and certification that the signs and materials supplied against the assigned work meets all the stipulated requirements and carry the stipulated warranty and that the contractor/supplier is the authorized converter of the particular sheeting.

All signs shall be dated during fabrication with indelible markings to indicate the start of warranty. The warranty shall also cover the replacement obligation by the sheeting

manufacturer as well as contractor for replacement/repair/restoration of the retro-reflective efficiency.

A certificate in original shall be given by the sheeting manufacturer that its offered retroreflective sheeting has been tested for various parameters such as co-efficient of retroreflection, day/night time colour and luminance, shrinkage, flexibility, linear removal, adhesion, impact resistance, specular gloss and fungus resistance; the tests shall be carried out by a Government Laboratory in accordance with various ASTM procedures and the results must show that the sheeting has passed the requirements for all the above mentioned parameters. A copy of the test reports shall be attached with the certificate.

801.4 Installation

801.4.1 The traffic signs shall be mounted on support posts, which may be of GI pipes conforming to IS: 1239, Rectangular Hollow Section conforming to IS:4923 or Square Hollow Section conforming to IS:3589. Sign posts, their foundations and sign mountings shall be so constructed as to hold these in a proper and permanent position against the normal storm wind loads or displacement by vandalism. Normally, signs with an area up to 0.9 sq.m shall be mounted on a single post, and for greater area two or more supports shall be provided. Post-end(s) shall be firmly fixed to the ground by means of properly designed foundation. The work of foundation shall conform to relevant Specifications as specified.

801.4.2 All components of signs (including its back side) and supports, other than the reflective portion and G.I. posts shall be thoroughly de-scaled, cleaned, primed and painted with two coats of epoxy/ fibre glass/ powder coated paint. Any part of support post below ground shall be painted with protective paint.

801.4.3 The signs shall be fixed to the posts by welding in the case of steel posts and by bolts and washers of suitable size. After the nuts have been tightened, the tails of the bolts shall be furred over with a hammer to prevent removal.

801.5 Measurement for Payment

The measurement of standard cautionary, mandatory and information signs shall be in numbers of different types of signs supplied and fixed, while for direction and place identification signs, these shall be measured by area in square metres.

801.6 Rate

The Contract unit rate shall be payment in full for the cost of making the road sign, including all materials, installing it at the site furnishing of necessary test certificates, warranty and incidentals to complete the work in accordance with these Specifications.

802 OVERHEAD SIGNS

802.1 Scope

The work shall consist of fabrication, supply and installation of overhead traffic signs on roads. The details of the signs shall be as shown in the drawings and in conformity with the Code of Practice for Road Signs, IRC:67-2010.

802.2 Height

Overhead signs shall provide a vertical clearance of not less than 5.5 m over the entire width of the pavement and shoulders except where a lesser vertical clearance is used for the design of other structures. The vertical clearance to overhead sign structures or supports need not be greater than 300 mm in excess of the minimum clearance of other structures.

802.3 Lateral Clearance

802.3.1 The minimum clearance outside the usable roadway shoulder for signs mounted at the road side or for overhead sign supports either to the right or left side of the roadway shall be 1.80 m. This minimum clearance of 180 m shall also apply outside of an unmountable kerb. Where practicable, a sign should not be less than 3 m from the edge of the nearest traffic lane. Large guide signs should be farther removed preferably 9 m or more from the nearest traffic lane, unless otherwise specified. Lesser clearances, but not generally less than 1.80 m, may be used on connecting roadways or ramps at inter-changes.

802.3.2 Where a median is 3.6 m or less in width, consideration should be given to spanning over both roadways without a central support. Where overhead sign supports cannot be placed at a safe distance away from the line of traffic or in an otherwise protected site, they should either be so designed as to minimize the impact forces or protect motorists adequately by a physical barrier or guard rail of suitable design.

802.4 Materials for Overhead Sign and Support Structures

802.4.1 Aluminium alloy or galvanized steel to be used as truss design supports shall conform to relevant IS. These shall be of sections and type as per structural design requirements as shown on the plans.

802.4.2 After steel trusses have been fabricated and all required holes punched or drilled on both the horizontal truss units and the vertical and support units, they shall be galvanized in accordance with IS Specifications.

802.4.3 Where aluminium sheets are used for road signs, they shall be of smooth, hard and corrosion resistant aluminium alloy conforming to IS:736 - Material Designation 24345 or 1900. The thickness of sheet shall be related to the size of the sign with minimum thickness of sheet as 1.5 mm.

802.4.4 High strength bolts shall conform to IS: 1367 whereas precision bolts, nuts etc. shall conform to IS: 1364.

802.4.5 Plates and support sections for sign posts shall conform to IS:226 and IS:2062.

802.4.6 The overhead signs shall be of micro prismatic retro-reflective sheeting.

802.5 Size and Locations of Signs

802.5.1 The size of the signs, letters and their placement shall be as specified in the Contract drawings and Specifications.

802.5.2 In the absence of details or for any missing details in the Contract documents, the signs shall be provided as directed by the Engineer.

802.6 Installation

802.6.1 From safety and aesthetic considerations, overhead signs shall be mounted on overhead bridge structures. Where these are required to be provided at some other locations, the support system providing pleasing aesthetics, should be properly designed based on sound engineering principles, to safely sustain the dead load, live load and wind load on the completed sign system. For this purpose, the overhead signs shall be designed to withstand a wind loading of 150 kg/m² normal to the face of the sign and 30 kg/m² transverse to the face of the sign. In addition to the dead load of the structure, walkway loading of 250 kg concentrated live load shall also be considered for the design of the overhead sign structure.

802.6.2 The supporting structure and signs shall be fabricated and erected as per details given in the plans and at locations directed by the engineer.

802.6.3 Sign posts, their foundations and sign mountings shall be so constructed as to hold signs in a proper and permanent position to adequately resist swaying in the wind or displacement by vandalism.

802.6.4 The work of construction of foundation for sign supports including excavation and backfill, forms, steel reinforcement, concrete and its placement shall conform to the relevant Specifications given in these Specifications.

802.6.5 The structures shall be erected with the specified camber and in such a manner as to prevent excessive stresses, injury and defacement.

802.6.6 Brackets shall be provided for mounting signs of the type to be supported by the structure. For better visibility, they shall be adjustable to permit mounting the sign faces at any angle between a truly vertical position and three degree from vertical. This angle shall be obtained by rotating the front lower edge of the sign forward. All brackets shall be of a length equal to the heights of the signs being supported.

- 802.6.7** Before erecting support structures, the bottom of each base plate shall be protected with an approved material which will adequately prevent any harmful reaction between the plate and the concrete.
- 802.6.8** The end supports shall be plumbed by the use of levelling nuts and the space between the foundation and base plate shall be completely filled with an anti-shrink grout.
- 802.6.9** Anchor bolts for sign supports shall be set to proper locations and elevation with templates and carefully checked after construction of the sign foundation and before the concrete has set.
- 802.6.10** All nuts on aluminium trusses, except those used on the flanges shall be tightened only until they are snug. This includes the nuts on the anchor bolts. A thread lubricant shall be used with each aluminium nut.
- 802.6.11** All nuts on galvanized steel trusses, with the exception of high strength bolt connections, shall be tightened only to a snug condition.
- 802.6.12** Field welding shall not be permitted.
- 802.6.13** After installation of signs is complete, the sign shall be inspected by the Engineer. If specular reflection is apparent on any sign, its positioning shall be adjusted by the Contractor to eliminate or minimize this condition.

802.7 Measurements for Payment

- 802.7.1** Aluminium or steel overhead sign structure shall be measured for payment by the specific unit (each) complete in place as indicated in the Bill of Quantities and the detailed drawings(s).
- 802.7.2** Fiat sheet aluminium signs with retro-reflective sheeting thereon shall be measured for payment by the square metre, complete in place.

802.8 Rate

- 802.8.1** The Contract unit rate for overhead sign structure shall be payment in full compensation for furnishing all labour, materials, tools, equipment, excavation for foundation, concrete, reinforcement, painting of structural steel and sign back, fabrications and installation, furnishing of necessary test certificates, warranty and all other incidental costs necessary to complete the work to these Specifications.
- 802.8.2** The Contract unit rate for aluminium sheet signs shall include the cost of making the sign including all materials and fixing the same in position and all other incidental costs necessary to complete the work to these Specifications.

803 ROAD MARKINGS

803.1 Scope

The work shall consist of providing road markings of specified width, layout and design using paint of the required specifications as given in the Contract and as per guidelines contained in from IRC:35-1997.

803.2 Materials

Road markings shall be of ordinary road marking paint hot applied thermoplastic compound, reflectorised paint or cold applied reflective paint as specified in the item and the material shall meet the requirements as specified in these Specifications.

803.3 Ordinary Road Marking Paint

803.3.1 Ordinary paint used for road marking shall conform to Grade I as per IS:164.

803.3.2 The road marking shall preferably be laid with appropriate road marking machinery.

803.4 Hot Applied Thermoplastic Road Marking

803.4.1 Thermoplastic Material

803.4.1.1 General

The thermoplastic material shall be homogeneously composed of aggregate, pigment, resins and glass reflectorizing beads. The colour of the compound shall be white or yellow (IS colour No. 356) as specified in the drawings or as directed by the Engineer.

803.4.1.2 Requirements:

- i. **Composition:** The pigment, beads, and aggregate shall be uniformly dispersed in the resin. The material shall be free from all skins, dirt and foreign objects and shall comply with requirements indicated in Table 800-9.

Table 800-9 : Proportions of Constituents of Marking Material (Percentage by Weight)

Constituent	White	Yellow
Polymer	100	100
Pigment	100	100
Filler	100	100
Hardener	100	100
Accelerator	100	100
UV Stabilizer	100	100
Other Additives	100	100

- ii. Properties: The properties of thermoplastic material, when tested in accordance with ASTM D36/BS-3262-(Part I), shall be as below:
 - a. **Luminance:**
 White: Daylight luminance at 45°-65 percent min. as per AASHTO M 249
 Yellow: Daylight luminance at 45°-45 percent min. as per AASHTO M 249
 - b. **Drying time** : When applied at a temperature specified by the manufacturer and to the required thickness, the material shall set to bear traffic in not more than 15 minutes. .
 - c. Skid resistance: not less than 45 as per BS:6044.
 - d. Cracking resistance at low temperature: The material shall show no cracks on application to concrete blocks.
 - e. Softening point: 102.5°C ± 9.5°C as per ASTM D 36.
 - f. Yellowness index (for white thermoplastic paint): not more than 0.12 as per AASHTO M 249
- iii. Storage life: The material shall meet the requirements of these Specifications for a period of one year. The thermoplastic material must also melt uniformly with no evidence of skins or unmelted particles for the one year storage period. Any material not meeting the above requirements shall be replaced by the manufacturer/supplier/ Contractor.
- iv. Reflectorising: Shall be achieved by incorporation of beads, the grading and other properties of the beads shall be as specified in Clause 803.42.
- v. Marking: Each container of the thermoplastic material shall be clearly and indelibly marked with the following information:
 - The name, trade mark or other means of identification of manufacturer
 - Batch number
 - Date of manufacture
 - Colour (white or yellow).
 - Maximum application temperature and maximum safe heating temperature.
- vi. Sampling and Testing: The thermoplastic material shall be sampled and tested in accordance with the appropriate ASTM/BS method. The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturers of the thermoplastic material showing results of all tests specified herein and shall certify that the material meets all requirements of this Specification.

803.4.2 Reflectorizing Glass Beads

803.4.2.1 General

This Specification covers two types of glass beads to be used for the production of reflectorised pavement markings.

Type 1 beads are those which are a constituent of the basic thermoplastic compound vide Table 800-9 and Type 2 beads are those which are to be sprayed on the surface vide Clause 803.6.4.

803.4.2.2 The glass beads shall be transparent, colourless and free from milkiness, dark particles and excessive air inclusions.

These shall conform to the requirements spelt out in Clause 803.4.2.3.

803.4.2.3 Specific Requirements

- a) Gradation: The glass beads shall meet the gradation requirements for the two types as given in Table 800-10.

Table 800-10: Gradation Requirements for Glass Beads

Sieve Size	Type 1 Beads		Type 2 Beads	
	Min.	Max.	Min.	Max.
75	100	100	100	100
150	100	100	100	100
300	100	100	100	100
425	100	100	100	100
750	100	100	100	100
1060	100	100	100	100
1500	100	100	100	100
2100	100	100	100	100
2500	100	100	100	100
3000	100	100	100	100
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9000	100	100	100	100
10600	100	100	100	100
12500	100	100	100	100
15000	100	100	100	100
18000	100	100	100	100
21000	100	100	100	100
25000	100	100	100	100
30000	100	100	100	100
36000	100	100	100	100
42500	100	100	100	100
50000	100	100	100	100
60000	100	100	100	100
75000	100	100	100	100
90000	100	100	100	100
106000	100	100	100	100
125000	100	100	100	100
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900000	100	100	100	100
1060000	100	100	100	100
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2100000	100	100	100	100
2500000	100	100	100	100
3000000	100	100	100	100
3600000	100	100	100	100
4250000	100	100	100	100
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6000000	100	100	100	100
7500000	100	100	100	100
9000000	100	100	100	100
10600000	100	100	100	100
12500000	100	100	100	100
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21000000	100	100	100	100
25000000	100	100	100	100
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36000000	100	100	100	100
42500000	100	100	100	100
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60000000	100	100	100	100
75000000	100	100	100	100
90000000	100	100	100	100
106000000	100	100	100	100
125000000	100	100	100	100
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180000000000	100	100	100	100
210000000000	100	100	100	100
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300000000000	100	100	100	100
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600000000000	100	100	100	100
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900000000000	100	100	100	100
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1500000000000	100	100	100	100
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3000000000000	100	100	100	100
3600000000000	100	100	100	100
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7500000000000	100	100	100	100
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10600000000000	100	100	100	100
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18000000000000	100	100	100	100
21000000000000	100	100	100	100
25000000000000	100	100	100	100
30000000000000	100	100	100	100
36000000000000	100	100	100	100
42500000000000	100	100	100	100
50000000000000	100	100	100	100
60000000000000	100	100	100	100
75000000000000	100	100	100	100
90000000000000	100	100	100	100
106000000000000	100	100	100	100
125000000000000	100	100	100	100
150000000000000	100	100	100	100
180000000000000	100	100	100	100
210000000000000	100	100	100	100
250000000000000	100	100	100	100
300000000000000	100	100	100	100
360000000000000	100	100	100	100
425000000000000	100	100	100	100
500000000000000	100	100	100	100
600000000000000	100	100	100	100
750000000000000	100	100	100	100
900000000000000	100	100	100	100
1060000000000000	100	100	100	100
1250000000000000	100	100	100	100
1500000000000000	100	100	100	100
1800000000000000	100	100	100	100
2100000000000000	100	100	100	100
2500000000000000	100	100	100	100
3000000000000000	100	100	100	100
3600000000000000	100	100	100	100
4250000000000000	100	100	100	100
5000000000000000	100	100	100	100
6000000000000000	100	100	100	100
7500000000000000	100	100	100	100
9000000000000000	100	100	100	100
10600000000000000	100	100	100	100
12500000000000000	100	100	100	100
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18000000000000000	100	100	100	100
21000000000000000	100	100	100	100
25000000000000000	100	100	100	100
30000000000000000	100	100	100	100
36000000000000000	100	100	100	100
42500000000000000	100	100	100	100
50000000000000000	100	100	100	100
60000000000000000	100	100	100	100
75000000000000000	100	100	100	100
90000000000000000	100	100	100	100
106000000000000000	100	100	100	100
125000000000000000	100	100	100	100
150000000000000000	100	100	100	100
180000000000000000	100	100	100	100
210000000000000000	100	100	100	100
250000000000000000	100	100	100	100
300000000000000000	100	100	100	100
360000000000000000	100	100	100	100
425000000000000000	100	100	100	100
500000000000000000	100	100	100	100
600000000000000000	100	100	100	100
750000000000000000	100	100	100	100
900000000000000000	100	100	100	100
1060000000000000000	100	100	100	100
1250000000000000000	100	100	100	100
1500000000000000000	100	100	100	100
1800000000000000000	100	100	100	100
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2500000000000000000	100	100	100	100
3000000000000000000	100	100	100	100
3600000000000000000	100	100	100	100
4250000000000000000	100	100	100	100
5000000000000000000	100	100	100	100
6000000000000000000	100	100	100	100
7500000000000000000	100	100	100	100
9000000000000000000	100	100	100	100
10600000000000000000	100	100	100	100
12500000000000000000	100	100	100	100
15000000000000000000	100	100	100	100
18000000000000000000	100	100	100	100
21000000000000000000	100	100	100	100
25000000000000000000	100	100	100	100
30000000000000000000	100	100	100	100
36000000000000000000	100	100	100	100
42500000000000000000	100	100	100	100
50000000000000000000	100	100	100	100
60000000000000000000	100	100	100	100
75000000000000000000	100	100	100	100
90000000000000000000	100	100	100	100
106000000000000000000	100	100	100	100
125000000000000000000	100	100	100	100
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180000000000000000000	100	100	100	100
210000000000000000000	100	100	100	100
250000000000000000000	100	100	100	100
300000000000000000000	100	100	100	100
360000000000000000000	100	100	100	100
425000000000000000000	100	100	100	100

a 100 mm stem and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be free of lumps and clusters and shall flow freely through the funnel.

- ii. The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS:6088 and BS:3262 (Part I).
- iii. The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of these Specifications. However, if so required, these tests may be carried out as directed by the Engineer.

803.4.3 Application Properties of Thermoplastic Material

803.4.3.1 The thermoplastic material shall readily get screeded/extruded at temperatures specified by the manufacturers for respective method of application to produce a line of specified thickness which shall be continuous and uniform in shape having clear and sharp edges.

803.4.3.2 The material upon heating to application temperatures shall not exude fumes, which are toxic, obnoxious or injurious to persons or property.

803.4.4 Preparation

- i. The material shall be melted in accordance with the manufacturer's instructions in a heater with a mechanical stirrer to give a smooth consistency to the thermoplastic material to avoid local overheating. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material should be used as expeditiously as possible and for thermoplastic material which has natural binders or is otherwise sensitive to prolonged heating, the material shall not be maintained in a molten condition for more than 4 hours.
- ii. After transfer to the laying equipment, the material shall be maintained within the temperature range specified by the manufacturer for achieving the desired consistency for laying

803.5 Reflectorised Paint

Reflectorised paint, if used, shall conform to the Specification by the manufacturers and approved by the Engineer. Reflectorising glass beads for reflectorising paints where used shall conform to the requirements of Clause 803-4.2.

803.6 Application

803.6.1 Marking shall be done by machine. For locations where painting cannot be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to cause minimum inconvenience to traffic compatible with protecting the workmen.

803.6.2 Where the compound is to be applied to cement concrete pavement, a sealing primer as recommended by the manufacturer, shall be applied to the pavement in

advance of placing of the stripes to ensure proper bonding of the compound. On new concrete surface any laitance and/or curing compound shall be removed before the markings are applied.

803.6.3 The thermoplastic material shall be applied hot either by screeding or extrusion process. After transfer to the laying apparatus, the material shall be laid at a temperature within the range specified by the manufacturer for the particular method of laying being used. The paint shall be applied using a screed or extrusion machine

803.6.4 The pavement temperature shall not be less than 10°C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease, oil and all other foreign matter before application of the paint.

The material, when formed into traffic stripes, must be readily renewable by placing an overlay of new material directly over an old line. Such new material shall so bond itself to the old line that no splitting or separation takes place.

Thermoplastic paint shall be applied in intermittent or continuous lines of uniform thickness of at least 2.5 mm unless specified otherwise. Where arrows or letters are to be provided, thermoplastic compound may be hand-sprayed. In addition to the beads included in the material, a further quantity of glass beads of Type 2, conforming to the above noted Specification shall be sprayed uniformly into a monolayer on to the hot paint line in quick succession of the paint spraying operation. The glass beads shall be applied at the rate of 250 grams per square metre area.

803.6.5 The minimum thickness specified is exclusive of surface applied glass beads. The method of thickness measurement shall be in accordance with Appendices B and C of BS:3262 (Part 3).

803.6.6 The markings shall be done to accuracy within the tolerances given below:

- i. Width of lines and other markings shall not deviate from the specified width by more than 5 percent.
- ii. The position of lines, letters, figures, arrows and other markings shall not deviate from the position specified by more than 20 mm.
- iii. The alignment of any edge of a longitudinal line shall not deviate from the specified alignment by more than 10 mm in 15 m.
- iv. The length of segment of broken longitudinal lines shall not deviate from the specified length by more than 150 mm.

In broken lines, the length of segment and the gap between segments shall be as indicated on the drawings; if these lengths are altered by the Engineer, the ratio of the lengths of the painted sections shall remain the same.

803.6.7 Properties of Finished Road Markings

The finished lines shall be free from ruggedness on sides and ends and be parallel to the general alignment of the carriageway. The upper surface of the lines shall be level, uniform and free from streaks.

- a) The stripe shall not be slippery when wet.
- b) The marking shall not lift from the pavement in freezing weather.
- c) After application and proper drying, the stripe shall show no appreciable deformation or discoloration under traffic and under road temperatures upto 60°C.
- d) The marking shall not deteriorate by contact with sodium chloride, calcium chloride or oil dripping from traffic.
- e) The stripe or marking shall maintain its original dimensions and position. Cold ductility of the material shall be such as to permit normal movement with the road surface without chopping or cracking.
- f) The colour of yellow marking shall conform to IS Colour No. 356 as given in IS: 164

803.6.8 Measurements for Payment

803.6.8.1 The painted markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any).

803.6.8.2 In respect of markings like directional arrows and lettering, etc., the measurement shall be by numbers.

803.6.9 Rate

The Contract unit rate for road markings shall be payment in full compensation for furnishing all labour, materials, tools, equipment, including all incidental costs necessary for carrying out the work at the site conforming to these Specifications complete as per the approved drawing(s) or as directed by the Engineer and all other incidental costs necessary to complete the work to these Specifications.

803.7 Cold Applied Reflective Paint

803.7.1 General

The work shall consist of marking traffic stripes using a solvent based cold applied paint, which shall be applied on the asphalt/cement concrete road surface by brush or by Road Marker (Spray equipment capable of spraying the paint on the road). Glass beads shall be subsequently spread pneumatically on to the paint when it is still wet so that the beads will be firmly held by the paint after drying. Colour of the paint shall be white or yellow (IS Colour No. 356) as specified in the drawings or as directed by the engineer.

803.7.2 Material

803.7.2.1 The cold applied paint material shall be homogeneously composed of binder, pigment, extenders and other additives as required for the formulation.

803.7.2.2 Composition

The pigments and extenders shall be uniformly dispersed in the binder medium dissolved in organic solvents. The material shall be free from skin, dirt and foreign objects and shall comply with requirements indicated in Table 800-11.

Table 800-11 : Proportions of Constituents or Paints (Percentage by Weight)

Constituents	Percentage by Weight	Remarks
Binder	65-75	
Pigments	15-25	
Extenders	10-20	
Solvents	10-20	

803.7.2.3 Properties

Non-Volatile Matter content by weight shall be a minimum of 65 percent as determined in accordance with test method ASTM DI 644. The liquid paint shall have a density of 1.3 g/cc minimum as determined in accordance with test method ASTM D1475.

803.7.2.4 Appearance

Drying Time of the paint as determined by the test method ASTM D711 shall be a maximum of 20 minutes at a wet film thickness of 350 micron. The paint shall set to bear traffic after 40 minutes when the ambient temperature is higher than 240C. The paint shall not be applied when the surface temperature of the road is higher than 400C.

803.7.2.5 Properties of the Dried Paint Film

When tested using a sand abrasion tester as described in ASTM D968, the quantity of sand required for removal of a 75 micron thick unbeaded dry film shall be greater than 65 litres.

803.7.2.6 Elongation

The unbeaded dry film shall pass the test in accordance with ASTM D 1737 and ASTM D 2205.

803.7.2.7 Water Resistance

The unbeaded dry film shall pass the test in accordance with ASTM DI 647 and ASTM D2205.

803.7.2.8 Skid Resistance

Skid resistance for the beaded dry film shall be not less than 45 as per BS 6044.

803.7.2.9 Storage Life

The material shall meet the specifications for a period of one year. During this period, the paint material when stored in an airtight container shall not form skin. The material shall also not form a cake at the bottom of the container.

803.7.2.10 Minimum Thickness of the Unbeaded Cold Applied Paint Coat

The minimum thickness of the wet unbeaded coat of paint shall not be less than 400 micron, and the minimum thickness of the dry unbeaded coat of paint shall not be less than 200 microns.

803.7.2.11 Retro-reflective Properties

The co-efficient of retro-reflection as per British Standards BS EN 1436: 1998 shall be as under:

Type of Road Surface	Coefficient of Retro-reflection
Dry Road Surface	0.15
Wet Road Surface	0.10
Road Surface with Aggregate	0.10

The luminous Co-efficient as per British Standards BS EN 1436: 1998 shall be as under:

Type of Road Surface	Luminous Co-efficient
Dry Road Surface	0.15
Wet Road Surface	0.10
Road Surface with Aggregate	0.10

803.7.3 Marking

- i. Each container of the cold-paint shall be clearly and indelibly marked with the following information:
- ii. The name, trade/patent mark
- iii. Batch No.
- iv. Month of Manufacture
- v. Colour (White or Yellow)

803.7.4 Sampling and Testing

The cold applied reflective road marking paint shall be sampled and tested in accordance with appropriate ASTM/BS test methods.

The contractor shall furnish to the Engineer a copy of certified test methods from the manufacturer of cold applied reflective road marking paint showing the results of:

- a) No pick up time as per ASTM D 711.
- b) Resistance to wear as per ASTM D 4060 or as per ASTM D 968 from approved laboratories.
- c) material safety data sheet shall be obtained from the manufacturer and kept with the paint materials.

803.7.5 Reflectorising Glass Beads

803.7.5.1 General

Reflection shall be achieved by pneumatically spreading glass beads on to the paint when it is still wet. The beads shall be firmly held by the paint after drying.

803.7.5.2 The glass beads shall be transparent, colourless and free from milkiness, . dark particles and excessive air inclusions. These shall conform to the requirements spelt out in Clause 803.6.7.3.

803.7.5.3 Specific Requirements

- i. Gradation: The glass beads shall meet the gradation requirements as per No. 4 of BS•.6088 as given in Table 800-12.

Table 800-12 : Gradation Requirements for Glass Beads

- ii. **Roundness:** The glass beads shall have a minimum of 70 percent true Spheres.
- iii. **Refractive Index:** The glass beads shall have a minimum refractive Index of 1.50.
- iv. **Free Flowing Properties:** The glass beads shall be free of hard lumps, clusters and shall dispense readily under any conditions suitable for paint striping. They shall pass the free flow-test es given in Clause 803.6.5.4.

803.7.5.4 Test Methods

The specific requirements shall be tested with the following methods:

- i. **Free-Flow Test:** Spread 100 grams of beads evenly in a 100 mm diameter glass dish. Place the dish in a 250 mm inside diameter dessicator which is filled within 25 mm of the top of a dessicator plate with sulphuric acid water solution (specific gravity 1.10). Cover the desiccator and let it stand for 4 hours at 200C to 290C. Remove sample from desiccator, transfer beads to a pan and inspect for lumps or clusters. Then pour beads into a clean, dry glass funnel having a 100 mm stern and 6 mm orifice. If necessary, initiate flow by lightly tapping the funnel. The glass spheres shall be free of lumps and clusters and shall flow freely through the funnel.
- ii. The requirements of gradation, roundness and refractive index of glass beads and the amount of glass beads in the compound shall be tested as per BS:6088 and BS:3262 (Part-1).
- iii. The Contractor shall furnish to the Engineer a copy of certified test reports from the manufacturer of glass beads obtained from a reputed laboratory showing results of all tests specified herein and shall certify that the material meets all requirements of these Specifications. However, if so required, these tests may be carried out as directed by the Engineer.

803.7.5.5 Preparation

The cold applied reflective road marking paint shall be stirred well to form homogeneously with the thinner recommended/supplied by the manufacturer and put into the machine with the consistency level recommended by the machine manufacturer by using proper viscometers. The thinner shall not be added more than that recommended by the manufacturer to avoid bleeding.

803.7.5.6 Application

803.7.5.6.1 Marking shall be done by machine. For locations where painting can not be done by machine, approved manual methods shall be used with prior approval of the Engineer. The Contractor shall maintain control over traffic while painting operations are in progress so as to Cal-ISE minimum inconvenience to traffic compatible with protecting the workmen.

803.7.5.6.2 The cold applied paint shall be applied on the asphalt/cement concrete road surface by brush or by Road Marker/Spray equipment capable of spraying the paint on the road surface. Glass beads @ 300 gms per sq.m shall be subsequently spread pneumatically on to the paint when it is still wet so that the beads will be firmly held by the paint after drying.

803.7.5.6.3 The pavement temperature shall not be more than 40° C during application. All surfaces to be marked shall be thoroughly cleaned of all dust, dirt, grease oils and all other foreign matter before application of paint.

803.7.5.6.4 The material, when formed into traffic stripes, must be readily renewable by placing an overlay of a new material directly over an old line. Such new material shall so bond itself to the old line that no splitting or separation takes place.

803.7.5.6.5 Cold applied paint shall be applied in intermittent or continues lines of uniform thickness of at least 200 micron of unbeaded dry film thickness unless specified otherwise. When arrows or letters are to be provided, cold applied paint may be applied manually. In addition to the beads recommended for, a further quantity of 300 gms of glass beads per sqm. conforming to the specification shall be sprayed uniformly in to a mono-layer on to the cold paint line in quick succession of the cold paint spraying operation.

803.7.5.6.6 The minimum. thickness specified above in Clause 803.7.5.5.5 is exclusive of surface applied glass beads.

803.7.5.6.7 The finished line shall be free from ruggedness on sides and ends and be parallel to general alignment of the carriage way.

The upper surface of the lines shall be of uniform level and free from streaks.

803.7.5.7 Properties of Finished Road Marking

As per Clause 803.67.

803.7.6 Measurement for Payments

As per Clause 803.5.2.1.

803.7.7 Rate

As per Clause 803.5.3.

803.8 Audible and Vibratory Pavement Markings

803.8.1 Description

The work shall involve application of audible and vibratory pavement markings in accordance with the drawings or the direction of the Engineer.

803.8.2 Materials

Thermoplastic: thermoplastic material shall meet the requirements of Clause 803.4.1 of these Specifications.

Glass Spheres: Use glass spheres meeting the requirements of Clause 803.4.2. The Engineer will take random samples of glass spheres in accordance with ASTM D 1214 and the Department's Sampling, Testing and Reporting Guide schedule.

803.8.3 Equipment

The equipment capable of providing continuous, uniform heating of the striping material to temperatures exceeding 200°C, mixing and agitating the material in the reservoir shall be used to provide a homogenous mixture without segregation. Equipment will maintain the striping material in a plastic state, in all mixing and conveying parts, including the line dispensing device until applied. Equipment shall be capable of producing a consistent pattern of transverse bars positioned at regular and predetermined intervals. It shall meet the following requirements:

- 1 capable of travelling at a uniform rate of speed, both uphill and downhill, to produce a uniform application of striping material and capable of following straight lines and making normal curves in a true arc.
- 2 capable of applying glass spheres to the surface of the completed stripe by automatic sphere dispensers attached to the striping machine such that the glass spheres are dispensed closely behind the installed line. The glass sphere dispensers should be equipped with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material and applies the glass spheres uniformly on the entire traffic stripe surface with 50 percent to 60 percent embedment equipped with a special kettle for uniformly heating and melting the striping material.

- 3 equipped with special kettle for uniformly heating and melting the stripping material. The kettle must be equipped with an automatic temperature control device and material thermometer for positive temperature control and to prevent overheating or scorching of the thermoplastic material.
- 4 meets the requirements of the fire safety standards.

803.8.4 Application

803.8.4.1 General

Before applying traffic stripes and markings, any material that would adversely affect the bond of the traffic stripes shall be removed by a method approved by the Engineer.

Before applying traffic stripes to any portland cement surface, a primer, sealer or surface preparation adhesive of the type recommended by the manufacturer shall be applied. Longitudinal lines should be offset by at least 50 mm from construction joints of Portland cement concrete pavement.

Traffic stripes or markings shall be applied only to dry surface, and when the ambient air and surface temperature is at least 1 OOC and rising for asphalt surfaces and 160C and rising for concrete surface.

Striping shall be applied to the same tolerances in dimensions and in alignment. When applying traffic stripes and marking over existing markings, ensure that not more than 50 mm on either end and not more than 25 mm on either side of the existing line is visible.

803.8.4.2 Thickness

Base lines shall be applied having a thickness of 2 mm to 2.2 mm exclusive of the transverse audible bars, when measured above the pavement surface at the edge of the base line.

As an alternative to the flat base line, a profiled baseline meeting the following dimensions may be applied. The profiled baseline shall have a minimum height of 4 mm, when measured above the pavement surface at the edge of the inverted rib profile. The thickness in the bottom of the profile marking shall be 0.9 mm to 1.3 mm. The individual profiles shall be located transversely across the full width of the traffic stripe at approximately 25 mm. On center, with a bottom width between 2.5 mm and 8 mm.

803.8.5 Dimensions of Transverse Audible Bars

The raised transverse bars shall be applied with a profile such that the leading and trailing edges are sloped at a sufficient angle to create an audible and vibratory warning,

Transverse bars on shoulder and centerline markings shall have a height of 11 mm to 14 mm, including the base line. The height shall be measured above the pavement surface at the edge of the marking, after application of drop-on glass spheres. The bars shall have an approximate length of 65 mm. The bars may have a drainage channel on each bar, the width of each

drainage channel will not exceed 6.5 mm at the bottom of the channel. The longitudinal distance between bars shall be 750 mm.

803.8.6 Retro-reflectivity

White and yellow audible and vibratory markings shall attain an initial retro reflectance of not less than 300 mcd/1xm2 and not less than 250 mcd/lx m2, respectively.

803.8.7 Glass Spheres

Glass spheres shall be applied to all markings. The manufacturer shall determine if a single or double application of glass spheres is used and the recommended drop rates for each application shall be adopted.

803.8.8 Contractor's Responsibility

The Engineer shall be notified by the contractor, prior to the placement of audible and vibratory markings. The contractor shall furnish the Engineer with the manufacturer's name and LOT numbers of the thermoplastic materials and glass spheres to be used. He will ensure that the LOT numbers appear on the thermoplastic materials and glass spheres packages. The contractor shall furnish a copy of certified test reports to the Engineer, showing results of tests specified in these Specifications or as per appropriate ASTM/BS method. The Engineer would have the right to test the markings within 3 days of receipt of the Contractor's certification. If the retro reflectivity values measure less than the values shown above, it shall be removed and the stripping reapplied.

803.8.9 Protection of Newly Applied Audible and Vibratory Markings

Traffic shall not be allowed onto or vehicles permitted to cross newly applied pavement markings until they are sufficiently dry. Any portion of the pavement markings damaged by passing traffic or from any other cause shall be removed and replaced.

803.8.10 Observation Period

Pavement markings shall be subject to a 180 day observation period under normal traffic. The observation period will begin with the satisfactory completion and acceptance of the pavement marking work. The pavement markings shall show no signs of failure during the observation period. Any pavement markings that do not perform satisfactorily under traffic during the 180 day observation period, shall be replaced by the contractor at his own cost.

803.8.11 Measurement for Payment

Audible and vibratory pavement markings shall be measured in linear metre. Payments will be full compensation for all work specified in this Section, including, ail cleaning and preparing of surfaces, furnishing of all materials, application, curing and protection of all items, protection of traffic, furnishing of all tools, machines and equipment, and all incidentals necessary to complete the work.

804 REFLECTIVE PAVEMENT MARKERS (ROAD STUDS) AND SOLAR POWERED ROAD MARKERS (SOLAR STUDS)

804.1 Scope

The work shall cover the providing and fixing of reflective pavement marker (RPM) or road stud, a device which is bonded to or anchored within the road surface, for lane marking and delineation for night-time visibility, as specified in the Contract.

804.2 Material

804.2.1 Plastic body of RPM/road stud shall be moulded from ASA (Acrylic Styrene Acrylonitrile) or HIPS (Hi-impact Polystyrene) or Acrylonitrile Butadiene Styrene (ABS) or any other suitable material approved by the Engineer. The markers shall support a load of 13,635 kg tested in accordance with ASTM D 4280.

804.2.2 Reflective panels shall consist of number of lenses containing single or dual prismatic cubes capable of providing total internal reflection of the light entering the lens face. Lenses shall be moulded of methyl methacrylate conforming to ASTM D 788 or equivalent.

804.3 Design

The slope or retro-reflecting surface shall preferably be 35 ± 50 to base and the area of each retro-reflecting surface shall not be less than 13.0 sq.cm.

804.4 Optical Performance

804.4.1 Unidirectional and Bi-directional Studs

Each reflector or combination of reflectors on each face of the stud shall have a Coefficient of Luminous Intensity (C.I.L). not less than that given in Tables 800-13 or 800-14 as appropriate.

804.4.2 Omni-directional Studs

Each Omni-directional stud shall have a C.I.L. of not less than 2 mcd/lx.

Table 800-13: Minimum C.I.L. Values for Category 'A' Studs

Category	Unidirectional and Bi-directional Studs	Omni-directional Studs
Category 'A'	1.0 mcd/lx	2.0 mcd/lx

Table 800-14: Minimum C.I.L. Values for Category 'B' Studs

Category	Minimum C.I.L. Values
Category 'B' Studs	Minimum C.I.L. Values

804.5 Tests

804.5.1 Co-efficient of luminance intensity can be measured by procedure described in ASTM E 809 "Practice for Measuring Photometric Characteristics" or as recommended in BS:873-Part 4: 1973.

804.5.2 Under test conditions, a stud shall not be considered to fail the photometric requirements if the measured C.I.L. at any one position of measurement is less than the values specified in Tables 800-13 or 800-14 provided that

- i. the value is not less than 80 percent of the specified minimum, and
- ii. the average of the left and right measurements for the specific angle is greater than the specified minimum.

804.6 Solar Powered Road Markers (Solar Studs)

The solar studs shall be made of Aluminium alloy and poly carbonate material which shall be absolutely weather resistant and strong enough to support a load of 13,635 kg tested in accordance with ASTM D4280. Its colour may be white, red, yellow, green or blue or combination as directed by the Engineer. Its water resistance shall meet the requirements of IP 65 in accordance with IS: 12063: 1987 Category 2 for protection against water ingress. The dimensions of solar studs shall not be less than 100 mm x 100 mm x 10 mm. It shall have super bright LEDs so as to provide (ong visibility from a distance of more than 800 m. Its flashing rate shall not be less than 1 Hz. Its should be able to give the prescribed performance in the temperature range of -400C to +550C. Its life shall be not less than 3 years.

804.7 Fixing of Reflective Markers

804.7.1 Requirements

The enveloping profile of the head of the stud shall be smooth and the studs shall not present any sharp edges to traffic. The reflecting portions of the studs shall be free from crevices or ledges where dirt might accumulate. Marker height shall not be less than 10 mm and shall not exceed 20 mm. and its width shall not exceed 130 mm. The base of the marker shall be flat within 1.3 mm. If the bottom of the marker is configured, the outermost faces of the configurations shall not deviate more than 1.3 mm from a flat surface. All road studs shall be legibly marked with the name, trade mark or other means of identification of the manufacturer.

804.7.2 Placement

The reflective marker shall be fixed to the road surface using the adhesives and the procedure recommended by the manufacturer. No nails shall be used to affix the marker so that they do not pose safety hazard on the roads. Regardless of the type of adhesive used, the markers shall not be fixed if the pavement is not surface dry and on new asphalt concrete surfacing until the surfacing has been opened to traffic for a period of not less than 14 hours. The portions of the highway surface, to which the marker is to be bonded by the adhesive, shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers, paint and any other material which would adversely affect the bond of the adhesive.

The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the of the marker in a quantity sufficient to result in complete coverage of the area of contract of the marker with no voids present and with a slight excess after the marker has been lightly pressed in place. For epoxy installations, excess adhesive around the edge of the marker, excess adhesive on the pavement and adhesive on the exposed surfaces of the markers shall be immediately removed.

804.7.3 Warranty and Durability

The contractor shall submit a two year warranty for satisfactory field performance including stipulated retro-reflectance of the reflecting panel, to the Engineer. In addition, a two year warranty for satisfactory infield performance of the finished road marker shall also be given by the contractOF who carries out the work of fixing of reflective road markers. In case the markers are displaced, damaged, get worn out or lose their reflectivity compared to stipulated standards, the contractor would be required to replace all such markers within 15 days of the intimation from the Engineer, at his own cost.

804.8 Measurement for Payment

The measurement of reflective road markers/solar powered road studs shall be in numbers of different types of markers supplied and fixed.

804.9 Rate

The contract unit rate for reflective road markers/solar powered road studs shall be payment in full compensation for furnishing all labour, material, tools, equipment including incidental costs necessary for carrying out the work at site conforming to the specification complete as per approved drawings or as directed by the Engineer.

805 DISTANCE INDICATOR POSTS

805.1 Scope

The work shall cover the supply, painting, lettering and fixing of distance indicator stones along the highway to assist the drivers/users in estimating the distance traveled or remains to be travelled to reach destination, to identify incident location and to provide assistance in maintenance and operations. These devices shall show Hectometre, Kilometre and 5th Kilometres as the case may be.

805.2 These posts shall be in "accordance with those prescribed in IRC:26 "Type Designs for 200 Metre Stones" and IRC:8 "Type Designs for Highway Kilometre Stones". They may also be provided in the form of sign systems on highways and roads.

805.3 The material may be made of local stones, concrete or any other material available locally and approved by the Engineer for the devices in accordance with the IRC:26 and IRC:8. For the device(s) provided as the sign system, the material shall be same as that for a traffic sign with retro-reflective sheeting; rectangular in shape (longer side vertical), with colour scheme as that for Advance Direction/Destination signs. The signs shall contain 250 mm white numerals on a 300 mm wide blue or green background (as the case may be) with white border. They shall be 600, 900 or 1200 mm in height for one, two or three digits respectively and shall contain the abbreviation km in 100 mm white letters so that they are clearly visible to approaching vehicle driver from a distance of at least 100 m. They shall be mounted at a minimum height and lateral placement as that for delineators. These devices shall be bedded into the ground with adequate foundations as indicated in the drawings or in the relevant IRC Specifications or as directed by the Engineer. The orientation and location of the devices shall be as indicated in the drawings or in the relevant IRC Specifications or as directed by the Engineer.

805.4 Measurements for Payment

The measurement will be in numbers of 200 metre, kilometre and 5th kilometre distance indicator posts fixed at site, complete job as per these Specifications or as directed by the Engineer.

805.5 Rate

The Contract unit rate for hectometer/kilometer/5th kilometer distance measurement posts shall be payment in full compensation for furnishing all labour, materials, tools, equipment and making, painting and lettering and fixing at site and all other incidental costs necessary to complete the work to these Specifications.

806 ROAD DELINEATORS

806.1 Scope

The work shall cover supplying and fixing roadway indicators, hazard markers and object markers. Roadway indicators shall be properly installed to indicate the horizontal alignment and vertical profile of the roadway so as to outline the vehicle path for safe driving. Hazard markers shall be installed immediately ahead of obstruction of vehicular path such as just before a narrow bridge. Object markers shall be erected where obstruction within the roadway starts such as channelising island in approaches to intersections.

806.2 The design, materials to be used and the location of the road delineators (roadway indicators, hazard markers and object markers) shall conform to Recommended Practice for Road Delineators, IRC:79, and to relevant drawings or as otherwise directed by the Engineer. The steel drums such as empty bitumen drums shall not be used as they could pose safety hazards, The delineators shall be retro-reflectorised as shown on the drawings or as directed by the Engineer. The reflectors on the delineators shall be of retroreflective sheeting with encapsulated

lens and with the visibility of 300 m under clear weather conditions, when illuminated by the upper beam of the car headlights.

806.3 Installation

The delineators shall be so installed that their posts do not change their orientation and the reflectorised faces are always perpendicular to the direction of travel.

806.4 Measurement for Payments

The measurement shall be made in number of delineators supplied and fixed at site.

806.5 Rates

The Contract unit rates of delineators shall be payment in full compensation for furnishing all labour, materials, tools, equipment including incidental costs necessary to complete the work to these Specifications.

807 BOUNDARY STONES

807.1 Scope

The work shall cover supply and fixing boundary stones as per designs. and Specifications given in IRC:25 "Type Designs for Boundary Stones" and at locations indicated in the drawings or as directed by the Engineer. The material to be used shall conform to IRC:25.

807.2 Measurements for Payment

The measurement shall be made in numbers of boundary stones supplied and fixed at site.

807.3 Rate

The Contract unit rate for boundary stones shall be full compensation for furnishing all labour, materials, tools, equipment for preparing, supplying and fixing and all other incidental costs necessary to complete the work to these Specifications.

808 TRAFFIC CONTROL AND SAFETY DEVICES IN CONSTRUCTION ZONE

808.1 Scope

The work shall cover supply and installation at site. Traffic Control Devices in the construction zone comprising of signs delineators, traffic cones, drums, barricades, longitudinal barriers, warning tapes, flagmen, reflective jackets, headgears.

808.2 Signs

Traffic signs shall be in accordance with IRC:67 and in accordance with IRC:SP:55. Its material and other requirements shall be in accordance with Clause 801 of these Specifications.

808.3 Delineators

Delineators in constructions zone are in form of vertical posts, cones, traffic cylinders, tapes, drums etc. Vertical posts shall be in accordance with the provisions contained in IRC:79.

808.4 Traffic Cones

808.4.1 Traffic cones may be of height 500 mm, 750 mm and 1000 mm, and 300 to 500 mm in diameter or in a square shape. They shall be of brilliant red/orange/yellow, ultraviolet stabilized colour for maximum visibility and fade resistance under all weather conditions and ambient working temperature of -30°C to +140°C. The material shall be Linear Low Density Polyethylene (LLDP), plastic or rubber so that there is no damage to the vehicle when they are stuck. Cone and base are to be of one continuous layer to prevent tearing and base separation. They should be non-crushable/flexible/tear resistant and UV stabilized and made from non-fading colours. They should return to their original shape in just 20 seconds after being crushed. The bases of cones shall be loaded with ballast (but they should not present a hazard if the cones are inadvertently struck) or anchored to check their being blown away. Their base should be designed for easy stacking without sticking. They may have retro-reflective white band and mounted flashing warning light for enhanced night visibility. All traffic cones shall conform to BS:873 (part 8) Catalogue A and the provisional European Standard EN 13422.

808.4.2 The measurement shall be for each piece and payment for each piece.

808.5 Drums

808.5.1 The drums shall be of size 800 mm to 1000 mm in height and 300 mm in diameter. They shall be constructed of lightweight, flexible, and deformable materials of LLDP or plastic so that no damage is caused to the vehicle when stuck. Steel drums shall not be used. They may be of bright red, yellow or white colours. They should be portable enough to be shifted from place to place within a temporary traffic control project to accommodate changing conditions but would remain in place for a prolonged period. The markings on drums shall be horizontal, circumferential, alternative orange and white retro-reflective stripes 100 to 150 mm wide. Each drum shall have a minimum of two orange and two white stripes. Any non-retro reflective spaces between the horizontal orange and white stripes, shall not exceed 50 mm wide. Drums shall have closed tops that will not allow collection of roadwork or other debris. When they are used in regions susceptible to freezing, they should have drainage holes in the bottom so that water will not accumulate and freeze, causing a hazard if struck by a motorist. Ballast shall not be placed on top of drum.

808.5.2 The measurement shall be for each piece and payment for each piece, for providing and maintenance at site as per the direction of the Engineer.

808.6 Barricades

The barricades may be portable or permanent. Barricades may be of wooden, metal or other suitable material panels. They shall be stable under adverse weather conditions and appear significant but not to cause damage to the vehicle if they are stuck. They can be classified in 3 types, namely Type-I, Type-II and Type-III. Type-I and Type-II are portable and Type-III permanent. Because of their vulnerable position and the hazard they could create, they should be constructed of lightweight materials and should have no rigid stay bracing for A-frame designs.

808.6.1 Type-I and Type II Barricade

The rail/panel length shall be 2000 mm to 2500 mm for Type I and 1000 mm to 1200 mm for Type II barricade. The width of rails shall be 200 mm to 300 mm. The rails shall be painted in alternate yellow and white stripes of 150 mm width each, sloping away at an angle of 45° in the direction of traffic. The support shall be on a "A-Configuration" or otherwise at the top to permit convenient folding and staking for transportation. Their stability shall be improved by ballasting. On highways or in other situations where barricades may be susceptible to overturning in the wind, sandbags shall be used for ballasting. Sandbags may be placed on lower parts of the frame or stays to provide the required ballast but shall not be placed on top of any striped rail. Barricades shall not be ballasted by heavy objects such as rocks or chunks of concrete.

808.6.2 Type-III Barricade

Type-III is the permanent type and may be made of wood, metal or other suitable material. The typical configuration shall include 3 or more panels/rails, of minimum 1000 mm length (maximum length as per site requirement) and 300 mm width each, painted with alternate yellow and white stripe of 150 mm width sloping at an angle of 45°. They shall be supported and secured on 2 or more vertical supports of same material. On highways or in other situations where barricades may be susceptible to overturning in the wind, sandbags should be used for ballasting. Sandbags may be placed on lower parts of the frame or stays to provide the required ballast but shall not be placed on top of any striped rail. Barricades shall not be ballasted by heavy objects such as rocks or chunks of concrete.

808.6.3 Application

808.6.3.1 Type I or Type II barricades shall be used in situations where traffic is maintained through the temporary traffic control zone. They may be used singly or in groups to mark a specific condition, or they may be used in a series for channelizing traffic. Type I barricades normally would be used on conventional roads or urban streets and arterials. Type II barricades have more retro-reflective area and are intended for use on highways and expressways or other high-speed roadways.

808.6.3.2 Type III barricades be used for road closure and may extend completely across a roadway or from kerb to kerb. Where provision is made for access of authorized equipment and vehicles, the responsibility should be assigned to a person to ensure proper closure at the end of each work day.

When a highway is legally closed but access must still be allowed for local traffic, the Type III barricade should not be extended completely across a roadway. A sign with the appropriate legend concerning permissible use by local traffic shall be mounted.

Signs may be erected on barricades, particularly those of the fixed type, that offer a most advantageous facility for this purpose. The ROAD CLOSED and DETOUR or ARROW signs, and the large arrow warning signs, for example, can be mounted effectively on or above the barricade that closes the roadway.

808.7 Longitudinal Safety Barriers

808.7.1 Longitudinal channelising barricades are light weight channelising devices that can be used singly as Type-I, II or III barricades, or connected so that they are highly visible and have good target value. They should be interlocked to delineate or channelise the traffic flow and mark the work zone. The inter-locking barricade wall should not have gaps that allow pedestrians or vehicles to stray from the channelising path. Longitudinal channelising barricades are located adjacent to traffic and therefore, are subject to impact by errant vehicles. Because of their vulnerable positions, longitudinal channelising barricades should be constructed of light weight materials and be crash worthy. They shall be of high density polyethylene, non-fading, and high impact and U.V. resistant. They shall be of orange, white or custom colours. Their size should be minimum 1500 mm in length, 1000 mm in height, 600 mm in width. They could be filled with water through an aperture on the top and emptied by removing a plug at the base.

On roads with low speed traffic, GI sheets material could be considered for longitudinal barricades. They shall be firmly secured to vertical support system with no sharp edges to pose any hazard when struck. Their configuration shall be as per the drawing or as directed by the Engineer.

808.7.2 Measurement shall be per running metre of longitudinal barrier and payment for the running metre of complete job of providing, installation and maintenance at site as per the drawing/direction of the Engineer.

808.8 Flagman

808.8.1 The flagmen or flaggers shall be deployed where:

- * Workers or equipment intermittently block an unprotected traffic lane,
- * One lane is used for two directions of traffic,
- * It is considered necessary to guide, warn or control traffic is considered necessary.

The flagman should be alert, intelligent and capable to effectively perform the assigned duties. Flagman shall be provided with hand signalling devices such as flags and sign paddles. Flagmen must be provided with and must wear warning garments, safety headgear, footwear and gloves for their protection and for conspicuity, while flagging. Warning garments worn at night must be of reflective material. Flags for signalling shall be minimum 600 mm x 600 mm and made of good

red cloth and securely fastened to a staff of approximately of 1 m. in length. Sign paddles should be at least 600 mm wide provided with a rigid handle. The background colour of STOP should be red and its shape shall be octagonal conforming to IRC:67. The word STOP would be in white colour. Background of SLOW sign should be yellow with black letters and borders.

808.9 Reflective Clothings

808.9.1 In the work zones and construction sites, all the workers, supervisors and inspecting officers shall wear high visibility fluorescent clothing with retro-reflective material, so that their presence is conspicuous from a distance of 300 m. Clothing may be in form of vests, T-shirts, jackets, pants and raincoats etc., depending upon weather conditions and ease of usage. They shall be of bright colours of fluorescent red-orange or fluorescent yellow green.

808.9.2 The reflective clothing's shall have reflective bands of width appropriate for the garments viz. vests, T-shirts, jackets, pants and raincoats. It shall have 360° visibility with at least one retro-reflective band encircling the torso, There shall be appropriate separation distances of vertical and horizontal bands placed on torso, sleeves and trouser areas. The garment shall be free of roughness and sharp edges so as not to cause excessive irritation and the wearer should get the best possible degree of comfort and protection.

808.9.3 The reflective clothing shall meet the requirements of standards given in IS: 15809-2008 or EN 471:2003 The material shall be tested for colour and luminance, colour fastness with cracking, perspiration, laundering and UV light exposure. The material shall meet the requirements of brightness after rainfall performance, temperature variation, abrasion resistance, flexing, cold folding and variation in temperature.

808.9.4 Measurement shall be for the unit piece of clothing and payment for providing and maintaining at site as per direction of the Engineer.

808.10 Personal Protection Equipment for Workers

All the workers, exposed to moving roadway traffic or equipment in road construction zones shall wear high-visibility safety apparel, headgear, boots, gloves and other protective gears for their protection. The safety apparel shall be in accordance with Clause 813.9. The safety headgear or protective helmet shall protect the wearer against falling objects and possible serious injury. It shall address requirements of shock absorption, resistance to penetration, flame resistance, chin strap anchorages, comfortable wearing and shall meet the requirements of IS:2925 or EN 397. The safety shoes or boots shall provide personal protection from any possible hazard posed by the activity being done and provide comfortable wearing without giving any hindrance in the expected tasks. The work gloves shall provide protection against any personal injury that could be caused by the activities to be performed and comfort in wearing without giving any hindrance in the expected tasks. If the worker is to be exposed to dust in the work zone, he shall have respiratory protection by dust mask meeting the requirements of IS:9473-2008. Depending upon the task, workers engaged in welding operations shall have eye protection through passive welding sheet meeting the requirements of EN 175 or auto darkening sheet meeting the requirement of EN 379/EN 169.

808.11 Measurement

The traffic control device of providing traffic signs shall be measured in number. Traffic control devices like barriers and delineators and supply of flagman shall be measured in number and days for which they are used unless specified otherwise in the Contract. Other traffic control devices such as drums, cones, warning tapes, reflective jackets, headgears for workmen shall be considered incidental to the work.

808.12 Rate

Rate for providing traffic signs shall be inclusive of supply of materials, fabrication, installation and maintenance of signs. The rate for provision of barriers and delineators shall be on a rental basis per number-days. The rate for supply of flagmen shall be full wages including their reflective jackets and headgear per man-days of deployment.

809 QUALITY CONTROL FOR ROAD WORKS

810 GENERAL

810.1 All materials to be used, all methods to be adopted and all works to be performed shall be strictly in accordance with the requirements of these Specifications. The Contractor shall set up a field laboratory at locations approved by the Engineer and equip the same with adequate equipment and personnel in order to carry out Quality Control for works and all the required tests as per Specifications and/or as directed by the Engineer. The provision and maintenance of the laboratory shall be as per Clause 120 and/or as directed by the Engineer. The list of equipment and the facilities to be provided shall be got approved from the Engineer in advance.

810.2 The Contractor's laboratory shall be manned by a qualified Materials Engineer/Civil Engineer assisted by experienced technicians, and the set-up should be got approved by the Engineer.

810.3 The Contractor shall carry out quality control tests on the materials and work to the frequency stipulated in subsequent paragraphs. In the absence of clear indications about method and or frequency of tests for any item, the instructions of the Engineer shall be followed.

810.4 For satisfying himself about the quality of the materials and work, quality control tests will also be conducted by the Engineer (by himself, by his Quality Control Units or by any other agencies deemed fit by him), generally to the frequency set forth hereunder. Additional tests may also be conducted where, in the opinion of the Engineer, need for such tests exists.

810.5 The Contractor shall provide necessary co-operation and assistance in obtaining the samples for tests and carrying out the field tests as required by the Engineer from time to time. This shall include provision of laboratory equipment, transport, consumables, personnel including labour attendants, assistants in packing and dispatching and any other assistance considered necessary in connection with the tests.

- 810.6** For the work of embankment, subgrade and pavement, construction of subsequent layer of same or other material over the finished layer shall be done after obtaining permission from the Engineer. Similar permission from the Engineer shall be obtained in respect of all other items of works prior to proceeding with the next stage of construction.
- 810.7** The Contractor shall carry out modifications in the procedure of work, if found necessary, as directed by the Engineer. Works falling short of quality shall be rectified/ redone by the Contractor at his own cost, and defective work shall also be removed from the site of works by the Contractor at his own cost.
- 810.8** The cost of laboratory building including essential supplies like water, electricity, sanitary services and their maintenance and cost of all equipment, tools, materials, labour and incidentals to perform tests and other operations of quality control according to the Specification requirements shall be deemed to be incidental to the work and no payment shall be made for the same. If, however, there is a separate item in the Bill of Quantities for setting up of a laboratory and installing testing equipment, such work shall be paid for separately.
- 810.9** For testing of soils/soil mixes, granular materials and mixes, bituminous materials and mixes, cement concrete materials and mixes, aggregates, cores etc., samples in the required quantity and form shall be supplied by the Contractor at his own cost
- 810.10** For cement, bitumen, steel, emulsion, road marking paint, sign boards, geo-synthetics and similar other materials where essential tests are to be carried out in the presence of Engineer at the manufacturer's plants or at laboratories other than the site laboratory, the cost of samples, sampling, testing and furnishing of test certificates shall be borne by the Contractor.
- Manufacturer's test certificate together with invoice or delivery challan shall be furnished for every lot of supply apart from tests to be conducted at site laboratory for prime properties of the material like cement, bitumen, etc. Where facilities for testing of materials are not available at site laboratory the same shall be tested at an outside laboratory in the presence of the Engineer. For specialized items such as sign boards, road marking paint, etc. the Engineer may order for third party test from an approved laboratory.
- 810.11** The method of sampling and testing of materials shall be in accordance with the requirements of the relevant Indian Standards and these Specifications. Where they are contradicting, the provisions in these Specifications shall be followed. Where they are silent, sound engineering practices shall be adopted. The sampling and testing procedure to be used shall be as approved by the Engineer and his decision shall be final and binding on the Contractor. The cost of all tests shall be borne by the Contractor.
- 810.12** The materials for embankment construction shall be got approved from the Engineer. The responsibility for arranging and obtaining the land for borrowing or exploitation in any other way shall rest with the Contractor who shall ensure smooth and uninterrupted supply of materials in the required quantity during the construction period.

Similarly, the supply of aggregates and other materials for construction shall be from sources approved by the Engineer. Responsibility for arranging uninterrupted supply of materials from the source shall be that of the Contractor.

810.13 Defective Materials

All materials which the Engineer has determined as not conforming to the requirements of the Contract shall be rejected whether in place or not; they shall be removed immediately from the site as directed. Materials, which have been subsequently corrected, shall not be used in the work unless approval is accorded in writing by the Engineer. Upon failure of the Contractor to comply with any instruction of the Engineer, the Engineer shall have authority to cause the removal of rejected material and to deduct the removal cost thereof from any payments due to the Contractor.

810.14 Imported Materials

The Contractor shall furnish a list of materials/finished products manufactured, produced or fabricated outside India which he proposes to use in the work. The Contractor shall not be entitled to extension of time for acts or events occurring outside India and it shall be the Contractor's responsibility to make timely delivery to the job site of all such materials obtained from outside India.

The materials imported from outside India shall conform to the relevant Specifications of the Contract. In case where materials/finished products are not covered by the Specifications in the Contract, the details of laboratories/establishments where tests are to be carried out shall be specifically brought out and agreed to in the Contract.

The Contractor shall furnish to the Engineer a certificate of compliance of the tests carried out. In addition, certified mill test reports clearly identified in the lot of materials shall be furnished at the Contractor's cost.

811 CONTROL OF ALIGNMENT, LEVEL AND SURFACE REGULARITY

811.1 General

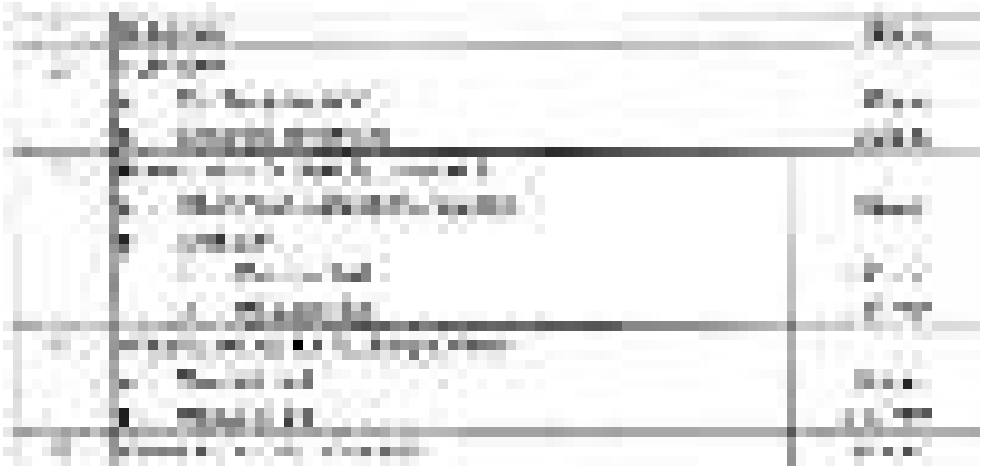
All works performed shall conform to the lines, grades, cross sections and dimensions shown on the drawings or as directed by the Engineer, subject to the permitted tolerances described herein-after.

811.2 Horizontal Alignment

Horizontal alignment shall be reckoned with respect to the centre line of the carriageway as shown on the drawings. The edges of the carriageway as constructed shall be correct within a tolerance of ± 10 mm therefrom. The corresponding tolerance for edges of the roadway and lower layers of pavement shall be ± 25 mm.

811.3 Surface Levels

The levels of the subgrade and different pavement courses as constructed, shall not vary from those calculated with reference to the longitudinal and cross-profile of the road shown on the drawings or as directed by the Engineer beyond the tolerances mentioned in Table 900-1.



Item	Tolerance (mm)	Remarks
Subgrade		
Subgrade	±10	
Sub-base	±10	
Pavement Courses		
Base Course	±10	
Wearing Course	±10	

Provided, however, that the negative tolerance for wearing course shall not be permitted in conjunction with the positive tolerance for base course, if the thickness of the former is thereby reduced by more than the following limits:

- mm for bituminous wearing course of thickness 40 mm or more
- mm for bituminous wearing course of thickness less than 40 mm
- mm for concrete pavement slab

For checking compliance with the above requirement for subgrade, sub-base and base course, measurements of the surface levels shall be taken on a grid of points placed at 625 m longitudinally and 3.5 m transversely. For any 10 consecutive measurements taken longitudinally or transversely, not more than one measurement shall be permitted to exceed the tolerance as above, this one measurement being not in excess of 5 mm above the permitted tolerance.

For checking the compliance with the above requirement for bituminous wearing courses and concrete pavements, measurements of the surface levels shall be taken on a grid of points spaced at 6.25 m along the length and at 0.5 m from the edges and at the centre of the pavement. In any length of pavement, compliance shall be deemed to be met for the final road surface, only if the tolerance given above is satisfied for any point on the surface.

811.4 Surface Regularity of Pavement Courses

The longitudinal profile shall be checked with a 3 metre long straight edge/moving straightedge as directed by the Engineer at the middle of each traffic lane along a line parallel to the centre line of the road.

The maximum permitted number of surface irregularities shall be as per Table 900-2.

Table 900-2 : Maximum Permitted Number of Surface Irregularities

Category	1/2 Year old by the end of the 1st year of the contract				After 1 year of opening to traffic by the end of the 2nd year of the contract			
	100%	75%	50%	25%	100%	75%	50%	25%
Number of surface irregularities per 100 sq. m.	1	2	3	4	1	2	3	4
Number of surface irregularities per 100 sq. m. (by the end of the 1st year of the contract)	1	2	3	4	1	2	3	4
Number of surface irregularities per 100 sq. m. (by the end of the 2nd year of the contract)	1	2	3	4	1	2	3	4

* Category of each section of road as described in the Contract.

The maximum allowable difference between the road surface and underside of a 3 m straightedge when placed parallel with, or at right angles to the centre line of the road at points decided by the Engineer shall be:

for pavement surface (bituminous and cement concrete)	3 mm
for bituminous base courses	6 mm
for granular sub-base/base courses	8 mm
for sub-bases under concrete pavements	10 mm
for subgrade	15 mm

811.5 Rectification

Where the surface regularity of subgrade and the various pavement courses fall outside the specified tolerances in Clause 902.4, the Contractor shall be liable to rectify these in the manner described below and to the satisfaction of the Engineer.

- **Subgrade:** Where the surface is high, it shall be trimmed and suitably compacted. Where the same is low, the deficiency shall be corrected by scarifying the lower layer and adding fresh material and recompacting to the required density. The degree of compaction and the type of material to be used shall conform to the requirements of Clause 305.
- **Granular Sub-base:** Same as at (i) above, except that the degree of compaction and the type of material to be used shall conform to the requirements of Clause 401.
- **Lime/Cement Stabilized Soil Sub-base:** For lime/cement treated materials where the surface is high, the same shall be suitably trimmed while taking care that the material below is not disturbed due to this operation. However, where the surface is low, the same shall be corrected as described herein below.

For cement treated material, when the time elapsed between detection of irregularity and the time of mixing of the material is less than 2 hours, the surface shall be scarified to a depth of 50 mm, supplemented with freshly mixed materials as necessary and recompacted as per the relevant

specification. When this time is more than 2 hours, the full depth of the layer shall be removed from the pavement and replaced with fresh material to Specification. This shall also apply to lime treated material except that the time criterion shall be 3 hours instead of 2 hours.

- Water Bound Macadam/Wet Mix Macadam Sub-base/Base: Where the surface is high or low, the top 75 mm shall be scarified, reshaped with added material as necessary and recompact as per Clause 404 in the case of Water Bound Macadam and to Clause 406 in the case of Wet Mix Macadam.
- Bituminous Constructions: For bituminous construction other than wearing course, where the surface is low, the deficiency shall be corrected by adding fresh material over a suitable tack coat, if needed, and recompact as per specifications. Where the surface is high, the extra thickness in the affected layer shall be removed and replaced with fresh material and compacted to Specifications.

For wearing course, where the surface is high or low, the full depth of the layer shall be removed and replaced with fresh material and compacted to specifications. In all cases where the removal and replacement of a bituminous layer is involved, the area treated shall not be less than 5 m in length and not less than 3.5 m in width.

- Dry Lean Concrete Sub-Base: The defective length of the course shall be removed to full depth and replaced with material conforming to Clause 601. The area treated shall be at least 3 m long, not less than 1 lane width and extend to the full depth. Before relaying the course, the disturbed subgrade or layer below shall be corrected by leveling, watering and compacting.
- Cement Concrete Pavement: The defective areas having irregularity exceeding 3 mm but not greater than 6 mm when tested with a 3 metre long straight edge may be rectified by scrabbling or grinding using approved equipment. When required by the Engineer, areas which have been reduced in level by the above operation(s) shall be retextured in an approved manner either by cutting grooves (5 mm deep) or roughening the surface by hacking the surface. If high areas in excess 6 mm or low areas in excess of 3 mm occur, exceeding the permitted numbers and if the Contractor cannot rectify, the slab shall be demolished and reconstructed at the Contractor's expense and in no case the area removed shall be less than the full width of the lane in which the irregularity occurs and full length of the slab.

If deemed necessary by the Engineer, any section of the slab which deviates from the specified levels and tolerances shall be demolished and reconstructed at the Contractor's cost.

811.6 Riding Quality

The riding quality of bituminous concrete wearing surface, as measured by a standard towed fifth wheel bump integrator, shall not be more than 2000 mm per Km.

812 QUALITY CONTROL TESTS DURING CONSTRUCTION

812.1 General

The materials supplied and the works carried out by the Contractor shall conform to the specifications prescribed in the Clauses for the relevant items of work.

For ensuring the requisite quality of construction, the materials and works shall be subjected to quality control tests, as described hereinafter. The testing frequencies set forth are the desirable minimum and the Engineer shall have the full authority to carry out additional tests as frequently

as he may deem necessary, to satisfy himself that the materials and works comply with the appropriate specifications. However, the number of tests recommended in Tables 900-3 and 900-4 may be reduced at the discretion of the Engineer if it is felt that consistency in the quality of materials can still be maintained with the reduced number of tests.

Test procedures for the various quality control tests are indicated in the respective Sections of these Specifications or for certain tests within this Section. Where no specific testing procedure is mentioned, the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Engineer.

Table 900-3: Control Tests and their Minimum Frequency for Sub-Bases and Bases (Excluding Bitumen Bound Bases)

Sl. No.	Particulars	Unit	Estimated Quantity
1	Excavation	m ³	10000
	Backfill	m ³	10000
	Gravel	m ³	10000
	Concrete	m ³	10000
	Reinforcement	m ³	10000
	Labour	m ³	10000
2	Supply of Materials		
	Gravel	m ³	10000
	Concrete	m ³	10000
	Reinforcement	m ³	10000
	Labour	m ³	10000
	Transport	m ³	10000
3	Supply of Services		
	Gravel	m ³	10000
	Concrete	m ³	10000
	Reinforcement	m ³	10000
	Labour	m ³	10000
	Transport	m ³	10000
4	Supply of Materials		
	Gravel	m ³	10000
	Concrete	m ³	10000
	Reinforcement	m ³	10000
	Labour	m ³	10000
	Transport	m ³	10000

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Sl. No.	S.No.	Description	Remarks
10	10.1	Construction of Road	Construction of Road
	10.2	Construction of Road	Construction of Road
	10.3	Construction of Road	Construction of Road
	10.4	Construction of Road	Construction of Road
	10.5	Construction of Road	Construction of Road
	10.6	Construction of Road	Construction of Road
	10.7	Construction of Road	Construction of Road
	10.8	Construction of Road	Construction of Road
	10.9	Construction of Road	Construction of Road
	10.10	Construction of Road	Construction of Road
	10.11	Construction of Road	Construction of Road
	10.12	Construction of Road	Construction of Road
11	11.1	Construction of Road	Construction of Road
	11.2	Construction of Road	Construction of Road
	11.3	Construction of Road	Construction of Road
	11.4	Construction of Road	Construction of Road
	11.5	Construction of Road	Construction of Road
	11.6	Construction of Road	Construction of Road
	11.7	Construction of Road	Construction of Road
	11.8	Construction of Road	Construction of Road
	11.9	Construction of Road	Construction of Road
	11.10	Construction of Road	Construction of Road
	11.11	Construction of Road	Construction of Road
	11.12	Construction of Road	Construction of Road

Sl. No.	Task / Sub-task	Item	Frequency/Period
1	Site Survey and Data Collection	1. Survey of Right of Way (ROW) and Adjacent Properties	Once at the start of the project
		2. Collection of Topographic Data and Soil Samples	Once at the start of the project
		3. Collection of Hydrological Data (Rainfall, River Discharge, etc.)	Once at the start of the project
		4. Collection of Geotechnical Data (Soil Strength, etc.)	Once at the start of the project
		5. Collection of Environmental Data (Air Quality, Noise, etc.)	Once at the start of the project
		6. Collection of Socio-economic Data (Population, Land Use, etc.)	Once at the start of the project
2	Design and Construction of Road	1. Design of Road Alignment and Cross-section	Once at the start of the project
		2. Design of Road Pavement Structure	Once at the start of the project
		3. Design of Road Drainage System	Once at the start of the project
		4. Design of Road Lighting System	Once at the start of the project
		5. Design of Road Safety Features (Signage, Barriers, etc.)	Once at the start of the project
		6. Design of Road Construction Details (Roadway, Shoulder, etc.)	Once at the start of the project
		7. Design of Road Construction Details (Drainage, Lighting, etc.)	Once at the start of the project
		8. Design of Road Construction Details (Safety, Barriers, etc.)	Once at the start of the project
		9. Design of Road Construction Details (Roadway, Shoulder, etc.)	Once at the start of the project
		10. Design of Road Construction Details (Drainage, Lighting, etc.)	Once at the start of the project
		11. Design of Road Construction Details (Safety, Barriers, etc.)	Once at the start of the project
		12. Design of Road Construction Details (Roadway, Shoulder, etc.)	Once at the start of the project

Sl. No.	Particulars	Unit	Rate per unit (Rs.)
1	1. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
2	2. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
3	3. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
4	4. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
5	5. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
6	6. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
7	7. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
8	8. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
9	9. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
10	10. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
11	11. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
12	12. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
13	13. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
14	14. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
15	15. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
16	16. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
17	17. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
18	18. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
19	19. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
20	20. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
21	21. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
22	22. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
23	23. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
24	24. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
25	25. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
26	26. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
27	27. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
28	28. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
29	29. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000
30	30. Provision of 100mm thick concrete base for 100mm thick concrete slab	sq.m	10000

Note: Daily, weekly, monthly reports on test results shall be prepared indicating the location of sampling and testing, deviation from the specified values for materials and works and remedial action taken in respect of removal of defective work shall certified be prepared by the Contractor. The test record shall be certified by the Engineer that these tests were done in his presence and testing carried as per prescribed methodology.

812.2 Tests on Earthwork for Embankment, Subgrade Construction and Cut Formation

812.2.1 Borrow Material

Grid the borrow area at 25 m c/c (or closer, if the variability is high) to full depth of proposed working. These pits should be logged and plotted for proper identification of suitable sources of material. The following tests on representative samples shall be carried out for every 3000 cum for each source:

- Sand Content [IS:2720 (Part-4)]: 2 tests per 3000 cu.m of soil.
- Plasticity Test [IS:2720 (Part-5)]: Each type to be tested, 2 tests.
- Density Test [IS:2720 (Part-8)]: Each soil type to be tested, 2 tests.
- Deleterious Content Test [IS:2720 (Part-27)]: As and when required by the Engineer.
- Moisture Content Test [IS:2720 (Part-2)]: Two tests.
- CBR Test on materials to be incorporated in the subgrade on soaked/ unsoaked samples [IS:2720 (Part-1 6)] : One CBR test (average of three specimens) or closer as and when required by the Engineer.

812.2.2 Compaction Control.

Control shall be exercised on each layer by taking at least one set of ten measurements of density for each 3000 sq.m of compacted area, or closer as required to yield the minimum number tests results for evaluating a day's work on statistical basis. The determination of density shall be in accordance with IS: 2720 (Part-28). Test locations shall be chosen only through random sampling techniques. If non-destructive tests are carried out, the number of tests shall be doubled. If considerable variations are observed between individual density results, the minimum number of tests in one set of measurement shall be increased. The acceptance criteria shall be subject to the condition that the mean density is not less than the specified density plus:



However, for earthwork in shoulders (earthen) and in the subgrade, at least one set of ten density measurements shall be taken for every 2000 sq.m for the compacted area. In other respects, the control shall be similar to that described earlier.

812.2.3 Cut Formation

Tests for the density requirements of cut formation shall be carried out in accordance with Clause 903.2.2.

812.3 Tests on Sub-bases and Bases (Excluding Bitumen Bound Bases)

The tests and their frequencies for the different types of bases and sub-bases shall be given in Table 900-3. The evaluation of density results and acceptance criteria for compaction control shall be on lines similar to those set out in Clause 903.2.2.

812.3.1 Acceptance Criteria

The acceptance criteria for tests on the strength of cement/lime stabilized soil and distribution of stabilizer content shall be subject to the condition that the mean value is not less than the specified value plus:



812.4 Tests on Bituminous Construction

812.4.1 Tests and Frequency

The tests and their minimum frequencies for the different types of bituminous works shall be as given in Table 900-4. The Engineer may direct additional testing as required.

812.4.2 Acceptance Criteria

The acceptance criteria for tests on density shall be subject to the condition that the mean value is not less than the specified value plus:



812.4.3 Where the Contract specifies the surface roughness requirements, in terms of Bump Integrator value, the surface roughness shall be measured by a calibrated Bump Integrator as per the procedure described in [REDACTED]. The measurements shall be taken at centre line of each lane for a minimum completed length of one Km.

812.5 Quality Control Tests for Concrete Road Construction

812.5.1 Dry Lean Concrete Sub-base

812.5.1.1 Sampling and Testing of Cubes

Samples of dry lean concrete for making cubes shall be taken from the uncompacted material from different locations immediately before compaction at the rate of 3 samples for each 1000 sq.m or part thereof laid each day. The sampling of mix shall be done from the paving site.

Test cubes of 150 mm size shall be made immediately from each mix sample.

Cubes shall be made in accordance with the methods described in IS:516 except that the cubes shall be compacted by means of a vibratory hammer with the moulds placed on a level and rigid base. The vibrating hammer shall be electric or pneumatic type fitted with a square or rectangular foot having an area of between 7500 to 14000 sq-mm. The compaction shall be uniformly applied for 5 seconds with a downward force of between 300 N and 400 N on to each of the three layers of the lean concrete material placed into the mould. The surface of each compacted layer shall be

scarified before the next layer is added to give key for the next layer. The final layer shall be finished flush with the top of the cube mould.

The dry lean concrete shall be cured in accordance with IS:516.

812.5.1.2 In-situ Density

The dry density of the laid material shall be determined from three density holes at locations equally spaced along a diagonal that bisects each 2000 sq.m or part thereof laid each day and shall comply with the requirements as per Clause 601.6.5.1. This rate of testing may be increased at the discretion of the Engineer in case of doubt or to determine the extent of defective area in the event of non-compliance. Density holes at random may be made to check the density at edges.

812.5.1.3 Thickness

The average thickness of the subbase layer as computed by the level data of sub-base and subgrade or lower sub-base shall be as per the thickness specified in the contract drawings. The thickness at any single location shall not be 8 mm less than the specified thickness. Such areas shall be corrected as stated in Clause 601.6.5.5. Areas which cannot be repaired should be replaced over full width. The extent of deficient area should be decided based on cores.

812.5.1.4 Frequency of Quality Control Tests

The frequency of quality control tests for levels, alignment and materials shall be as given in Table 900-6.

812.5.2 Pavement Concrete

812.5.2.1 Sampling and Testing of Beam and Cube Specimens

At least three beams and three cube specimens, one set of three each for 7 day and 28 day strength tests shall be cast for every 150 cu.m (or part thereof) of concrete placed during construction. On each day's work, not less than three pairs of beams and cubes shall be made for each type of mix from the concrete delivered to the paving plant. Each pair shall be from a different delivery of concrete and tested at a place to be designated by the Engineer in accordance with the testing procedure as outlined in Clause 602.3.3. Groups of four consecutive results from single specimens tested at 28 days shall be used for assessing the strength for compliance with the strength requirements. The specimens shall be transported in an approved manner to prevent sudden impact causing fractures or damage to the specimen. The flexural strength test results shall prevail over compressive strength tests for compliance.

812.5.2.2 A quality control chart indicating the strength values of individual specimens shall be maintained for continuous quality assurance. Where the requirements are not met with, or where the quality of the concrete or its compaction is suspect, the actual strength of the concrete in the slab shall be ascertained by carrying out tests on cores cut at the rate of 2 cores for every 150 cu.m of concrete. The average of the results of crushing strength tests on these cores shall not be less than 0.8×0.85

times the corresponding characteristic compressive strength of cubes, where the height to diameter ratio of the cores is two. Where height to diameter ratio is not two, necessary corrections shall be made in calculating the crushing strength of cubes in the following manner.

The crushing strengths of cylinders with height to diameter ratios between 1 and 2 may be corrected to correspond to a standard cylinder of height to diameter ratio of 2 by multiplying with the correction factor obtained from the following equation:

$$K = \left(\frac{h}{d} \right)^{1.65}$$

The corrected test results shall be analysed for conformity with the specification requirements for cube samples. Where the core tests are satisfactory, they shall have precedence for assessing concrete quality over the results of moulded specimens. The diameter of cores shall not be less than 150 mm.

If, however, the tests on cores also confirm that the concrete is not satisfying the strength requirements, then the concrete corresponding to the area from which the cores were cut should be replaced, i.e., at least over an area extending between two transverse joints where the defects could be isolated or over larger area, if necessary, as assessed by additional cores and their test results. The equivalent flexural strength at 28 days shall be estimated in accordance with Clause 602.3.3.2.

In order to ensure that the specified minimum strength at 28 days is attained in 1 in 20 of all test beams, the mix shall be proportioned to give an average strength at 28 days exceeding the specified strength by 1.65 times the standard deviation calculated first from the flexural strengths of test beams made from the trial mix and subsequently from the accumulating result of flexural strengths of job control test beams. The standard deviation shall be re-calculated from the test results obtained after any change in the source or quality of materials and the mix shall be adjusted as necessary to comply with the requirements.

An individual 28 day test strength below the specified strength shall not be evidence for condemnation of the concrete concerned if the average 28 day strength of this beam plus the preceding 5 and succeeding 4 beams exceeds the specified strength by 1.65 times the standard deviation and provided that there is no other evidence that the concrete mix concerned is substandard.

Beams shall be made each day in pairs at intervals, each pair being from a different batch of concrete. At the start of the work, and until such time as the Engineer may order a reduction in the number of beams required, at least six pairs of beams and cubes shall be made each day, one of each pair for testing at 28 days for determination of minimum permissible flexural strength and the other for testing at an early age for the Engineer to assess the quality of the mix. When the first thirty number of 28-day results are available, and for so long as the Engineer is satisfied with the quality of the mix, he may reduce the number of beams and cubes required.

During the course of construction, when the source of any material is to be changed, or if there is any variation in the quality of the materials furnished, additional tests and necessary adjustments in the mix shall be made as required to obtain the specified strength.

The flexural strengths obtained on beams tested before 28 days shall be used in conjunction with a correlation between them and the 28 day flexural strengths to detect any deterioration in the quality of the concrete being produced. Any such deterioration shall be remedied without awaiting the 28 day strengths but the earlier strengths shall not constitute sole evidence of non-compliance of the concrete from which they were taken.

Concrete shall be deemed not to comply with the Specification when more than one test beam in a batch has a 28 day strength less than the specified strength and the average 28 day flexural strength of the batch of beams is less than the specified strength plus 1.65 times the standard deviation of the batch.

Should the concrete fail to comply with the Specification for strength as described above, the Contractor may, all at his own expense, elect to cut cores from the suspect concrete as the Engineer shall direct. From the relation between cube strength and flexural strength, the core strength shall be converted to flexural strength.

The equivalent flexural strength at 28 days shall be the estimated in-situ strength multiplied by 100 and divided by the age-strength relation obtained from Table 900-5.

Any concrete that fails to meet the strength specification shall be removed and replaced at Contractor's expense.

Table 900-5 : Age-Strength Relation Concrete (Related to 100 percent at 28 Days)

Days	0	2	4	6	8
0		41.0	60.0	71.0	77.5
10	81.5	85.0	87.5	90.0	92.0
20	94.0	96.0	97.5	98.5	100.0
30	101.0	102.0	103.5	104.5	105.5
40	106.5	107.0	108.0	109.5	110.0
50	110.5	111.0	112.0	112.5	113.0
60	114.0	114.5	115.0	115.5	116.0
70	116.5	117.0	117.5	118.0	118.5
80	119.0	119.5	119.5	120.0	120.5
90	121.0	121.5	122.0	122.0	122.5
100	123.5	123.5	123.5	124.0	124.5
110	125.0	125.0	125.5	125.5	126.0

120	126.0	126.0	127.0	127.0	127.5
130	127.5	128.0	128.5	128.5	129.0
140	129.0	129.5	129.5	130.0	130.0
150	130.5	130.5	131.0	131.0	131.5
160	131.5	131.5	132.0	132.0	132.5
170	131.5	132.5	133.0	133.0	133.5
180	133.5	134.0	134.0	134.5	134.5
190	135.0	135.0	135.0	135.5	135.5
200	135.5	135.5	136.0	136.0	136.5
210	136.5	136.5	137.0	137.0	137.0
220	137.0	137.5	137.5	137.5	138.0
230	138.0	138.5	138.5	138.5	138.5
240	139.0	139.0	139.0	139.5	139.5
250	139.5	140.0	140.0	140.0	140.0
260	140.5	140.5	140.5	140.5	141.0
270	141.0	141.0	141.5	141.5	141.5
280	142.0	142.0	142.0	142.0	142.0
290	142.5	142.5	142.5	142.5	142.5
300	143.0	143.0	143.0	143.0	143.5
310	143.5	143.5	144.0	144.0	144.0
320	144.0	144.5	144.5	144.5	144.5
330	144.5	145.0	145.0	145.0	145.0
340	145.0	145.5	145.5	145.5	145.5
350	146.0	146.0	146.0	146.0	146.0
360	146.0	146.0	146.5	146.5	146.5

812.5.2.3 In-situ Density

The density of the compacted concrete shall be such that the total air voids are not more than 3 percent. The air voids shall be derived from the difference between the theoretical maximum dry density of the concrete calculated from the specific gravity of the constituents of the concrete mix and the average value of three direct density measurements made on cores at least 150 mm diameter. Three cores shall be taken from trial lengths and in first two km length of the pavement, while the slab is being constructed during normal working. The proportions of the mix and the

vibratory effort imparted i.e. the frequency and magnitude of vibration shall be adjusted to achieve the maximum density.

All cores taken for density measurement in the trial section shall also be checked for thickness. The same cores shall be made use of for determining in-situ strength. In *case of doubt, additional cores may be ordered by the Engineer and taken at locations decided by him to check the density of concrete slab or the position of dowel/tie bars without any compensation being paid for the same.

In calculation of the density, allowance shall be made for any steel in cores.

Cores removed from the main carriageway shall be reinstated with compacted concrete with mix proportions of 1 part of Portland cement: 2 parts of fine aggregate:2 parts of 10 mm nominal size single sized coarse aggregate by weight. Before filling the fine mix, the sides shall be hacked and cleaned with water. Thereafter cement-sand slurry shall be applied to the sides just prior to filling the concrete mix.

812.5.2.4 Thickness

Thickness shall be controlled by taking levels as indicated in Clause 902.3. Thickness of the slab at any point checked as mentioned above shall be within a tolerance of -5 mm to + 10 mm of the specified thickness as per Drawing. Thickness deficiency more than 5 mm may be accepted and paid for at a reduced rate given in Clause 602.16.3. In no case, however, thickness deficiency shall be more than 10 mm.

812.5.2.5 Summary of Control Tests

Table 900-6 gives a summary of frequency of testing of pavement concrete.

*This table appears in *Quarterly Journal of Economics*, Vol. 100, No. 1, 1985.

1. General Information 1.1 Project Name: [Project Name] 1.2 Project Number: [Project Number] 1.3 Project Location: [Project Location] 1.4 Project Start Date: [Project Start Date] 1.5 Project End Date: [Project End Date] 1.6 Project Manager: [Project Manager]			
2. Project Description 2.1 Project Purpose: [Project Purpose] 2.2 Project Objectives: [Project Objectives] 2.3 Project Scope: [Project Scope] 2.4 Project Risks: [Project Risks] 2.5 Project Benefits: [Project Benefits]			
3. Project Organization 3.1 Project Sponsor: [Project Sponsor] 3.2 Project Steering Committee: [Project Steering Committee] 3.3 Project Manager: [Project Manager] 3.4 Project Team: [Project Team] 3.5 Project Stakeholders: [Project Stakeholders]			
4. Project Budget 4.1 Project Budget: [Project Budget] 4.2 Project Funding: [Project Funding] 4.3 Project Costs: [Project Costs] 4.4 Project Revenue: [Project Revenue] 4.5 Project Profit: [Project Profit]			
5. Project Schedule 5.1 Project Timeline: [Project Timeline] 5.2 Project Milestones: [Project Milestones] 5.3 Project Deliverables: [Project Deliverables] 5.4 Project Risks: [Project Risks] 5.5 Project Benefits: [Project Benefits]			
6. Project Conclusion 6.1 Project Summary: [Project Summary] 6.2 Project Recommendations: [Project Recommendations] 6.3 Project Next Steps: [Project Next Steps] 6.4 Project Contact Information: [Project Contact Information] 6.5 Project Approval: [Project Approval]			

Sl. No.	Particulars	Estimate	Remarks
1	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
2	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
3	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
4	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
5	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
6	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
7	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
8	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
9	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.
10	Construction of 1000 sq. m. area	1.500	Construction of 1000 sq. m. area for the purpose of the project.

Table D-2 List of Codes

Code no.	Description
IRC: 37-2018	Guidelines for the Design of Flexible Pavement
IRC: 35-2015	Code of practice for Road Markings
IRC: 106-1990	Guidelines for Capacity of Roads in urban Areas
IRC: 67-2012	Code of Practice for Road Signs
IRC: 86-2018	Geometric Design Standards for Urban Roads in Plains
IRC: SP: 23-1983	Vertical curves for Highways
IRC: SP: 41-1994	Guidelines for the Design of At-Grade Intersections in Rural & Urban Areas
IRC: SP: 50-2013	Guidelines on Urban Drainage
IRC: SP: 44-1994	Highway Safety Code
IRC: SP: 19-2001	Manual for survey, investigation, and Preparation of Road Projects
MORT&H (5 th Revision)	Technical Specification for Roads and Bridges
IRC: 38-1988	Guidelines for the Design of Horizontal curves for Highways and Design Tables
MORT&H	Type Designs for Intersections on National Highways, 1992
IRC SP 63	
Manual for Safety in Road Design	
Institute of Urban Transport	

D 2. WATER SUPPLY

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer.

Standard Basic Specifications

The “Standard Specifications (civil works)” issued by the **CPWD**, set out the specifications that shall be followed for construction of General Works under the **INTEGRATED MANUFACTURING CLUSTER, HISAR at Haryana**. Particular Technical Specifications for the works to be tendered are as set out in these Schedules.

In the event of any discrepancy between the provisions of the Standard Basic Specifications and the Particular Technical Specifications, the provisions of the Particular Technical Specifications will prevail.

Table D-3 Relevant IS codes

Sr. No.	Code or Standard	Description
1.	Manual for Water Supply & Treatment	CPHEEO Manual for Water Supply & Treatment - 1999- MoUD, GoI
2.	Manual on operation and Maintenance on water supply	CPHEEO Manual on Operation and Maintenance of water supply systems, 2005 MoUD, GoI
3.	SP 7 (Part-9 Section-1) 1983	National Building Code of India
4.	SP 35:1987	Handbook on water supply & drainage
5.	IS 2065:1983	Code of practice for water supply in buildings
6.	IS 1172 :1993	Code of Basic requirements for water supply, drainage and Sanitation
7.	IS. 3370 part I to IV	Code of practice for concrete structure for the storage of liquids
8.	IS 456-2000	Code of Practice for plain and reinforced concrete
9.	IS 1893-2002 part I to V	Criteria for earthquake –resistant design of structures
10.	IS 13920-1993	Detailing of reinforced concrete structures subjected to seismic forces
11.	IS. - 11682 / 1985	Criteria for design of R.C.C. staging for overhead tanks.
12.	IS 1992-1969 / IS 6403-1971.	Code for exploration to find the safe bearing capacity
13.	IS 2309-1969	Code for Lighting arrestors

Sr. No.	Code or Standard	Description
14.	IS 875 part I to III,1987	Code of practice for design loads for building and structures
15.	IS 7357	Code of practice for structural design of tanks
16.	IS 1786-1985	High strength deformed steel bars and wires for concrete reinforcement
17.	IS 3589-2000	Electrically welded steel pipes for water, gas and sewerage (150 to 2000 mm nominal size)
18.	IS 5822	Code of practice for laying of welded steel pipes for water supply
19.	IS 1916-1989	Code for outside coatings for MS pipes
20.	IS 7322-1989	Code for MS Specials
21.	IS 4711	Method for sampling of steel pipes, tubes and fitting
22.	IS 10221	Code of practice for coating and wrapping of underground steel pipelines
23.	IS: 8329-2000	Centrifugally Cast (spun) ductile iron pressure pipes for water, gas and sewage
24.	IS: 5382-1985	Specification for Rubber sealing rings for gas mains, water mains and sewers.
25.	IS: 8112	Specification for 43 Grade ordinary Portland cement.
26.	IS: 638	Specification for rubber and insertion jointing.
27.	I.S. 1538 (Part I to XXII) 1976	Specification for cast Iron fittings for pressure pipes for water, gas and sewage
28.	IS: 3658-1981	Code of practice for liquid penetrant flaw detection
29.	IS. 226-1975	Specification for Structural steel
30.	IS 4984/1995	High density polyethylene pipes for potable water supplies
31.	IS: 9523	Ductile iron fittings for pressure pipes for water, gas and sewerage
32.	IS: 1500	Code for Hardness test for DI pipes
33.	IS:909-1976	Code for C.I. Fire Hydrants
34.	IS 7634 Part-2 (2012)	Code of practice for plastic pipework for potable water supplies –Laying and jointing of polyethylene pipes
35.	IS 8360 :2003	Fabricated high Density polyethylene (HDPE) fittings for potable water supplies
36.	IS 8008	Injection-molded HDPE fittings for potable water supplies
37.	IS 11606-1986	Methods of sampling cast iron pipes and fittings
38.	IS 1726 : 1991	Cast iron manhole covers and frames -specification
39.	IS 3764-1966	Safety code of Excavation works and related Drilling Operations

Sr. No.	Code or Standard	Description
40.	IS 11906:1986	Recommendations for cement mortar lining for cast iron, Mild steel and Ductile Iron pipes and fittings for transportation of water
41.	IS 5477	Methods for fixing the capacities of reservoirs
42.	IS 9668:1980	Code of practice for provision and maintenance of water supply for fire fighting
43.	IS 8062	Code of practice for cathodic protection for steel structures
44.	IS 12288:1987	Code of practice for laying of ductile iron
45.	IS 779:1994	Water meters (Domestic Type)
46.	BIS IS 2104: 1981	Water meter boxes (domestic type)
47.	IS2373:1981	Water meter (bulk type)
48.	BIS IS 2401: 1973	Code of Practice for fire selection, installation and maintenance of domestic water meters
49.	IS 6784:1996	Method for performance testing of water meters (domestic type)
50.	IS 14846:2000	Sluice valves for water works purposes (50 to 1200 mm size)
51.	IS 2906:1990	Sluice valves for water works purposes (350 to 1200 mm size)
52.	IS 2685:1971	Code of practice for selection, installation, and maintenance of sluice valves
53.	IS 3950:1979	Surface boxes for sluice valves
54.	IS 5312	Swing check type reflux (non-return) valves for water works purposes
55.	IS 9739:1981	Pressure reducing valves for domestic water supply systems
56.	IS 2692:1978	Ferrules for water services
57.	IS 10446:1983	Glossary of terms relating to water supply and sanitation
58.	IS 10500:2012	Drinking water quality
59.	IS2951-1965	Recommendation for estimation of flow of liquids in closed conduits.
60.	A guideline note on continuous water supply (24X 7 supply)	Guidelines for preparation of DPRs for water supply system by MoUD, 2013
61.	Advisory note on improving Urban Water Supply & Sanitation Services	Guidelines for preparation of DPRs for water supply system by MoUD, 2013

Table D-4: Relevant International Standards & specifications

Sr. No.	Code or Standard	Description
1	ISO: 10803-1997	Design method for ductile iron pipes
2	ISO: 2531-1991	Ductile iron pipes, fittings and accessories for pressure pipelines.
3	ISO: 4179-1985	Ductile iron pipes for pressure and non-pressure-Centrifugal cement mortar lining – General requirements.
4	BS: 3416	Bitumen based coatings for cold application, suitable for use in contact with Potable water.
5	ISO: 8179-1995	Ductile iron pipes-External coating-Part-1 Metallic Zinc with finishing layer.
6	ISO: 4633-1996	Rubber seals-Joint rings.
7	AWWA C600	Installation of ductile iron water mains and their appurtenances
8	BSEN -545	Code for Ductile Iron Flanges and Specials
9	AWWA Manual M11	Steel Pipe- A guide for design and Installation (Fourth Edition)
10	AWWA Manual M41	Ductile Iron Pipe and Fittings (Third Edition)
11	AWWA Manual M55	PE Pipe- Design and Installation (First Edition)

Particular Specification

Materials for pipelines

Each pipeline shall be constructed in a material compatible with the fluid conveyed through that pipeline, i.e., the materials used in the pipes which are or can be in contact with the untreated or treated water, shall not contain any matter which could impart taste or odour or toxicity or otherwise be harmful to health or adversely affect the water conveyed. Nor shall any pipe be adversely affected by the fluid being conveyed through that pipe.

HDPE pipes and specials

The pipes shall be of High-Density Polyethylene Pipes (HDPE) as per IS 4984 except mentioned otherwise. The material used for the manufacturing of pipes should not constitute toxic hazard, should not support microbial growth, should not give rise to unpleasant taste or odour, cloudiness or discoloration of water. Pipe manufacturers shall obtain a certificate to this effect from the manufacturers of raw material by any internationally reputed organization to the satisfaction of the Engineer- in -Charge.

- **Grade of material**

Raw material used to manufacture the HDPE pipes shall be 100% virgin PE compound or Natural black PE resin confirming to IS: 4984, IS: 7328 and ISO: 4427 for this a certification has to be obtained by the resin manufacturer as per clause 3.2.3 of IS: 4984. The resin proposed to be used for manufacturing of the pipes should also comply with the norms as per ISO 9080. The minimum grade of HDPE pipe should be PE 100.

- The specified base density shall be as prescribed in IS 7328. The MFR of the material shall be as prescribed in IS 2530. The resin shall be compounded with carbon black. The carbon black content in the material shall be as per IS 2530.
- The pressure rating of HDPE pipes and specials shall be of PN 6 confirming of IS: 4984.
- The colour of the HDPE pipe shall be confirming to IS4984:1995 or of ISO 4427:1996.
- Black colour for potable water and blue colour for non-potable water uses.
- Addition of not more than 10 percent of the manufacturer's own reworked material resulting from the manufacture of pipes is permissible, as per the clause 5.4 of IS 4984:1995. No other reworked or recycled material shall be used. The material to be used shall be clean and should be derived from the same resin as used for the relevant production.
- **Antioxidant:** The percentage of antioxidant used shall not be more than 0.3 percent by mass of finished resin. The anti-oxidant used shall be physiologically harm less and shall be selected from the list given in IS 10141
- Testing of pipes during manufacturing
- Visual appearance

The internal and external surfaces of the pipes shall be smooth, clean and free from grooving and other defects. The ends shall be cleanly cut and shall be square with axis of the pipes. Slight shallow longitudinal grooves or irregularities in the wall thickness shall be permissible, provided that the wall thickness remains within the permissible limits.

- Hydraulic characteristics

When subjected to internal pressure creep rupture test in accordance with the procedure given in Annex B of IS 4984, the pipes shall show no signs of localized swelling, leakage or weeping and shall not burst during the prescribed test duration. The temperatures, duration of test and induced stresses for the test shall confirm to those specified in the Table 6 of IS 4984.

- Length test

The length of straight pipe shall be 5 m to 20 m, as agreed between the manufacturer and the purchaser.

- Melt flow rate

When tested from a composite sample of minimum three pipes as per IS 2530:1963, at 190deg C with nominal load of 5kgf.

- Quality certificates

Quality assurance certificate as above for the raw material proposed to be used for the project, from one of the certifying agencies in India or other internationally reputed organization shall be submitted as per the direction of Engineer in Charge.

- Pressure rating

The pressure rating of HDPE pipes and specials shall be of PE-100-PN-10 confirming to IS: 4984.

- Dimensions and Tolerances

The pipe dimensions shall be as per latest revisions and amendment of IS 4984:1995. The pipes up to diameters 110mm shall be supplied in coils of 100m length. The coils shall be as per the provisions of IS4984:1995. Pipe beyond 110mm shall be supplied in straight lengths of minimum 6m to 12m as per Engineer- in -Charges instructions. The internal diameter, wall thickness, length and other dimensions of pipes shall be as per relevant tables of IS: 4984 for different class of pipes. Each pipe shall be of uniform thickness throughout its length.

- Performance requirements

The pipe supplied should have passed the acceptance tests as per IS4984:1995. The manufacturer should provide the test certificates for the tests conducted, as specified in IS4984:1995 along with supply of pipes. These tests can be performed in the in-house laboratory of the pipe manufacturer or at an approved laboratory. The Employer will fix the third party for inspection of pipes at factory as per the requirement. The cost of such inspection shall be borne by the contractor.

Each straight length of the pipe shall be clearly marked in inedible ink / paint on either end and for coils at every 5m as per the provisions of IS4984:1995, the following information shall be provided on the pipe:

- The manufacturer's name and/ trademark
- Designation of the pipe as per IS

- Lot number / Batch number

The pipe manufacturer who is going to supply the pipe for the project has to have a valid BIS license to do so for the kind of pipes required for this project.

DETECT ABILITY:

HDPE Pipes should be detectable when buried underground, by providing a copper wire of 1.20mm+/-0.2mm diameter, co extruded or firmly secured by self-adhesive tapes along the entire length of the pipes duly ISI marked or any other equivalent method enabling measurement/detectability from the top of ground including supply of 3 sets of such instrument to the SPV.

Copper wire shall have PE (Polyethylene) insulation, if laid separately and secured by self-adhesive tapes on the pipe. The insulation shall be free from voids and shall be strong enough to withstand mechanical and thermal stress of underground buried conditions. The thickness of the PE insulation shall not be less than 1.25mm or more, if specified in the relevant BIS Standards.

The pipe shall generally meet the specifications as per IS 4984/ relevant ISO with latest amendments.

The engineer-in-charge reserves the right to witness all tests and the contractor shall provide all facilities, to the engineer in charge in this regard and shall inform sufficiently in advance to enable the engineer in charge to depute his representative to witness the same. HDPE pipes should preferably be with co- extruded copper wire.

SPECIALS AND FITTINGS

All HDPE fittings / specials shall be moulded for lower diameter upto 200mm diameter and fabricated for other diameter in accordance with IS: 8360 (Part I & III). PE Injection moulded fittings shall be as per IS: 8008 (Part I to IX). All fittings / specials shall be fabricated, or injection moulded at factory only. No fabrication or moulding will be allowed at site, unless specifically permitted by the Engineer- in -Charge. Fittings will be electro-fusion welded on to the pipes or other fittings by use of heat fusion.

- HDPE bends shall be plain square ended conforming to IS: 8360 Part I & III Specifications. Bends may be fabricated by jointing several small sections of pipes to reach the required angle
- HDPE Tees shall be plain square ended conforming to IS: 8360 Part I & II Specifications. Tees may be equal tees or reduced take off tees. Tees may be moulded or fabricated from pipes elements
- HDPE Reducers shall be plain square ended conforming to IS: 8008 Part I & VII Specifications. Reducer must be moulded.

- HDPE Stub ends shall be square ended conforming to IS: 8008 Part I & VII Specifications. Stub ends will be welded on the pipe. Flange will be of slip on flange type as described below
- Slip-on flanges shall be metallic flanges covered by epoxy coating or plastic powder coating. Slip-on-flanges shall be conforming to standard mating relevant flange of valves, pipes etc. Nominal pressure rating of flanges will be PN 6.

HANDLING, TRANSPORTATION STORAGE AND LOWERING OF PIPES

During handling, transportation, storage and lowering, all sections shall be handled by such means and in such a manner that no distortion or damage is done to the section or to the pipes as a whole. The following procedures should be followed so as to eliminate potential damage to pipes and fittings and to maintain maximum safety during unloading, lifting and lowering.

- Pipes must not be stored or transported where they are exposed to heat sources likely to exceed 60°C.
- Pipes shall be stored such that they are not in contact with direct sunlight, lubricating or hydraulic oils, petrol, solvents and other aggressive materials.
- Scores or scratches to a depth of greater than 10% or more of wall thickness are not permissible; any pipes having such defects should be strictly rejected.
- HDPE pipes should not be subjected to rough handling during loading and unloading operations. Rollers shall be used to move, drag the pipes across any surface.
- Only polyester webbing slings should be used to lift heavy PE (>315mm) pipes by crane. Under no circumstances, chains, wire ropes and hooks be used on HDPE pipes.
- Pipes shall not be dropped to avoid impact or bump. If any time during handling or during installation, any damage, such as gouge, crack or fracture occurs, the pipe shall be repaired if so permitted by the competent authority before installation.
- During coiling care should be taken to maintain the coil diameter at or above the specified minimum to prevent kinks. Coiling shall be done when the pipe attains the ambient temperature from the extruder. In uncoiling or recoiling care should be taken that sharp objects do not scour the pipe.
- When releasing coils, it must be remembered that the coil is under tension and must be released in a controlled manner. The end of the coil should be retained at all times, then the straps released steadily, one at a time. If the coil has bands at different layers of the coil, then they should be released sequentially starting from the outer layers. The amount of the energy locked up in the coil will depend on the size of the pipe, the SDR of the pipe, and the size of the coil.
- Straight lengths should be stored on horizontal racks giving continuous support to prevent the pipe taking on a permanent set
- Bare coils shall be wrapped with hessian cloth for long distance (> 300Kms) transportation. The truck used for transportation of the HDPE pipes shall be exclusively used of HDPE pipes only

with no other material loaded – especially no metallic, glass and wooden items. The truck shall not have sharp edges that can damage the Pipe.

- Lowering and laying of pipes

- o Each pipe shall be thoroughly checked for any damages before laying and only the pipes which are approved by the Engineer shall be laid.
- o While installing the pipes in trenches, the bed of the trench should be level and free from sharp edged stones. In most cases, the bedding is not required, as long as the sharp and protruding stones are removed, by sieving the dug earth, before using the same as backfill material. While laying in rocky and black cotton areas suitable bedding should be provided as per the specification for bedding.
- o As HDPE pipes are flexible, long lengths of fusion-jointed pipes having joints made above ground can be rolled or snaked into narrow trenches. Such trenches can be excavated by narrow buckets.
- o During the pipe laying of continuous fusion jointed systems, due care and allowance should be made for the movements likely to occur due to the thermal expansion/contraction of the material. This effect is most pronounced at end connections to fixed positions (such as valves etc) and at branch connections. Care should be taken in fixing by finishing the connections at a time the length of the pipe is minimal (lower temperature times of the day.)
- o For summer time installations with two fixed connection points, a slightly longer length of PE pipe may be required to compensate for contraction of the pipe in the cooler trench bottom.
- o The final tie-in connections should be deferred until the thermal stability of the pipeline is achieved.
- o The flexibility of polyethylene pipes allows the pipe to be cold bend. The fusion jointed PE pipe is also flexible as the plain Pipe. Thus the total system enables directional changes within the trench without recourse to the provision of special bends or anchor blocks. However, the pipe should not be cold bend to a radius less than 25 times the OD of the pipe.
- o The Installation of flanged fittings such as connections to sluice/air/gate valves and hydrant tees etc., requires the use of stub ends (collars/flange adaptors complete with backing rings and gaskets. Care should be taken when tightening these flanges to provide even and balance torque.
- o Provision should be made at all heavy fittings installation points for supports (such as anchoring of the flange in the soil) for the flange joint to avoid the transfer of valve wheel turning torque on to the PE flange joint.
- o PE pipe is lighter than water. Hence care should be taken for normal installations where there could be a possibility of flooding of the trench thus the trench shall be kept free of water till the jointing has been properly done

- o When flooded, some soils may lose cohesiveness, which may allow the PE pipe to float out of the ground. Several design checks are necessary to see if groundwater flotation may be a concern. Obviously, if the pipeline typically runs full or nearly full of liquid, or if groundwater is always below the pipe, flotation may not be a significant concern. In this case contractor has to design necessary weights by way of concrete blocks (anchors) so that the PE pipe does not float when suddenly the trench is flooded and the soil surrounding the pipe is washed away.

JOINTING OF PIPES

- Below 110 mm diameter: Push type compression joints.
- Equal and Above 110 mm diameter: Butt-fusion (Heat Fusion Process)

WELDING PROCEDURE

Jointing between HDPE pipes and specials shall be done as per the latest IS: 7634 part II. Method of jointing between the pipes to pipes and pipes to specials shall be with butt fusion welding using automatic, hydraulically operated, superior quality butt fusion machines which will ensure good quality butt fusion welding of HDPE pipes.

FLANGED JOINTS

Jointing of PE Pipes with fittings, valves, metal pipes, and where non-PE pipes are to be joined with PE pipes shall be carried out using Flanged joints. Flanges will be used to fit together elements of different materials such as valves (in cast or ductile iron) with HDPE pipes through the use of a flange adaptor. The nominal pressure rating shall be at least equal to the highest-pressure rating of the pipes or fittings to which they are attached, but with a minimum PN 6.

GASKETS FOR FLANGED JOINTS

Gaskets for flanged pipe joints shall be of inside bolt circle type and the dimensions shall comply with BSEN 1514-2:2005 – Flanges and their joints.

The physical properties of gaskets shall comply with BS 7874:1998 (Method of test for microbiological deterioration of elastomeric seals for joints in pipework and pipelines for effects on water quality and resistance to microbiological deterioration). The Gaskets shall also comply with the relevant provisions in BS 7874:1998 for effects on water quality and resistance to microbiological deterioration. The Gasket material shall be EPDM/SBR and shall be of average hardness of 65-75.

The Gaskets shall be supplied by the manufacturer and shall suit for PN 10 flanges unless otherwise stated. Each gasket shall be marked clearly and durably in accordance with the following information in a manner that does not interfere with the sealing function of the gasket, complying with clause 10 of EN 681-1:1996.

- The nominal size
- Manufacturers identification

- The number of the BS or BSEN with seal type designation.
- Abbreviation for the elastomer

DI PIPES AND SPECIALS

The pipes shall be of centrifugally cast (spun) Ductile Iron pipes K-7 & K-9 class with internal cement mortar lining confirming to IS 8329: 2000. The pipes shall be of push on joint type (Rubber Gasket Joints). The flange connection shall be used only in case of fitting of specials or under special circumstances as directed by Engineer in Charge.

The pipes shall be coated with zinc coating and finishing layer shall be of bitumen and have factory provided internal cement mortar lining as per the provisions of IS 8329: 2000 the mortar thickness shall be minimum 5 mm as per Table 15 of the code. The tolerances for pipes and fittings regarding dimensions, mass, ovality and deviations from straight line in case of pipes shall be as per IS 8329/IS 9523.

The pipes shall be supplied in standard length of 5.50- and 6.00-meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety shall also be supplied with a rubber EPDM/ (SBR) gasket. The flanged joints shall confirm to Clause 6.2 of IS: 8329. The pipe supply shall include one rubber gaskets for each flange. Any change in the stipulated lengths will be approved by the Engineer- in -Charge. The gaskets shall conform to IS 5382:1985. The gaskets shall also be supplied by the contractor. They shall preferably be manufactured by the manufacturer of the pipes. In case they are not, it shall be the responsibility of the contractor to have them manufactured from a suitable manufacturer under his own supervision and have it tested at his / sub-contractors premises as per the instruction and to the satisfaction of the Engineer- in -Charge. The pipe contractor shall however be responsible for the compatibility and quality of the products. The flanged joints shall conform to Clause 6.2 of IS 8329.

INSPECTION AND TESTING OF PIPES DURING MANUFACTURE

MECHANICAL TESTS

Mechanical tests shall be carried out during manufacture of pipes and fittings as specified in IS: 8329 / IS: 9523. The frequency and sampling of tests for each batch of pipes shall be in accordance with IS: 8329. The method for tensile tests and the minimum tensile strength requirement for pipes and fittings shall be as per IS: 8329/IS: 9523.

BRINELL HARDNESS TEST

For checking the Brinell hardness, the pipes used for the ring test and tensile test shall comply with the requirements specified in IS: 1500/IS: 8329.

RETESTS

If any test piece representing a lot fails in the first instance, two additional tests shall be made on test pieces selected from two other pipes from the same lot. If both the test results satisfy the specified requirements, the lot shall be accepted. Should either of these additional test pieces fail to pass the test, the lot shall be liable for rejection.

HYDROSTATIC TEST

For hydrostatic test at works, the pipes and fittings shall be kept under test pressure as specified in IS: 8329 / IS: 9523 for a period of minimum 15 seconds, during which the pipes shall be struck moderately with a 700 g hammer for confirmation of satisfactory sound. They shall withstand the pressure test without showing any leakage, sweating or other defect of any kind. The hydrostatic test shall be conducted before surface coating and lining.

The pipes shall be subjected to following tests for acceptance:

- Visual and dimensional check as per Clause 13 and 15 of IS 8329
- Mechanical Test as per Clause 10 of IS 8329
- Hydrostatic Test as per Clause 11 of IS 8329
- The test report for the rubber gaskets shall be as per acceptance tests of IS 5832 and will be in accordance with Clause 3.8. The sampling shall be as per the provisions of the IS 8329.

MARKINGS

All pipes will be marked as per Clause 18 of IS 8329 along with the requisite information as provided below:

- Manufacturer name / stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot end

COATINGS

Pipe shall be supplied internally (cement mortar lining) and externally with Zinc coating along with a finishing layer of bituminous coating as per IS 8329:2000. The materials and finishing shall be as per the relevant specifications.

JOINTS

GENERAL

Jointing of DI pipes and fittings shall be done as per IS 12288 and manufacturer's recommendations. Rubber sealing rings/gaskets used for jointing shall conform to IS 638, IS

12820 and IS 5382.

SPIGOT AND SOCKET JOINTS

These shall have sockets which are integral with the pipe and incorporate an elastomeric rubber ring gasket conforming to IS 12820. The gaskets/sealant used for joints shall be suitable for water conveyance. The material of rubber gaskets for use with mechanical joints and push-on-joints shall conform to IS: 5382.

FLANGED JOINTS

These shall be of 10 bar rating and shall comply with dimensions and drilling details as specified in IS 8329. These shall have isolation gaskets between the flanges, isolation sleeves around all bolts and isolation washers under all bolt heads and nuts. The bolts shall be of mild steel unless otherwise specified. They shall be coated with cal tar epoxy coating after tightening.

SLIP ON TYPE COUPLINGS

Slip-on type couplings shall include the following couplings:

straight flexible couplings

stepped flexible couplings

Slip-on type couplings shall be procured from approved suppliers whose fittings meet the same Specification. The preparation of pipe ends for slip-on type couplings shall be in accordance with the requirements and the tolerances specified by the joint manufacturer. Couplings shall be installed fully in accordance with the manufacturer's recommendations.

Slip-on type couplings shall be protected if buried with Densomastic and Densotape wrapping or similar approved material applied in accordance with the manufacturer's recommendations. Flexible joints shall be harnessed or tied where shown on the Drawings. Flexible couplings shall be supplied with transit protection.

SPECIALS AND FITTINGS

All DI specials and fittings shall be manufactured and tested in accordance with IS: 9523 or BS: 4772. All DI fittings shall be supplied with one rubber ring gasket for each socket. The rubber ring shall conform to IS: 12820 and IS: 5382. Flanged fittings shall be supplied with one rubber gasket per flange along with the required number of nuts and bolts.

LUBRICANT FOR PIPES AND SPECIALS

Lubricant for the assembly of Ductile Iron pipes and specials suitable for Tyton push-on rubber ring joints shall conform to IS 9523.

DI PIPE HANDLING, LAYING, JOINTING, TESTING AND COMMISSIONING

- Laying of DI pipes shall conform to IS: 12288. All pipes, fittings and material shall be tested and approved by the Engineer- in -Charge before being laid. Polyethylene sleeves wound pipes shall be used for waterlogged areas as directed by the Engineer- in -Charge.
- The transportation and handling of pipes shall be made as per IS 12288.
- Cranes or chain pulley block or other suitable handling and lifting equipment shall be used for loading and un-loading of heavy pipes. However, for pipes up to 400 mm nominal bore, skid timbers and ropes may be used. When using crane hooks at sockets and spigot ends; hooks shall be broad and protected by rubber or similar material, in order to avoid damage to pipe ends and lining. Damage to lining must be repaired before pipe laying according to the instructions of the pipe manufacturer. the trench must not be refilled before laying of the pipes.
- All specials like bends, tees etc. and appurtenances like sluice or butterfly valves etc. shall be laid in synchronization with the pipes. No pipe shall be laid in wet trench conditions. On gradients of 1:15 or steeper, precautions should be taken to ensure that the spigot of the pipe laid does not move into or out of the socket of the laid pipe during the jointing operations. The designed anchorage shall be provided to resist the thrusts developed by internal pressure at bends, tees, etc.
- Where a pipeline crosses a watercourse, the design and method of construction should take into account the characteristics of the watercourse to ascertain the nature of bed, scour levels, maximum velocities, high flood levels, seasonal variation, etc. which affect the design and laying of pipeline. The assembly of the pipes shall be made as recommended by the pipe manufacturer using suitable tools.

PIPE TESTING AND COMMISSIONING

The pipeline shall be tested for tightness of barrels and joints, and stability of thrust blocks in sections. Preferably the pipeline stretches to be tested shall be between two chambers (air valve, scour valve, bifurcation, other chamber). Contractor shall test stretches not exceeding 1 km. After successful organization and execution of tests the length may be extended to more than 2 km after approval of the Engineer- in -Charge.

The water required for testing shall be arranged by the contractor himself. The Contractor shall fill the pipe and compensate the leakage during testing. Complete setting of the thrust blocks. Water used for testing should not be carelessly disposed off on land which would ultimately find its way to trenches. The testing conditions for the pipelines shall be as per the test pressures and condition laid out in IS 8329 for DI pipes.

THE TESTING CONDITIONS FOR THE PIPELINES ARE SUMMARIZED AS FOLLOWS:

- Maximum hydrostatic test pressure for DI K-7 / K9 pipes shall be 2.0 times of maximum design pressure in the pipeline.

- Pre-test and saturation period with addition of make-up water
- Pressure: Test pressure
- Duration: 3 hrs for DI pipes without cement mortar lining / 24 hrs for DI pipes with cement mortar lining
- Pressure test with addition of make-up water
- Pressure: Test pressure
- Duration: 3 hrs
- Test criteria for DI pipes: $Q=1$ litre / km per 10mm of pipe per 30 m test pressure per 24 hrs.

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount 'Q', calculated by the above formula. All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test have been obtained.

PIPE LAYING

EXCAVATION

The trench excavation of pipeline shall be in accordance with IS 12288. Pipe trenches shall be excavated to the lines and levels shown on the drawings or as directed by the Engineer. The depth of the excavated trench depth should be sufficient to provide a cover not less than 1000 mm or as directed by the Engineer. It may be necessary to increase the depth of pipeline to avoid land drains or in the vicinity of roads, railways or other crossings. The width of the trench at bottom between the faces of sheeting shall be such as to provide 200 mm clearance on either side of the DI / PE pipe except where rock excavation is involved. No pipe shall be laid in a trench until the section of trench in which the pipe is to be laid has been approved by the Engineer.

The bottom of the trench shall be trimmed and levelled to permit even bedding of the pipes. It should be free from all extraneous matter which may damage the pipe or the pipe coating. Additional excavation shall be made at the joints of the pipes, so that the pipe is supported along its entire length.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of the construction work and until it is safe for the traffic to use the roadways. The relevant Indian Standards and the rules and regulations of local authorities in regard to safety provisions shall be observed.

Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3 m apart and they shall not be

less than 75 mm in diameter or less than 1.2m above surface of the ground. There shall be two rails, one near the top of the post and the other about 450mm above the ground and each shall be from 50mm to 70mm in diameter and sufficiently long to run from post to post to which they shall be bound with strong rope. The method of projecting rails beyond the post and tying them together where they meet will not be allowed on any account. All along the edges of the excavation trenches a bank of earth about 1.2 m high shall be formed where required by the Engineer for further protection.

The road metal and also the rubble packing shall first be stripped off for the whole width of the trench/pit and separately deposited in such place or places as may be determined by the Engineer.

During excavation, large stones and rubble shall be separated and removed from the excavated soil and stacked separately. The material from excavation shall be deposited on either side of the trench leaving adequate clear distance from the edges of the trench and pit, or as may be necessary to prevent the sides of the trench pit to slip or fall, or at such a distance and in such a manner as to avoid covering fire hydrants, sluice valves, manholes and covers etc. so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organizations or otherwise as the Engineer may direct.

Contractor shall take into account additional excavation if any as the Engineer may require for locating the position of water pipes, drains, sewers etc. or any other works which may be met with. Such service lines if met with during excavation shall be properly maintained by Contractor, by means of shoring, strutting, planking over, padding or otherwise as the Engineer may direct, and shall be protected by the Contractor from damage during the progress of the work. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure / pipe line of water, gas, sewage etc.

Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than the minimum requirement. In case additional width is required it shall be provided only in the top portion from the ground level upto 300 mm above the top of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry otherwise at the discretion and to the satisfaction of the Engineer. If rock is met with, it shall be removed to 15 cm below the bottom of pipes and fittings/specials and the space resulting shall be refilled with granular materials and properly consolidated. Bottom of trenches / pits shall be saturated with water well rammed wherever the Engineer may consider it necessary to do so.

Wherever a socket or collar of pipe or fitting / special occurs, a grip is to be cut in the bottom of the trench or concrete bed to a depth of at least 75 mm below the bed of the pipe so that the pipe may have a fair bearing on its shaft and does not rest upon its socket. When welding is to

be carried out with the pipes and specials in the trench, additional excavation of not more than 60cm in depth and 90 cm in length shall be made at joints in order to facilitate welding. The excess excavated material shall be carried away from site of works to a place up to a distance as directed by the Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic.

The Contractor has to ensure the following:

- Safety protections as mentioned above have to be incorporated in the work process.
- Hindrances to the public have to be minimised.
- The trench must not be eroded before the pipes are laid.
- The trench must not be filled with water when the pipes are laid.
- The trench must not be refilled before laying of the pipes.

DEWATERING

During the excavation, if subsoil water is met with Contractor shall provide necessary equipment and labourers for dewatering the trenches. The Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the Contractor shall take necessary permission from the local authorities.

SPECIAL FOUNDATION IN POOR SOIL

Where the bottom of the trench and sub grade is found to consist of material which is unstable to such a degree that in the opinion of the Engineer, it cannot be removed and replaced with an approved material thoroughly compacted in place to support the pipe properly, suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant drawings be prepared by the Contractor and as instructed by the Engineer shall be constructed.

WOODEN SHORING

Contractor shall suitably design polling boards, waling and struts to meet different soil conditions that might be encountered in excavating trenches / pits. The horizontal and vertical spacing of struts shall be such that not only the sides of trenches shall be prevented from collapse but also easy lowering of pipe in trenches shall be ensured without creating undue obstructions for the excavation of the work. Any inconvenience and /or delay that might be caused in lowering pipes in trenches as a result of adopting improper spacing of struts by Contractor shall be his sole responsibility. No part of shoring shall at any time be removed by Contractor without obtaining permission from the Engineer. While taking out shoring planks the

hollows of any form must simultaneously be filled in with soft earth well rammed with rammers and with water.

The Engineer may order portions of shoring to be left in the trenches /pits at such places, where it is found absolutely necessary to do so to avoid any damage which may be caused to buildings, cables, gas mains, water mains, sewers etc. in close proximity of the excavation, by pulling out the shoring from the excavations. The Contractor shall not claim, on any reason whatsoever, for the shoring which may have been left in by him at his own discretion.

STEEL PLATE SHORING

Where the subsoil conditions are expected to be of a soft and unstable character in trench / pit excavation, the normal method of timbering may prove insufficient to avoid subsidence of the adjoining road surfaces and other services. In such circumstances, the Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, waling etc., as per the instructions, manner and method directed by the Engineer. Contractor shall supply pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Employer's Requirements.

BEDDING

The trench bottom shall be even and smooth so as to provide a proper support for the pipe over its entire length, and shall be free from stones, lumps, roots and other hard objects that may injure the pipe or coating. Holes shall be dug in the trench bottom to accommodate sockets so as to ensure continuous contact between the trench and the entire pipe barrel between socket holes. In case of sandy strata no separate bedding is required. However, the bottom face / trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density. In case excavation is through rock or Black Cotton Soil, bedding should be provided to give complete contact between the bottom of the trench and the pipe. The bedding material shall be well graded sand or another granular material passing 5.6 mm sieve suitably compacted/rammed. The bedding material shall be clean, well graded and free from topsoil, clay or vegetable matter and to the approval of the Engineer. The thickness of bedding shall be a minimum of 150 mm or $0.5 \times (\text{Outer dia})$ whichever is maximum.

The depth and type of bedding shall be as shown on the Drawings or as directed by the Engineer. Where rock or boulders are encountered, the trench shall be trimmed to a depth of at least 300 mm below the level at which the bottom of the barrel of the pipe is to be laid and filled to a like depth with sand as shown on the Drawings or as directed by Engineer.

The class of bed and surround to be used are indicated below:

Class of bed and surround	Brief description of bedding material
Class A	Mass Concrete
Class N	Well Graded Sand
Class S	Granular material

Class S bedding and surround shall be used on all pipes unless otherwise specified or shown on the Drawings.

The concrete to be used for Class A bedding and surround shall be M15 type. Class A bedding shall be used at all road crossings under the road and for a distance of 5 m back from the back edge of road or footpath.

Class N bed material shall only be used where the pipe trench is founded in hard rock or otherwise as directed by the Engineer. The sand shall be clean and well graded and free from topsoil, clay or vegetable matter and to the approval of the Engineer. If the sand supplied is unclean it shall be washed. In no case shall sand containing more than 3.5% by dry volume or 5% by wet volume of clay, loam or silt be accepted. Tests specified for determining silt in sand and organic impurities as described in IS: 383 shall apply.

The graded granular bed material for use in Class S bedding and surround shall consist of durable gravel, crushed stone or disintegrated rock. Selected material excavated from the pipe trench may be used, provided it contains no topsoil, clay or vegetable matter and is to the approval of the Engineer. Any imported bed and surround materials shall be to the approval of the Engineer and shall be supplied with certification which gives details of its content, source and grading. In all cases the soluble sulphate and chloride content of the granular material shall not exceed 0.5 % and 0.06 % by weight respectively.

BONING STAVES AND SIGHT RAILS

In laying the pipes and fittings/ specials the centre for each manhole / chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole/chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipe lines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by the Engineer.

Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of metres and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipeline, top of concrete bed, top of the

pipe etc. as the case may be.

The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The center line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the center lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail. The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black.

For the pipes converging to a manhole/chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60 M of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point. The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and the Engineer gives permission to proceed with the backfilling.

LAYING OF PIPES AND FITTINGS/SPECIALS

All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structure / pipeline of water, gas, sewage etc. After excavation of trenches, pipes shall not be lowered unless the dimensions of trenches and bedding work for pipes at the bottom of the trenches are approved and measured by Employer / Engineer. Pipes and fittings / specials shall be carefully lowered in the trenches. Special arrangements such as cranes, tripods with chain pulley block for lowering the pipes and fittings/specials shall be made by Contractor. In no case pipes and fittings/specials shall be dropped. Slings of canvas or equally non-abrasive material of suitable width or special attachment to fit the ends of pipes and fittings / specials shall be used to lift and lower the coated pipes and fittings/specials. The pipes and fittings /specials shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If doubt persists, further confirmation shall be done by pouring a little kerosene/dye on the inside of the pipe at the suspected spot. No sign of kerosene/dye should appear on the outside surface. Pipes and fittings/specials damaged during lowering or aligning shall be rejected by the Engineer.

All the pipes are to be laid perfectly true both in alignment and to gradient specified. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipeline runs uphill in which case the socket ends should face the upgrade. The laying of pipes shall always proceed upgrade of a slope. After placing a pipe in the trench, the spigot end shall be centered in the socket and the pipe forced home and aligned to required gradient. The pipes shall be secured in place with approved backfill material tamped under it except at the socket.

Pipes and fittings/specials which do not allow a sufficient and uniform space for joints shall be removed and replaced with pipes and fittings/specials of proper dimensions to ensure such uniform space. Precautions shall be taken to prevent dirt from entering the jointing space. At times when pipe laying is not in progress, the open ends of pipe shall be closed by a watertight plug or other means approved by the Engineer. During the period that the plug is on, the Contractor shall take proper precautions against floating of the pipe owing to entry of water into the trench. Wherever it is necessary to deflect pipe from a straight line, either in the vertical or horizontal plane, to avoid obstructions or where long radius curves are permitted the deflection allowed at joints shall not exceed $2\frac{1}{2}\%$. In case of pipes, with joint to be made with loose collars, the collars shall be slipped on before the next pipe is laid. The pipes shall be laid such that the marking on pipes appears at the top of the pipes. The cutting of pipe for inserting valves, fittings, or specials shall be done in a neat and workman like manner without damage to the pipe so as to leave a smooth end at right angles to the axis of the pipe. For this purpose, pipe cutting machine shall be used.

a) External protection

All underground pipe work having a cover less than 1.0 m shall be encased with M 15 concrete of minimum 200 mm thick all around.

b) Flexibility in Pipe work

The Contractor shall provide flexibility in the pipe work at joints in the main structures and shall submit proposals for the approval of the Engineer. Flexible joints or collars and cut pipes shall be allowed on all pipe work where necessary to allow for some margin of error in the building work. Wherever possible flexible joints shall be provided with tie bolts or other means to transfer longitudinal thrusts as a whole so that external anchorages may be kept to a minimum. Flexible joints shall also be provided for case of erection and future dismantling. Particular care shall be taken to ensure that pipe work thrusts are not transmitted to machinery or associated apparatus. The Contractor shall indicate on his detailed drawings what thrust blocks are required.

c) Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Engineer prior approval.

d) Support of Pipe work and Accessories

All necessary supports, saddles, slings, fixing bolts and foundation bolts shall be supplied to support the pipe work and its associated equipment in an approved manner. Valve, meters, strainers, and other devices mounted in the pipe work shall be supported independently of

the pipes to which they connect. All brackets or other forms of supports, which can conveniently be so designed, shall be rigidly built up of steel by rivetting or welding in preference to the use of castings. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer. After the collars and boxes or other fitting have been fixed in position, the floors, walls and roof structure will be made good by the Contractor.

e) Thrust Blocks

Thrust Blocks shall be provided, to counteract hydraulic thrust, at places wherever directed by the Engineer.

f) Jointing

Jointing for pipes and fittings / specials shall be done in accordance with the relevant Employer's Requirement depending upon the type of pipes being used.

g) Valve chamber

Valve chambers shall be constructed according to approved drawings suitable for the respective valve. They shall be constructed in RCC of M25 grade. The chambers shall be constructed after the laying of the pipes and the assembly of specials and valves. The size of the chambers shall be as follows/ as per direction of Engineer.

All the general specifications of RCC will be applied here Pipes passing through walls should be coated by two layer of soft material (hessian felt) to allow for differential settling and longitudinal expansion if directed by Engineer. Only metallic pipes may be cast into the walls for anchoring purposes.

h) Testing and Commissioning

Testing and commissioning of pipes shall be done in accordance with the relevant Employer's Requirement and as per the relevant IS codes of the pipe material used.

i) Backfilling

Backfilling of trenches for pipes shall be commenced after the pipes have been successfully tested. The backfilling material shall be properly consolidated by watering and ramming, taking due care that no damage is caused to the pipes.

All fill material shall be subject to the Engineer's approval. If any material is rejected by the Engineer, the Contractor shall remove the same forthwith from the site. Surplus fill material shall be deposited/disposed of as directed by Engineer after the filling work is completed.

BACK FILL MATERIAL

To the extent available, selected surplus soils from excavations shall be used as backfill provided that it complies to IS 12288 and such material consists of loam, clay, sand, fine gravel or other materials which are suitable for backfilling. All backfill material shall be free from clods,

salts, sulphates, cinders, ashes, slag, refuse, rubbish, lumps, vegetable or organic material, lumpy or frozen material, boulders, rocks or stone or other foreign material. All lumps of earth shall be broken or removed. If fill material is required to be imported, the Contractor shall make arrangements to bring such material from outside borrow pits. The material and source shall be subject to the prior approval of the Engineer.

BACKFILLING OF PIPE TRENCHES

For the purpose of back filling, the depth of the trench shall be considered as divided into the following three zones from the bottom of the trench to its top:

Zone A	From the bottom of the trench to the level of the centre line of the pipe in case of excavation in soil and from the top of the pipe bedding to the level of the centre line of the pipe in case of excavation in rock.	Backfilling in this zone shall be done with carefully selected excavated material compacted by hand in layers not exceeding 150 mm with 95% proctor density. The back-filling material shall be deposited in the trench for its full width of each side of the pipe, specials and appurtenances simultaneously. Special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.
Zone B	From the level of the centre line of the pipe to a level 300 mm above the top of the pipe.	Backfilling in this zone shall be done with carefully selected excavated material compacted by hand or approved mechanical methods in layers not exceeding 150 mm with 95% proctor density, special care being taken to avoid injuring or moving the pipe.
Zone C	From a level 300 mm above the top of the pipe to the top of the trench.	Backfilling in this zone shall be done with suitable excavated material and shall be compacted using mechanical compactors in layers not exceeding permissible thickness relevant to the type of mechanical compactors deployed to achieve 95% Proctor Density.

Filling of the trenches shall be carried out simultaneously on both sides of the pipe to avoid unequal pressure on the pipe.

Where the excavation is made through permanent pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire back-fill to the subgrade of

the structures shall be made with sand in accordance with IS 12288.

The Contractor shall take proper precautions against the risks of floatation. Should any section of the pipeline be affected by floatation shall be removed and reinstalled to the satisfaction of the Engineer?

The Contractor shall carry out field tests that on each layer to confirm that the specified density has been obtained.

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Engineer, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Engineer, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

Trenches crossing a road shall be backfilled with selected material placed in layers not exceeding 15 cm in thickness after compacting, wetted and compacted to a density of not less than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any deficiency in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal of refuse or unsuitable soil.

j) Reinstatement of Road/Footpath

Reinstatement of road/footpath shall be done as per the requirements of local authorities and the Employer's Requirement after completion of work.

k) Clearing of Site

All surplus materials, all tools and temporary structures shall be removed from the site as directed by the Engineer and the construction site left clean to the satisfaction of the Engineer.

l) Disinfection of Water Mains

The mains intended for potable water supplies should be disinfected before commissioning them for use. Special care should be taken to ensure disinfection of new mains. Among possible sources of contamination are sewer drainage, contaminated soil in the trench, contamination from workmen or their equipment or both and unavoidable foreign material present in the trench during construction.

Education of crew members as to the need for avoiding contamination of the main during construction is fundamental. Contractors and workmen should be thoroughly familiar with all pertinent state and local requirements governing installation of mains. All sewers, water mains and other underground conduits should be located prior to construction, relocated, if necessary, to prevent contamination during construction. Pipe should be strung on high ground. At all times when construction is not actually in progress, watertight plugs should be installed in all pipe openings. Gunny sack and rags are not adequate. Provision should be made to pump any other water that might collect in the trench. Special care should be taken to avoid contamination of valves, fittings, and pipe interiors, both before and during construction each of them should be inspected and, if necessary, cleaned before installation.

After pressure testing the main, it should be flushed with clean water at sufficient velocity to remove all dirt and other foreign materials in the constructed pipeline. When this process has been completed, disinfection (using liquid chlorine, sodium or calcium hypochlorite) should proceed by one of the recommended methods as described in the following clauses

CONTINUOUS FEED

In this method, water from the distribution system or other approved source and the chlorine is fed at constant rate into the new main at a concentration of atleast 20 mg/l. A properly adjusted hypochlorite solution injected into the main with a hypo-chlorinator, or liquid chlorine injected into the main through a solution feed chlorinator and booster pump may be used. The chlorine residual should be checked at intervals to ensure that the proper level is maintained. Chlorine application should continue until the entire main is filled. All valves, hydrants, etc., along the main should be operated to ensure their proper disinfection. The water should remain in the main for a minimum of 24 hours. Following the 24 hours period no less than 10 mg/l chlorine residual should remain in the main. The Contractor is requested to provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work. The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved. Waste chlorine residual water must be neutralized before it is discharged to any drainage.

SLUG METHOD

In this method a continuous flow of water is fed with a constant dose of chlorine (as in the previous method) but with rates proportioned to give a chlorine concentration of at least 300 mg/l. The chlorine is applied continuously for a period of time to provide a column of chlorinated water that contacts all interior surfaces of the main for a period of at least 3 hours. As the slug passes tees, crosses, etc., proper valves shall be operated to ensure their disinfection. This method is used principally for large diameter mains where continuous feed is impractical.

Regardless of the method used, it is necessary to make certain that backflow of the strong chlorine solution into the supplying line does not occur. Following the prescribed contact period, the chlorinated water should be flushed to waste until the remaining water has a chlorine residual approximating that throughout the rest of the system. Bacteriological tests as prescribed by the authorities should be taken, and if the results fail to meet minimum standards, the disinfecting procedure should be repeated, and the results again tested before placing the main in service. If continuous feed method is difficult to apply, Retention Method shall be considered as alternative way. The area or pipeline to be disinfected shall be fed with chlorine solution from upstream under flowing water condition. The chlorine solution fed in the pipeline shall be kept for 1 day before measurement of residual chlorine is undertaken. After 3 days later, the chlorine residual value shall be tested at sampling points at upstream and at downstream end to check whether the value is in range or not. The Contractor shall provide photo and take a record the value of chlorine residual at starting point and after 24 hours before completion of work. The Engineer shall jointly check the test at sites. If the value is insufficient, the disinfections work shall be repeated until satisfactory results are achieved. Waste chlorine residual water must be neutralized before it is discharged to any drainage, as approved by Engineer.

m) Dynamic commissioning

The dynamic commissioning shall commence after the work has been physically completed to the satisfaction of the Engineer- in -Charge. It shall simulate the design and operation conditions which are as follows:

- Water being put into the system through overhead tank or direct pumping as the case maybe.
- Closing of the valves against full static or dynamic pressure.
- Operation of all valves including scour valves (open-close-open).
- Operation of all air valves.

SERVICE CONNECTIONS (PLOT SERVICE CONNECTIONS)

The service connection shall include HDPE pipe (PN10, PE 100) of required length, reducing tee fittings, specials and ball valves of appropriate size as required. The HDPE pipes shall conform to IS 4984. The plot connections are provided using the reducing tee & specials in the main pipe and providing plot connection by connecting HDPE as per the required diameter for individual plot along with connection of ball valve for its operation.

SERVICE CONNECTION VALVES / BALL VALVES

Service connection valves shall be precision moulded ball valves manufactured and tested in accordance with ISO: 4422-4, and with threads in accordance with ISO-7, BS: 21 or IS 554.

Valves shall be manufactured from high quality PVC resin or ABS, and the valve body provided with threaded ends or compression couplings and adaptors to suit the service pipe and meter installation details. Valves shall be PN10 rated, and be suitable for continuous contact with water up to 60° C.

D 3. INSTRUMENTATION & AUTOMATION TECHNICAL DATASHEET FOR POTABLE WATER & RECYCLE WATER SYSTEM

The technical requirements for the instrumentation and automation items are detailed in the subsequent section of this document. The bidder must obtain approval from the client/consultant, ensuring compliance with the specified requirements before supplying the items. The bidder is also required to take prior approval from the client/consultant for the datasheets of any items not included in this document but necessary for the smooth operation of the system.

1. Electromagnetic Flow Meter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Full Bore Electromagnetic Flow Meter
1.3	Service	As per P&ID and Specification
1.4	Fluid	Potable/Sewage/Recycle Water
1.5	Area Classification	Non-Hazardous
2	Flow Sensor	
2.1	Type	DC pulsed
2.2	Electrode / Sensor MOC	Hast alloy C
2.3	Flow Tube MOC	SS304
2.4	Coil Housing MOC	Noncorrosive (SS 304) or Die cast aluminium with anti-corrosive grade paint suitable for application
2.5	Grounding Ring MOC	SS 304
2.6	Liner MOC	PTFE
2.7	Process Connection	Flanged
2.8	Flange MOC	CS
2.9	Housing Protection	IP 68
2.10	Pressure Rating	16 Kg/cm ²
2.11	Temperature	50 °C Ambient
2.12	Size(mm)	To suit mains flow parameters, with pipe reducers provided as necessary
3	Flow Indicator and Transmitter	
3.1	Type	Microprocessor Based, Remote Mounted
3.2	Power Supply	230 VAC Line Power

3.3	Accuracy	± 0.5 % of measured value
3.4	Repeatability	+/-0.1%
3.5	Transmitter Protection	IP67
3.6	Transmitter MOC	Dia-cast Aluminium with PU finish / Polycarbonate
3.7	Output	One Current – 4 to 20 mA (isolated) proportional to flow rate Hart (version 6 or above) One Scalable Pulse One Status Output
3.8	Communication	Modbus RS485
3.9	Display	2 Line Backlit LCD, Programmable
3.10	Maximum Digit Display	8 Digit
3.11	Indication on Display	Actual Flow Rate / Instantaneous Flow Rate Cumulative Forward Flow Cumulative Reverse Flow Cumulative Flow / Sum / Totalizers Alarm Five (5) digit backlit/Normal LCD, for flow rate in m3/hr. Eight (8) digit backlit/Normal LCD for totalized flow in ML • Display with 8 digits for main information. Index, menu and status symbols for dedicated information • Key for toggling through the information and reset customer totalizers and call-up function • Selectable default information and accessible menus: - Operator - Meter - Service - Data Logger
3.12	Zero and Span adjustment	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.
3.13	Facility for on line diagnosis	Required as following: Diagnostic • Continuous self test shall include - Coil current to drive the magnetic field - Signal input circuit - Data calculation, handling and storing • Features - Alarm statistics and logging for fault analyzing - Electrode impedance to check actual media contact

		- Flow simulation to check pulse and communication signal chain for correct scaling - Number of sensor measurements (excitations) - Transmitter temperature - Low impedance alarm for change in media - Flow alarm when defined high flow exceeds - Verification mode for fast measure performance check - Statistic flow and consumption data
3.14	Cable Gland	Required
3.15	Cable Length (sensor to transmitter)	10 Meter minimum or suit to site
3.16	Data Protection:	• All data shall be stored in an EEPROM. • Totalized statistic shall be backed up every 10 min • Power consumption and temperature Measurement statistic at every 4 hour • Minimum 30 days of data shall be stored in EEPROM. • Password protection of all parameters and hardware protection of calibration and revenue parameters.

2. Ultrasonic Open Channel Flow Meter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Open Channel Flow Meter
1.3	Service	Open Channel
1.4	Fluid	Potable/Sewage/Recycle Water
1.5	Area Classification	Non-Hazardous
2	Flow Sensor	
2.1	Type	Ultrasonic
2.2	Sensor MOC	PP / PVDF
2.3	Seal MOC	EPDM
2.4	Sensor Housing MOC	Di-cast Aluminium with PU finish / Polycarbonate
2.5	Process Connection	Flanged
2.6	Flange MOC	PP / CS
2.7	Housing Protection	IP 68

2.8	Temperature compensation	Required
2.9	Swirling arm arrangement for mounting of sensor	Required for access during maintenance
2.10	Size(mm)	To suit Open Channel flow parameters
2.11	Pressure Rating (Kg/cm ²)	Atmospheric
2.12	Temperature	50 °C Ambient
3	Flow Indicator and Transmitter	
3.1	Type	Microprocessor Based, Remote Mounted
3.2	Power Supply	230 VAC Line Power
3.3	Accuracy	± 0.5 % of measured value
3.4	Repeatability	+/-0.1%
3.5	Transmitter Protection	IP67
3.6	Transmitter MOC	Dia-cast Aluminium with PU finish / Polycarbonate
3.7	Output	One Current – 4 to 20 mA (isolated) proportional to flow rate Hart (version 6 or above) One Scalable Pulse One Status Output
3.8	Communication	Modbus RS485
3.9	Display	2 Line Backlit LCD, Programmable
3.10	Maximum Digit Display	8 Digit
3.11	Indication on Display	Actual Flow Rate / Instantaneous Flow Rate Cumulative Flow / Sum / Totaliser Alarm Five (5) digit backlit/Normal LCD, for flow rate in m ³ /hr. Eight (8) digit backlit/Normal LCD for totalized flow in ML • Display with 8 digits for main information. Index, menu and status symbols for dedicated information • Key for toggling through the information and reset customer totalizer and call-up function • Selectable default information and accessible menus: - Operator - Meter - Service - Data Logger

3.12	Zero and Span adjustment	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.
3.13	Facility for online diagnosis	Required as following: Diagnostic • Continuous self-test shall include - Signal input circuit - Data calculation, handling and storing • Features - Alarm statistics and logging for fault analyzing - Transmitter temperature - Flow alarm when defined high flow exceeds - Verification mode for fast measure performance check - Statistic flow and consumption data
3.14	Cable Gland	Required
3.15	Cable Length (sensor to transmitter)	10 Meter minimum or suit to site
3.16	Data Protection:	• All data shall be stored in an EEPROM. • Totalizers statistic shall be backed up every 10 min • Power consumption and temperature Measurement statistic at every 4 hour • Minimum 30 days of data shall be stored in EEPROM. • Password protection of all parameters and hardware protection of calibration and revenue parameters.

3. Pressure Gauge:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Pressure Gauge
1.3	Service	Discharge Pressure Local Measurement
1.4	Fluid	Potable Water/Sewage Water/Air
1.5	Area Classification	Non-Hazardous
2	Pressure Gauge	
2.1	Type	Bourdon with Diaphragm Seal
2.2	Sensor and other wetted parts M.O.C	SS 316
2.3	Process connection	½" NPT (M)

2.4	Dial size	150 mm
2.5	Material of dial	Aluminium with white background and black numerals
2.6	Glass	Shatterproof
2.7	Housing material	Die cast aluminium with epoxy coating
2.8	Accuracy	±1% of full scale or better
2.9	Over range protection	125% of maximum pressure
2.10	Gauge Protection	IP65
2.11	Temperature	50 °C Ambient
2.12	Range	As per pump design (Range to be finalised during detailed engineering without any cost implication)
2.13	Accessories	• Snubber • 3-way isolation valve • Impulse tubing, fittings • All other installation hardware
2.14	Diaphragm Seal M.O.C	SS316
2.15	3 Way Isolation Valve M.O.C	SS316
2.16	Impulse Tube Fitting M.O.C	SS316

4. Pressure Transmitter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Pressure Transmitter
1.3	Service	Pump/ Blower Discharge Common Header
1.4	Fluid	Potable Water/Sewage Water/Air
1.5	Area Classification	Non-Hazardous
2	Pressure Sensor	
2.1	Type	Diaphragm / piezoelectric
2.2	Sensor and other wetted parts M.O.C	SS 316
2.3	Process connection	½" NPT (F)
2.4	Sensor Fill Fluid	Silicon Oil
2.5	Temperature	50 °C Ambient
2.6	Range	As per pump design (Range to be finalised during detailed engineering without any cost implication)

3	Pressure Transmitter	
3.1	Type	SMART Type / Microprocessor Based, Head Mounted
3.2	Power Supply	230 VAC Line Power / 24 VDC
3.3	Accuracy	± 0.1 % of measured value
3.4	Response Time	100 ms.
3.5	Transmitter Protection	IP67
3.6	Transmitter MOC	SS316 /Di-cast Aluminium with PU finish
3.7	Output	One Current – 4 to 20 mA (isolated) proportional to pressure Hart (version 6 or above)
3.8	Display	Alphanumeric LCD Type, Programmable
3.9	Over range protection	125% of maximum pressure
3.10	Zero and span adjustment	Required
3.11	Cable Gland	Required
3.12	Accessories	• Snubber • 3-way isolation valve • Impulse tubing, fittings • Mounting Bracket • Tag Plate • All other installation hardware
3.13	Diaphragm Seal M.O.C	SS316
3.14	3 Way Isolation Valve M.O.C	SS316
3.15	Impulse Tube Fitting M.O.C	SS316

5. Pressure Switch:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Pressure Switch
1.3	Fluid	Potable/Sewage/Recycle Water
1.4	Area Classification	Non-Hazardous
2	Pressure Sensor	
2.1	Type	Diaphragm / piezoelectric
2.2	Sensor and other wetted parts M.O.C	SS 316
2.3	Process connection	½" NPT (F)
2.4	Temperature	50 °C Ambient

2.5	Range	As per pump design (Range to be finalised during detailed engineering without any cost implication)
2.6	Accuracy	+ /- 1% of full scale or better
2.7	Range	As per pump design, Adjustable setting over full span and as per P&ID.
2.8	Over range Protection	125% of range
2.9	Body Material of casing	Die Cast Aluminium / non-corrosive
2.10	Set point adjusting scale	Required
2.11	Accessories	• Snubber • 3 way isolation valve • Impulse tubing, fittings • All other installation hardware
2.12	Diaphragm Seal M.O.C	SS316
2.13	3 Way Isolation Valve M.O.C	SS316
2.14	Impulse Tube Fitting M.O.C	SS316

6. Ultrasonic Level Transmitter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Level Transmitter
1.3	Service	Sump / Tank
1.4	Fluid	Potable/Sewage/Recycle Water, Chemical Water
1.5	Area Classification	Non-Hazardous
2	Level Sensor	
2.1	Type	Ultrasonic
2.2	Sensor MOC	PP / PVDF
2.3	Seal MOC	EPDM
2.4	Sensor Housing MOC	Di-cast Aluminium with PU finish / Polycarbonate
2.5	Process Connection	Flanged
2.6	Flange MOC	PP / CS
2.7	Housing Protection	IP 68
2.8	Temperature compensation	Required
2.9	Swirling arm arrangement for mounting of sensor	Required for access during maintenance
2.10	Size(mm)	To suit Sump / Tank Height

2.11	Pressure Rating (Kg/cm2)	Atmospheric
2.12	Temperature	50 °C Ambient
3	Level Transmitter	
3.1	Type	Microprocessor Based, Remote Mounted
3.2	Power Supply	230 VAC Line Power
3.3	Accuracy	± 0.1 % of measured value
3.4	Repeatability	+/-0.1%
3.5	Transmitter Protection	IP67
3.6	Transmitter MOC	Di-cast Aluminium with PU finish / Polycarbonate
3.7	Output	One Current – 4 to 20 mA (isolated) proportional to Level Hart (version 6 or above)
3.8	Display	2 Line Backlit LCD, Programmable
3.9	Maximum Digit Display	8 Digit
3.10	Indication on Display	Actual Sump / Tank Level Alarm
3.11	Zero and Span adjustment	Factory set Password protection of all parameters and hardware protection of calibration and revenue parameters.
3.12	Cable Gland	Required
3.13	Cable Length (sensor to transmitter)	10 Meter minimum or suit to site

7. Displacer Type Level Switch:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Level Switch
1.3	Service	Sump / Tank
1.4	Fluid	Potable/Sewage/Recycle /Chemical Water
1.5	Area Classification	Non-Hazardous
2	Level Sensor	
2.1	Type	Displacer
2.2	Flexible Rope MOC	PP / SS316
2.3	Displacer MOC	PP / SS316
2.4	Spring Housing	PP / SS316

2.5	Process connection	Flanged
2.6	Process connection MOC	PP
2.7	Switching Type	Micro switch
2.8	Switching Contacts	2 SPDT, 5A
2.9	Housing material	Die cast aluminium with epoxy coating
2.10	Protection Class	IP65
2.11	Perforated Still well	PP
2.12	Temperature	50 °C Ambient
2.13	Range	As per Sump / Tank design (Range to be finalised during detailed engineering without any cost implication)

8. Conductivity Type Level Switch:

Sr. No.	Description	Particulars
1	General	
1.1	Service	As per P&ID
2	Level Probe	
2.1	Type	Rod / Rope type
2.2	Weather protection class	IP 65
2.3	Probe material	SS 316
2.4	Probe head material	Non-corrosive
2.5	Insulation on the probe	Teflon
2.6	Counterweight for rope type probe to keep it straight	Required
2.7	Spacers between the probes to avoid entangling with each other	Required
2.8	No. of electrodes	4 nos. (high, Low, Very low and reference)
2.9	Length of the electrodes	Suitable for reservoir dimensions
2.10	Stilling pipe	Perforated HDPE pipe Internal diameter to suit the level probe assembly
3		
3.1	Mounting	Inside local cabinet fabricated from sheet metal.
3.2	Weather protection class	IP 65
3.3	Alarm contacts	For high, Low and Lo-Lo.
3.4	Contact rating	24 VDC 2 A / 230VAC 1 A.
3.5	Power supply	230 VAC

3.6	Material of enclosure	Non-corrosive
3.7	Sensitivity adjustment for conductivity	Required

9. Dissolved Oxygen sensor and Transmitter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	DO Sensor & Transmitter
1.3	Service	As per P&ID
1.4	Fluid	Sewage/Recycle Water
1.5	Area Classification	Non-Hazardous
2	Dissolved Oxygen Sensor	
2.1	Principle	Optical / Luminescent / Fluorescence technology
2.2	Measurement range	0 – 20 mg/L(ppm)
2.3	Material	
	Wetted Parts	Silicone and SS316 TI
	Sensor	POM Polyoxymethylene or equivalent
2.4	Max Process temperature	50°C
2.5	Max Process pressure	10bar
2.6	Connection	Fixed cable connection
2.7	Ingres protection	IP68
2.8	Additional Certifications	Calibration certification
2.9	Resolution	0.01 mg/l
2.10	Inaccuracy	< 5 % of the measured value or 1 % of full scale
2.11	Repeatability	< 0.5% of measured value (range 0 to 10 NTU/FNU)
3	Dissolved Oxygen Transmitter	
3.1	Type	Microprocessor Based, Remote Mounted
3.2	Transmitter system	4 wire with analog outputs
3.3	Supply voltage	230 V AC, 50Hz
3.4	Material	Field Housing: ABS PC
3.5	Display	LC display with backlight, two lines, with status indicators
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006

3.7	Protection class of field housing	≥ IP 65
3.8	Ambient temperature	–20 ... +60 °C
3.9	Self-Diagnostic feature	Required
3.10	Transmitter channels	Two channel minimum required

10. TSS sensor and Transmitter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Suspended Sensor & Transmitter
1.3	Service	As per P&ID
1.4	Fluid	Sewage/Recycle Water
1.5	Area Classification	Non-Hazardous
2	Suspended Solid Sensor	
2.1	Principle	Light scattering at 90deg & 135deg four beam pulsed method with wavelength at 860nm+/- 30nm
2.2	Measurement range	0 to 4g/L
2.3	Material	Sensor shaft: Stainless steel 1.4404 (AISI 316 L) Optical window: sapphire O-rings: EPDM
2.4	Max Process temperature	50°C
2.5	Max Process pressure	10bar
2.6	Connection	Fixed cable connection
2.7	Ingres protection	IP68
2.8	accuracy	< 5 % of the measured value or 1 % of full scale
3	Suspended Solid Transmitter	
3.1	Type	Microprocessor Based, Remote Mounted
3.2	Transmitter system	4 wire with analog outputs
3.3	Supply voltage	230 V AC, 50Hz
3.4	Material	Field Housing: ABS PC
3.5	Display	LC display with backlight, two lines, with status indicators
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006
3.7	Protection class of field housing	≥ IP 65

3.8	Ambient temperature	-20 ... +60 °C
3.9	Self-Diagnostic feature	Required
3.10	Transmitter channels	Two channel minimum required

11. TOC / COD / BOD sensor and Transmitter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	TOC / COD / BOD Sensor & Transmitter
1.3	Service	As per P&ID
1.4	Fluid	Sewage/Recycle Water
1.5	Area Classification	Non-Hazardous
2	TOC / COD / BOD Sensor	
2.1	Measuring principle	UV photometric - SAC [Spectral absorption coefficient] method, Measurement at 254 nm without any sampling /conditioning requirements
2.2	Process temperature	50°C
2.3	Process pressure	10 bar
2.4	Sensor Ingress Protection rating	IP 68
2.5	Maximum measured error	2 % of upper end of measuring range
2.6	Measuring range	COD/BOD: 0 to 75mg/L, 370 mg/L, 1000 mg/L
		TOC: 0 to 30mg/L, 150mg/L, max up to 410mg/L
2.7	Repeatability	0.5 % of end of measuring range (for homogeneous medium)
2.8	Drift	Less 0.2 % of end of measuring range per week
3	TOC / COD / BOD Transmitter	
3.1	Type	Microprocessor Based, Remote Mounted
3.2	Transmitter system	4 wire with analog outputs
3.3	Supply voltage	230 V AC, 50Hz
3.4	Material	Field Housing: ABS PC / Polycarbonate
3.5	Display	LC display with backlight, two lines, with status indicators
3.6	Electromagnetic compatibility	Interference emission & immunity as per EN 61326-1:2006, class A
3.7	Protection class of field housing	≥ IP 65
3.8	Ambient temperature	-20 ... +60 °C
3.9	Self-Diagnostic feature	Required

3.10	Transmitter channels	Two channel minimum required

12. Chlorine sensor and Transmitter:

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	Residual Chlorine Sensor & Transmitter
1.3	Service	As per P&ID
1.4	Fluid	Sewage Water
1.5	Area Classification	Non-Hazardous
2	Residual Chlorine Sensor	
2.1	Type	Free Chlorine
2.2	Principle	Optical / Amperometric measurement of free chlorine.
2.3	Measurement range	0.01 - 5ppm free chlorine
2.4	pH Compensation	Required, add on pH sensor for compensation
2.5	Material	Sensor shaft: PVC
		Membrane: PTFE
		Membrane cap: PBT (GF30); PVDF
2.6	Process temperature	2°C - 45°C
2.7	Max Process pressure	1 bar
2.8	temperature sensor	Pt100
2.9	Connection	Analog / digital connection with Transmitter
2.10	Ingress protection	IP68
2.11	Resolution	0.01mg/l
2.12	Inaccuracy	1% of measured value
2.13	Sensor capability	The sensor connection should be able to withstand corrosion, moisture without loss of any data.
3	Residual Chlorine Transmitter	
3.1	Type	Microprocessor Based, Remote Mounted
3.2	Output	4-20 mA analog outputs
3.3	Supply voltage	230 V AC 50Hz
3.4	Material	Field Housing: ABS PC

3.5	Display	LC display with backlight, two lines, with status indicators
3.6	Electromagnetic compatibility	interference emission and interference immunity acc. to EN 61326-1:2006
3.7	Protection class of field housing	≥ IP 65
3.8	Ambient temperature	−20 ... +60 °C
3.9	Self-Diagnostic feature	Required
3.10	Transmitter channels	Two channel minimum required (Chlorine +pH)

13. Electromagnetic Smart AMR Water Meters for Asset Service Connection

MID approved with minimum Dynamic ratio (Q3/Q1) of 100:1, AMR Electromagnetic Water having no moving part in contact with water, with fully body made up of composite material, confirming to ISO 4064 along with manufacturing test certificate and Guarantee certificate with Battery life of min. 10 years with GSM / GPRS Technology for communication.

ITEM	SPECIFICATIONS
a) Measuring Principle	A battery operated inline non- Intrusive Electromagnetic water meter with no moving parts.
b) Power Supply	Power-Supply-Battery operation for complete meter including AMR with battery life of minimum 10 years to ensure recording at all times
c) Meter Lifetime	Minimum 10 years
d) Protection Class	Must comply to IP68 Standard for indoor and outdoor operation, including fully submerged installations
e) Approvals and certifications	The meter should be type approved and verified according to international water meter Standard OIML R 49 and or ISO 4064. The meter type approval from MID is also accepted.
f) Accuracy	+/-2% or better over typical operating range and temperatures. The Electromagnetic water meter should maintain its accuracy over its lifetime. Accuracy class 2 standards of OIMLR49.
g) Calibration	3-Point calibration with calibration certificate available for each unit.
h) Dynamic Ratio (Q3/Q1)	Minimum of 500:1. Measuring range shall be as per ISO 4064/OIMR R 49.
i) Material	The water meter body shall be made of Composite material or Engineering plastic.
j) Pressure Rating	Pressure rating shall be = PN16
k) Environmental Temperature	0 degree C to 50 degree C
l) Data Protection and tamper proof	The meter should be tamper proof with suitable data protection of calibration and revenue parameters
m) Self-diagnostics for error detection.	The smart meter should have advanced diagnostics with active alarm(s) indicated on display

n) Access to information	Display with =8 digits for main information. Index, menu and status symbols for dedicated information
o) Measuring Units	The measuring units should be m ³ for volume and m ³ /h or l/h for flow rate.
p) Facility for Remote Communication interface	The Electromagnetic water meter should be configured with battery operated remote reading capability using point-to-point RF.
q) Indicators / Alarms	Tampering, Reverse Flow, Leakage etc.

14. PLC System for Redundant System

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	PLC System
1.3	Service	Plant Automation
1.4	Area Classification	Non-Hazardous
2	PLC System	
2.1	Type of Control system	Programmable Logic Controller (PLC)
2.2	Offered PLC System configuration and PLC system hardware	Latest system available / being supplied in the international market by the manufacturer with proven performance record for the similar type of application
2.3	Operating System windows based	Windows –XP/7 or latest.
2.4	Hierarchical protection for operator & engineer functions	Multi-level security required
2.5	UPS – Input-415V AC, 3Ø, 50 Hz Output- 230 V AC, 1Ø, 50 Hz	UPS of adequate capacity with battery back-up of min. 1hour (SMF Nickel-Cadmium batteries).
2.6	No of UPS feeders (outgoing)	Bidder to indicate
2.7	UPS sizing	Bidder to indicate. Adequate capacity UPS considering 30 % spare load.
2.8	UPS Battery back-up time	Min. One (1) hour
2.9	Response time (Maximum) for	
2.10	Analog input	250 m sec
2.11	RTD	1 sec
2.12	Digital Input / output	25 - 50 m sec
2.13	Loop cycle time inclusive of controller processing time	250 m sec (Analog); 100 m sec (Digital)
2.14	Auto switchover time to backup/redundant component at a) Processor level	Instantaneous and bump-less (Bidder to indicate the time)

	b) Communication level c) Power supply level	
2.15	Card changeover, card wiring removal or communication cable change shall be possible on-line (PLC running) without causing any process interruption	PLC Card removal shall be hot swappable.
2.16	Display Call up time in HMI monitor	1 sec or better
2.17	Dynamic update time of parameters in the HMI monitor for measurement and control	1 sec. or better
2.18	Spare capacity required in the control processor considering spare I/O channels and future I/O modules to be located in the spare I/o slots	Minimum 20 %
2.19	Output status on controller failure	Configurable in engineering station
2.20	Output status on power supply failure	Configurable for switching to fail safe mode
2.21	Status indication for each channel in DI / DO card	LED indication required
2.22	Power supply healthiness status in all modules	LED indication required
2.23	Optical Isolation with IPR for DI / DO	Required
2.24	Galvanic isolation for AI / AO	Required
2.25	Fuse Protection for AI / DI modules	Required
2.26	Fused terminals with LED indications for each DO and also for Power supply to PLC	Required
2.27	All I/O module status monitoring (Channel & Module level) in PLC system HMI & shall be from same processor family.	Required
2.28	Self-diagnostics for all PLC modules	Required
2.29	Control processor with floating point arithmetic capability	64 bit processor
2.30	Capacity of RAM	2 MB minimum
2.31	Spare capacity in RAM	Minimum 50 % including spare I/Os
2.32	Processor Redundancy	Required. Dual redundant hot stand-by, Physical cable connectivity between primary and secondary controllers, loading of programs in primary controller alone.

2.33	Power supply source redundancy with Auto changeover scheme.	Required. Shall be implemented at each PLC side.
2.34	Power supply module redundancy in the PLC panel	Required
2.35	Communication module redundancy	Required
2.36	Failure of communication module/ data bus/ communication bus/Power supply module shall not lead to change over of Processor/CPU	Required
2.37	Network & Network module redundancy	Required
2.38	Hot redundant connectivity between processor to I/O rack	Required
2.39	Primary and secondary indication on controllers	LED indication & also in MMI required
2.40	Memory expandability	150% of offered capacity
2.41	RAM with Battery back up	Minimum 72 hr without power.
2.42	Supply of Flash RAM for memory /Program retention	Required
2.43	Closed loop control	Redundant I/O system
2.44	Open loop control (Logic, protection & interlock)	Non-redundant I/O modules
2.45	Maximum number of channels in I/O modules - Analog I/O modules RTD, Thermocouple Digital I/O modules	8 Channels (Differential type) 16 Channels 16 Channels
2.46	Input – Output Philosophy	
2.47	Power supply to the field transmitters	Analog input module shall drive the connected field transmitter on 2 wire loop
2.48	Interrogation voltage for Digital signals	24 V DC
2.49	Concept of I/O grouping	No two identical / similar equipment shall be grouped in the same I/O module I/Os related to equipment and I/Os related to its associated auxiliaries shall be connected to different modules. Inputs and outputs shall not be combined in a single module.
2.50	USB ports on Operator station	4 nos.
2.51	DVD R/W drives on Operator Station	One(1)
2.52	Displays on HMI monitor	Process mimic displays, trend displays, system status, alarm displays, logs /

		reports etc. HMI software shall have minimum 100 pages with unlimited tags.
2.53	Minimum no of plant mimics configurable	100
2.54	Time activated logs	Periodic logs, shift report, daily report, status change log, Control system fault log
2.55	Operator Work Station (OWS)	One no. Industrial grade OWS shall be considered. - Intel I5/ I7, Minimum 3.6 GHz processor or latest - 22" LED Monitor - 8 GB RAM min or better - 1 TB HDD - ASCII keyboard - DVD R/W Drive - Workstation model i. - Original OS & antivirus
2.56	Engineering Work Station cum OWS	One no. industrial grade EWS cum OWS shall be considered. - Intel I5 / I7, Minimum 3.6 GHz processor or latest - 22" LED Monitor - 8 GB RAM min or better - 1TB HDD - DVD R/W Drive - QWERTY Keyboard - Workstation model - Original OS & antivirus
2.57	Annunciation System	Integral to the PLC
2.58	Printers	One A3/A4 size colour laser jet printer (600 DPI resolution) shall be provided
2.59	Hot Spare I/O modules	20 % (wired up & mounted) hot spare modules for each type of I/O module shall be provided in the panel
2.60	Spare Channels in each I/O Module used	20 % (wired up) spare channels over the entire population of each type of module.
2.61	Spare slots in the I/O rack (wired with connector)	20% additional slots/base in each rack shall be provided which shall be wired with connectors for future provision. This is in addition to the required 20 % (wired & mounted) hot spare modules.
2.62	Fuse with led indication for I/O channels	- Individual for analog signals - Group of max 8 for digital channels
2.63	PLC hardware	G3 rated
2.64	SER	SER in PLC is envisaged for electrical signal only.
2.65	Interposing Relays	24 V DC with freewheeling diode across the coil – Relay contact rating A at 230 V AC

2.66	Panels / Cabinets	Self-Standing type with maximum height of 2200mm
2.67	Mechanical features	a) 2 mm thick CRCA steel sheet for panel walls. 3mm thick removable gland plate b) 2.5 mm thickness for double doors c) Panel - door switch d) Fans and louvers e) Paint as per RAL 7035 f) Automated panel Illumination by push buttons g) Suitable enclosure protection Anti-vibration pad of minimum 15mm thickness.
2.68	Panel Earthing	Safety earth for enclosure and electronic earth for PLC system.
2.69	Control room	Air Conditioned.
2.70	Quality Assurance	As per quality plan to be approved by the Purchaser / Engineer
2.71	Inspection Requirements	Factory Acceptance Test & Site Acceptance Test as per procedure approved by the Purchaser / Engineer.
2.72	Communication	The communication shall be redundant between the control processors and HMI as well as across processors and transmission rate shall be minimum 100 MBPS / 1GBPS through multi- port switch having FO ports, ensuring adequate number of spare ports. Also communication between control processors and I/O shall be redundant. PLC shall be provided with required number of Modbus ports. PLC shall have time synchronisation facility with master clock directly connected to PLC cards.
2.73	Undertaking for Spares & support	h) OEM's undertaking shall be furnished for Spares & service support for minimum 15 years.
2.74	Make of PLC	As per Approved List.
2.75	Control Cabinets/ Consoles:	
2.76	Type & Constructional Features	• Indoor, Self Standing type with maximum height of 2200 mm • Sheet Steel Thickness - 2.0 mm thick CRCA sheet for panel walls. 3mm thick removable gland plate. • Pant Finish as per RAL- 7032. • Enclosure Protection – IP54 Anti-vibration pad of minimum 15 mm thickness.
2.77	Accessories	• Panel - door switch • Fans and louvers

		Panel Illumination Lamps
2.78	Consoles & Chairs	Consoles for OWS, EOWS & Printers. Two (2) nos. operator chairs (revolving type)
2.79	Software:	
2.80	PLC Development License Software	Required
	SCADA Development License Software	Required
2.81	SCADA Run Time License Software	• Required
2.82	Workstation Operating System License Software	• Required

15. PLC Based RTU Unit

All RTU shall be installed in the Control Panel of appropriate size on roadside, preferably on pedestrian path nearby the valve chambers at 800 mm above ground level. Bidders to consider RTU panel for each RTU and cost of RTU shall be quoted including the RTU panel of specifications as provided below:

- RTU Panel shall provide enclosure protection for following devices
 - a) RTU with required IO card, Communication Card
 - b) Power supply modules.
 - c) Surge protection units.
 - d) Modem Switch with OFC Port.
 - e) UPS System
 - f) Selector switches for selection of auto mode, Manual Mode
 - g) Push buttons, MCB, Relay Boards, Interposing Relays etc.
- RTU Panel Enclosure shall be provided with proper sunshade. Panel top will be designed as Canopy top for protection of water logging.
- Minimum Sizes of Enclosure units are to be chosen of 800mmX400mmx1000mm (WXDxH) or bigger as all the Panel accessories can be suitably mounted inside panel with proper clearance.
- The cabinets shall be fabricated from cold rolled sheet steel of 2 mm thickness with 3mm thick gland plate with powder coating and shall be suitable for pedestal mounting.
- The cabinet shall be properly painted from inside and from outside by paint shade RAL 7035.
- The cabinet shall conform to IP 65 weather protection and shall have built in locking facility.
- The cabinet shall be earthed properly.
- The panel shall have bottom cable opening with proper glanding arrangement.

- Voltage level for control schemes and power supply for instruments in the panels shall be limited to 230 VAC. Any other necessary voltage shall be derived by the Contractor using necessary inverters, converters, transformers, rectifiers etc. which shall be in his scope of supply.
- The panel shall be provided with either a fluorescent lighting fixture rated for 230 VAC supply for the interior illumination of the panel during maintenance. Additionally, the panel shall be provided with 230 VAC combined 5 amps and 15 amps, 3 pin receptacle with a switch and neon indicating.
- All the equipment mounted inside the panels shall be provided with individual labels with equipment designation engraved. The labels shall be mounted directly below the respective equipment. Also the panel shall be provided at the top with a label engraved with panel designation.
- Each control panel shall be provided with necessary arrangement for receiving, distributing, isolating and protecting of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Miniature Circuit Breakers (MCBs). Potential circuits for relaying also shall be protected by MCBs.
- Connections within a panel, between panel mounted devices and terminal blocks or between two panels mounted devices shall be made PVC insulated stranded copper conductor. The wires shall be shielded for all analogue signals.
- Terminal blocks shall be one-piece moulded, complete with stud type terminals, washers, nuts and lock nuts and identification markings. Terminal block design shall include a white fibre marking strip with clear plastic, hinged terminal covers. Markings on the terminal strips shall correspond to wire numbers on the wiring diagrams.
- All spare contacts and terminals of the panel mounted equipment and devices shall be wired to terminal blocks.
- Panel internal wiring shall not be looped directly from instrument to instrument. The same shall be looped through the panel terminal block only.
- PLC Based Remote Terminal Unit (RTU) with all necessary Hardwire and software for Establishment of communication and transmission of Data from RTU System of the Distribution Flow and Electrical Actuator are communicating with main SCADA system at ICCCL through GSM/GPRS/LPWAN/Other wireless communication technology). Monitoring of Flow to be done at SCADA and Remote-Control operation from Main SCADA to be provided. Following Instruments and Components connected to RTU, necessary Digital/Analog IO to be considered by bidder.

Proposed locations for RTU Panels are to be considered at side of road preferably on pedestrian pathway and enclosure units to be installed in such way that this will be protected from any Vehicular and Pedestrian movement. Panels will be installed at 800 m above ground level as the PLC Unit will be mounted at 1.2 m above from ground.

15.1 Micro PLC Specification for RTU Unit

S. No.	Parameters	Minimum Specification
1	Rated supply voltage	24 V DC
2	Discrete input number	24
3	Analogue input number	2 at 0...10 V
4	Discrete output type	Transistor
5	Discrete output number	16 transistor 4 fast output
6	Discrete output voltage	24 V DC
7	Discrete output current	0.5 A
8	Discrete I/O number	40
9	Maximum number of I/O expansion module	7 or More for relay output
10	Supply voltage limits	20.4...28.8 V
11	Inrush current	Max 35 A
12	Maximum power consumption in W	Max 20 W at 24 V (with max number of I/O expansion module)
		Max 6 W at 24 V (without I/O expansion module)
13	Power supply output current	Max 0.5 A 5 V for expansion bus
		Max 0.3 A 24 V for expansion bus
14	Discrete input logic	Sink or source (positive/negative)
15	Discrete input voltage	24 V
16	Discrete input voltage type	DC
17	Analogue input resolution	10 bits
18	LSB value	10 mV
19	Conversion time	Max 1 ms per channel + 1 controller cycle time for analogue input analog input
20	Permitted overload on inputs	+/- 30 V DC for 5 min (maximum) for analog input
		'+/- 13 V DC (permanent) for analog input
21	Voltage state 1 guaranteed	>= 15 V for input
22	Voltage state 0 guaranteed	<= 5 V for input
23	Discrete input current	7 mA for discrete input
		5 mA for fast input
24	Input impedance	Max 3.4 kOhm for discrete input
		Max 100 kOhm for analog input
		Max 4.9 kOhm for fast input

S. No.	Parameters	Minimum Specification
25	Response time	Max 35 μ s turn-off, I2...I5 terminal(s) for input
		Max 5 μ s turn-on, I0, I1, I6, I7 terminal(s) for fast input
		Max 35 μ s turn-on, other terminals terminal(s) for input
		Max 5 μ s turn-off, I0, I1, I6, I7 terminal(s) for fast input
		Max 100 μ s turn-off, other terminals terminal(s) for input
		Max 300 μ s turn-on, turn-off, other terminals terminal(s) for output
		Max 5 μ s turn-on, turn-off, Q0...Q3 terminal(s) for output
26	Configurable filtering time	0 ms for input
		3 ms for input
		12 ms for input
27	Discrete output logic	Negative logic (sink)
28	Maximum current per output common	4A
29	Output frequency	0.1 kHz for output at Q4...Q15
		100 kHz for fast output (PWM/PLS mode) at Q0...Q3
30	Absolute accuracy error	+/- 1 % of full scale for analog input
31	Maximum leakage current	0.1 mA for transistor output
32	Maximum voltage drop	<1 V
33	Mechanical durability	20000000 cycles for transistor output
34	Memory capacity	256 kB for user application and data RAM with 10000 instructions
		256 kB for internal variables RAM
		Or Better
35	Data backed up	256 kB built-in flash memory for backup of application and data
36	Data storage equipment	2 GB SD card
37	Battery type	BR2032 lithium non-rechargeable, battery life: Min.4 year(s)
38	Backup time	1 year at 25 °C (by interruption of power supply)
39	Execution time for 1K instruction	0.3 ms for event and periodic task
40	Execution time per instruction	0.2 μ s Boolean
41	Execution time for event task	60 μ s response time
42	Maximum size of object areas	8000 %MW memory words
		255 %TM timers

S. No.	Parameters	Minimum Specification
		512 %KW constant words
		255 %C counters
		512 %M memory bits
43	Realtime clock	With
44	Clock drift	<= 30 s/month at 25 °C
45	Regulation loop	Adjustable PID regulator up to 14 simultaneous loops
46	Positioning functions	Position PTO 4 axe(s)pulse/direction mode (100 kHz)
		Position PTO 2 axe(s)CW/CCW mode (100 kHz)
47	Function available	PLS
		PWM
		Frequency generator
48	Counting input number	4 fast input (HSC mode) at 100 kHz 32 bits
49	Counter function	A/B
		Single phase
		Pulse/direction
50	Integrated connection type	USB port with mini B USB 2.0 connector
		Non isolated serial link serial 1 with RJ45 connector and RS232/RS485 interface
		Ethernet with RJ45 connector
51	Supply	(serial)serial link supply: 5 V, <200 mA
52	Transmission rate	1.2...115.2 Kbit/s (115.2 Kbit/s by default) for bus length of 15 m for RS485
		1.2...115.2 Kbit/s (115.2 Kbit/s by default) for bus length of 3 m for RS232
		480 Mbit/s for USB
53	Communication protocol port	USB port: USB – So Machine-Network
		Non isolated serial link: Modbus master/slave - RTU/ASCII or So Machine-Network
		Ethernet
54	Port Ethernet	10BASE-T/100BASE-TX 1 port with 100 m copper cable
55	Communication service	DHCP client
		Modbus TCP slave device
		Ethernet/IP adapter
		Modbus TCP server
		Modbus TCP client
56	Local signalling	With LED
57	Electrical connection	removable screw terminal block for inputs & output

S. No.	Parameters	Minimum Specification
		Mini B USB 2.0 connector for a programming terminal
58	Insulation	Between input and internal logic at 500 V AC
		Between fast input and internal logic at 500 V AC
		Non-insulated between inputs
		Between output and internal logic at 500 V AC
		Non-insulated between analogue input and internal logic
		Non-insulated between analogue inputs
		Or Better
59	Marking	CE
60	Standards	EN/IEC 61131-2
		EN/IEC 61010-2-201
		EN/IEC 60664-1
61	Product certifications	LR
		CULus
		CSA
		EAC
		DNV-GL
		ABS
		RCM
		IACS E10
62	Environmental characteristic	Ordinary and hazardous location
63	Resistance to electrostatic discharge	8 kV in air conforming to EN/IEC 61000-4-2
		4 kV on contact conforming to EN/IEC 61000-4-2
64	Resistance to electromagnetic fields	10 V/m 80 MHz..1 GHz conforming to EN/IEC 61000-4-3
		3 V/m 1.4 GHz...2 GHz conforming to EN/IEC 61000-4-3
		1 V/m 2 GHz...3 GHz conforming to EN/IEC 61000-4-3
65	Resistance to magnetic fields	30 A/m 50/60 Hz conforming to EN/IEC 61000-4-8
66	Resistance to fast transients	2 kV (power lines) conforming to EN/IEC 61000-4-4
		2 kV (relay output) conforming to EN/IEC 61000-4-4

S. No.	Parameters	Minimum Specification
		1 kV (I/O) conforming to EN/IEC 61000-4-4
		1 kV (Ethernet line) conforming to EN/IEC 61000-4-4
		1 kV (serial link) conforming to EN/IEC 61000-4-4
67	Surge withstand	2 kV power lines (AC) common mode conforming to EN/IEC 61000-4-5
		2 kV relay output common mode conforming to EN/IEC 61000-4-5
		1 kV I/O common mode conforming to EN/IEC 61000-4-5
		1 kV shielded cable common mode conforming to EN/IEC 61000-4-5
		0.5 kV power lines (DC) differential mode conforming to EN/IEC 61000-4-5
		1 kV power lines (AC) differential mode conforming to EN/IEC 61000-4-5
		1 kV relay output differential mode conforming to EN/IEC 61000-4-5
		0.5 kV power lines (DC) common mode conforming to EN/IEC 61000-4-5
68	Resistance to conducted disturbances	10 V 0.15...80 MHz conforming to EN/IEC 61000-4-6
		3 V 0.1...80 MHz conforming to Marine specification (LR, ABS, DNV, GL)
		10 V spot frequency (2, 3, 4, 6.2, 8.2, 12.6, 16.5, 18.8, 22, 25 MHz) conforming to Marine
		specification (LR, ABS, DNV, GL)
69	Electromagnetic emission	Conducted emissions - test level: 79 dB μ V/m QP/66 dB μ V/m AV (power lines (AC)) at 0.15...
		0.5 MHz conforming to EN/IEC 55011
		Conducted emissions - test level: 73 dB μ V/m QP/60 dB μ V/m AV (power lines (AC)) at 0.5...300 MHz
		conforming to EN/IEC 55011
		Conducted emissions - test level: 120...69 dB μ V/m QP (power lines) at 10...150 kHz conforming to
		EN/IEC 55011
		Conducted emissions - test level: 63 dB μ V/m QP (power lines) at 1.5...30 MHz conforming to EN/
		IEC 55011

S. No.	Parameters	Minimum Specification
		Radiated emissions - test level: 40 dB μ V/m QP class A (10 m) at 30...230 MHz conforming to EN/
		IEC 55011
		Conducted emissions - test level: 79...63 dB μ V/m QP (power lines) at 150...1500 kHz conforming to
		EN/IEC 55011
		Radiated emissions - test level: 47 dB μ V/m QP class A (10 m) at 200...1000 MHz conforming to EN/
		IEC 55011
70	Immunity to microbreaks	10 ms
71	Ambient air temperature for operation	-10...55 °C (horizontal installation)
		-10...35 °C (vertical installation)
72	Ambient air temperature for storage	-25...70 °C
73	Relative humidity	10...95 %, without condensation (in operation)
		10...95 %, without condensation (in storage)
74	IP degree of protection	IP20 with protective cover in place
75	Pollution degree	≤ 2
76	Operating altitude	0...2000 m
77	Storage altitude	0...3000 m
78	Vibration resistance	3.5 mm at 5...8.4 Hz on symmetrical rail
		3.5 mm at 5...8.4 Hz on panel mounting
		1 gn at 8.4...150 Hz on symmetrical rail
		1 gn at 8.4...150 Hz on panel mounting
79	Shock resistance	147 m/s ² for 11 ms

16. SCADA Software

- SCADA software is required for 5000 Tags. SCADA software i.e., “Supervisory Control and Data Acquisition System software should allow an operator to make set point changes on distant process controllers, usually to control, monitor alarms, to analyses or report industrial automation applications. With SCADA, user should be able to collect data from experimental facility's sensors and devices and transform them into dynamic text, alarm or graphic scheme. The SCADA should have functionality viz Data Acquisition, Data Processing, Alarms, Data Archiving, Visualization, Controlling, Trending, Reporting and OPC Compatible.
- The SCADA software should be able to connect with PLC as well as FDAS hardware

through OPC.

- c) Suitable real time data management software shall be provided for receiving data from PLCs and transferring data to operator station on demand. This software shall be able to process and transmit the data very efficiently whenever required in any specific form (as specified by the operator / client through the network). It shall be programmable to limit the data storage from current month to three months. Layered password Control at various levels i.e. system configuration, changing alarm interlocks, set points etc. shall be possible to prevent unauthorized entry.
- d) SCADA should maintain its own standard library in displaying information to the operators. Standards should be available as pre-configured modules so that they can be used as it is in any installation. The software shall be compatible with latest PC configuration running with Windows operating system. The feature should also decrease the maintenance and troubleshooting time once the plant is in operation. English shall be the communication language. The software shall have open connectivity, object oriented graphical programming methods and event driven architecture. It shall read I/O's and assign internal variables (Process tags) and generate internal variables by mathematical operation like assigning special control signal computations as per the standard controller algorithms. The software shall not occupy much disk space. It shall export to Microsoft Word and Excel Package.
- e) Users shall be able to add, delete and modify PLC I/Os, graphics and supervisory control logic online without shutting down the plant/experimental facility. The Software Development Package shall include Data Acquisition & Control, Data Analysis, Data presentation and Report generation.
- f) Single configuration environment: The SCADA System should have a single configuration environment for configuring the whole project. The software should facilitate data entries at a single configuration environment to prevent human errors. The project environment should have features like:
 - 1) Graphical development for distributed monitoring and control systems
 - 2) Networked SQL compliant database for distributed data logging
 - 3) Building mimics
 - 4) Configuring the network nodes and the instruments under those network
 - 5) Creating the configuration files for the instruments
 - 6) Creating alarm groups
 - 7) IO manager for allocation of tags to the instruments
 - 8) Deploying the project to the operator station from the Development/ Engineering station.
 - 9) Creating the security features and deploying them.

- 10) Creating alarm groups –where tags to those alarm groups can be added by dragging those tags to the groups.
 - 11) OPC or equivalent software for -PLC communication
- g) Object Oriented Graphics: It should be easy to configure and reduce development times. Objects should have features like sizing, moving, and animating. Powerful object-oriented design tools should be available to create graphics. It should support video resolution supported by windows.
 - h) Animation Links: Animation links should be available for movement, position changes and more. It should include discrete, analog and string touch inputs.
 - i) Distributed Alarming: It should support multiple alarms simultaneously, which gives operators the ability to view alarm information from multiple remote locations at the same time. It should also support distributed alarm functions which let users implement 'point-and-click' alarm acknowledgment, alarm scroll bars and many other features for networked use.
 - j) Time Stamping: All the alarms and events that occur should be time stamped at source.
 - k) Distributed Historical Trending: Operation Server/Viewer should allow to dynamically specify different historical file data sources for each of the pens on a trend chart. The Operation Server/Viewer should preferably permit minimum of 8 pens per trend chart. The users should be able to view historical data at any given time.
 - l) Display navigation: The display should be user configurable. Screen navigation shall be designed so that the operator can page through displays at different levels starting with over-view, area displays, group displays, fascia displays, current and historical trend groups etc. A permanent alarm banner should be provided for immediate indication of abnormal plant conditions. Security is to be achieved via login and password.
 - m) Group Display: The system should allow for building graphics comprising of points across groups/areas. The areas are created for efficient alarm management. Group display should contain bar graph display of individual loops, their digital values & status display. In addition to this, one should have access to the tuning parameters, real time trends, historical & event trends. Auto/manual/remote selection for any loops or all loops should be possible from group display. Set point & alarm adjustment of any loop should also be possible from any display. This should be password protected.
 - n) Faceplates: Faceplates for all IO tags, control modules should be available by default in the SCADA software. It should allow some operator interaction with the device and provide an operational summary which should be displayed. The operator should be able to control the device by means of pushbuttons (for mode selection or for state selection on a digital device) or numeric values (for analog values such as set points). Numerical

values can be set either by selecting the displayed value and entering a new value or by selecting the associated bar graph and ramping up or down.

- o) Parametric/Loop Display: The SCADA system should have a faceplate for PID, Pulse Input, Analog Input, Device Control, and Input Selector function blocks etc. It should also contain a detail display for the PID parameters, and Device Control blocks.
- p) Trend Display the SCADA system should be capable of displaying Real time and historical data from the continuous history subsystems as well as from the event chronicle. Trends should be plotted on a graph. Online archiving of trends should be possible. The trend Package should allow the operator to carry out the following:
 - Move forward and backward in time
 - Zoom in on a particular area of the trend
 - Select a particular pen (the engineering units range of this pen is then displayed)
 - Position a hairline cursor to read off values and time stamp
 - Print display chart
- q) Reporting & Alarming Manager:
- r) Software Licenses: The Bidder shall provide software license for all software being used. The software licenses shall be provided for the project (e.g., organization or site license). All licenses shall be valid for the continuous service life of the plant.
- s) Software Upgrades: As a customer support, the Bidder shall periodically inform the designated engineer of the purchaser about the software upgrades/new releases that would be taking place after the system is commissioned so that if required, same can be procured & implemented at site.
- t) Operator Interface: The following features shall be possible:
 - 1) Online display of control groups, alarm summary, process mimics with online data and no limit for no. of mimic pages should be there. A sample mimic and a sample equipment control strategy shall be provided by the bidder.
 - 2) Trends for selected variables for selected time interval in different windows shall be available. The display panels should show X-Y and real time plots, bar graphs, trend graphs.
 - 3) Alarm settings for different levels and alarm generation.
 - 4) Controller mode of operation and performance behavior.
 - 5) Configurable O/P states for predictable performance in critical applications.
 - 6) Generation of shift wise log reports on demand log report for programmable time basis for selected process variables which shall be either on hard disk with security privilege and printout shall be routed to printer.

- 7) It shall be possible to generate reports from the data acquired by the system. DDE linkages shall be available through which data can be transferred to Packages like Microsoft EXCEL. Assign / change job for any other station from anywhere.
- 8) Each graphic Display shall be composed of graphic symbols and alphanumeric characters. The symbols shall be as per the latest revision of ISA standard (S5.5 or better).
- 9) All displays shall be graphically updated.

17. UPS System

Sr. No.	Description	Particulars
1	General	
1.1	Make	As per approved vendor list
1.2	Item	UPS
1.3	Service	Instrumentation & Automation System
1.4	Area Classification	Non-Hazardous
2	UPS	
2.1	Input	230V 1P AC
2.2	Output	230V AC, 50 Hz
2.3	UPS Capacity	*KVA (* KVA rating shall be finalized during detailed engineering)
2.4	UPS Battery back-up time	Minimum 60 min. (SMF Lead Acid)
2.5	No of UPS feeders (outgoing)	As per system requirement.
2.6	UPS Type	Online, Double Conversion, Industrial
2.7	Rectifier Charger Type	SCR / IGBT Based
2.8	Static Inverter Type	SCR / IGBT Based
2.9	Static Transfer Switch Type	SCR-SCR Based
2.10	Manual Bypass Switch Type	Change over
2.11	Battery Type	SMF Lead Acid
2.12	Isolation Transformer	Required, Built in within UPS- Output Side
2.13	Degree of Protection	IP20 or better
2.14	Cable Entry	Back Side Bottom
2.15	Communication - SNMP Card & MODBUS	Required
2.16	Potential Free Contacts	Rectifier Trip Inverter Trip Load on Battery

Sr. No.	Description	Particulars
		Battery low Pre-alarm Load on Static Bypass One Relay contact for each, Rating – 1A/230 VAC OR 2A / 12 VDC
2.17	Drawings / Documents	SLD, GA, Power & Control Wiring Diagram & Foundation Details, Type Test Certificate, FAT/SAT Procedure
2.18	Reference standard	IEC 62040-3 or equivalent

Instrument Signal Cables:

Sr. No.	Description	Particulars
1	Conductor	
i)	Single / Multi Pair	7 stranded / 0.53 mm dia (1.5 mm ²) stranded annealed tinned copper conductors of electrolytic grade copper.
2	Insulation	Cross-linked Polyethylene (XLPE) as per BS 5308/IS 7098.
3	Inner & outer sheath	PVC, fire retardant, low smoke, low halogen, low toxic, polymeric compound.
4	Pairs	Two insulated conductors shall be uniformly twisted together to form a pair at least 10 twists per metre.
5	Maximum DC resistance	Shall not exceed 12.3 ohms/ km at 20°C for cables with 1.5 mm conductor.
6	Mutual capacitance	BS 5308 Part 1
7	L/R ratio of adjacent cores / pairs	BS 5308 Part 1
8	Shield	Shield shall be aluminium backed Mylar / polyester tape bonded together with the metallic side down helically applied with either side having 25% overlap and 100% coverage. The minimum shield thickness shall be 0.05 mm in case of single pair and 0.075 mm in case of multi pair cable.

Sr. No.	Description	Particulars
9	Drain wire	Drain wire shall be provided for individual pair and overall shield with 0.5 mm ² multistranded bare tinned annealed copper conductor continuously in contact with aluminium side of shield. The drain wire resistance including shield shall not exceed 30 ohm/km. Electrostatic noise rejection ratio shall be over 76 dB.
10	Colour coding	Individual pair core insulation: Blue & Black Inner jacket: Black Outer jacket: Blue for intrinsically safe application and blue with black bands (4 bands at 90° apart) for non-IS applications.

18. Control cables:

Sr. No.	Description	Particulars
1	Conductor 2 Core / Multi-core type	7 stranded / 0.53 mm dia (1.5 mm ²) annealed tinned copper conductors of electrolytic grade copper.
2	Insulation	Cross-linked Polyethylene (XLPE) as per BS 5308 / IS 7098
3	Inner & outer sheath	PVC, fire retardant, low smoke, low halogen, low toxic, polymeric compound.
4	Maximum DC resistance	Shall not exceed 12.3 ohms/ km at 20°C for cables with 1.5 mm ² conductor
5	Core Identification	IS : 1554 / BS 6746

19. Power cables:

Sr. No.	Description	Particulars
1	Conductor	7 stranded / 0.67 mm dia (2.5 mm ²) annealed tinned copper conductors of electrolytic grade copper. The size of the conductor specified here is minimum; however, the exact size of the conductor shall be selected based on the length of cable and power consumption. For higher conductor Sizes, aluminium can be considered.

2	Insulation	Cross-linked Polyethylene (XLPE) as per BS 5308 / IS 7098
3	Core Identification	IS-1554 / BS 6746
4	Colour coding	Outer sheath colour –Black Neutral wire insulation colour – Black Phase wire insulation colour – Red Ground wire insulation colour - Green

D 4. MECHANICALWORKS-PUMPING STATION

VALVES

a. General

- Valves shall be as per internationally recognized standards. Flanges shall be machined on faces and edges. Flanges shall conform to ISO 7005, IS 6392, BS EN 1092-1/ BS 4504.
- Valves shall be double flanged type and the faces shall be parallel to each other. The flange face should be at right angles to the valve centerline. Back side of valve flanges shall be machined, or spot faced for proper seating of the head and nut.
- Valves buried or installed in underground chamber, where access to a hand wheel would be impractical, shall be operated by means of extension spindle and/or keys. Wherever extension spindle is provided, the valve shall also be provided with suitable headstock.
- Butterfly and non-return valves shall be provided with bypass arrangement having rising spindle gate valves. Bypass may be integral with valve or connected between pipes.
- The work of fixing appurtenances, i.e., butterfly valves, sluice valves, air valves, scour valves, etc. shall be carried out carefully so as not to damage them during handling, erection and fixing.
- For butterfly valves the gearbox shall be provided with self locking devices. A locking facility shall be provided for the butterfly valve in either the fully open, fully closed or intermediate position.
- Sluice valves and butterfly valves shall be provided with position indicators, to show whether the valve is in the open or close position.
- Gaskets shall be of Nitrile rubber and readymade matching with respective flanges. Gaskets cut out from rubber sheets are not acceptable.
- Valves for operation shall be so geared that under the operating conditions as specified herein, the maximum force on the rim of the hand wheel, crank, or other necessary for operation shall not exceed 20 kg and the maximum torque shall not exceed 5.5 kg/m. A spur, bevel, or worm gear reduction unit, if required, shall be attached to the pinion shaft of the operating mechanism.
- Valve of diameter 450 mm and above shall be provided with lifting eyes and shall have detachable bolted covers for inspection, cleaning, and servicing.
- Valve shall be suitable for frequent operation as well as operation after long periods of idleness in either open or closed position.
- The valve stem, thrust washers, screws, nuts and all other components exposed to the water shall be of a corrosion resistant grade of stainless steel.

- Valves shall be free from sharp projections which are likely to catch and hold stringy material.
- All the valves on the suction and delivery side of the pumping station shall be of Sluice.
- All the valves provided at the delivery side of the pumping station shall be motor operated.

b. Sluice Valves

Sluice valve shall generally confirm to IS 14846.

- (a) All valves shall be gland less (stem sealing rings) type
- (b) Sluice valves shall be of non-rising spindle type. The valve shall be furnished with a bushing arrangement for replacement of packing without leakage. Shoe and channel arrangement shall be limited to valves of 300 mm and above. The gap between the shoe and channel shall be limited to 1.5 mm.
- (c) Valves of 300mm and above shall be provided with thrust bearing arrangement for ease of operation.
- (d) Valves of diameter 300 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear of all valves shall be such that they can be opened and closed by one man against an unbalanced head 15% in excess of the maximum specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.
- (e) The sluice valves shall bear I.S.I. mark on them. All valves shall be double flanged. The pressure drop across valve shall be limited to 0.05 mwc.
- (f) All valve flanges shall be designed to withstand the stresses to which they will be subjected under hydraulic tests. Flanges shall be machined with raised joint faces / without raised face and designed in accordance with part IV of IS 1538 "Specifications for C.I. Fittings" and shall be drilled in accordance with the table VI of the IS 1538. The valve flanges shall be provided with scurtings so as to have proper sealing with the gasket at the time of installation.
- (g) The valves shall be designed so as to minimize erosion, cavitations and vibration in all positions and to minimize head loss in fully open position. Valve bodies or bonnets shall enable the wedge to be withdrawn well clear of the stream. The dimensions of all the components of valves shall be conforming to IS: 14846. The type and make of all bearings shall be indicated on the drawings and necessary arrangements for lubrication shall be provided.
- (h) Valves shall have two positions marked at the shut end of the scale, first one corresponding to the position of the gate tangential to the bore of the seating and the second position below the first, corresponding to the position of the gate as it sits on the

seating after moving a further distance equal to the depth of the seating.

- (i) All valves, spindles and hand wheels shall be positioned to give good access for operational personnel.
- (j) All Sluice valves shall be rated PN 1.0 as per IS:14846
- (k) All the hand wheels shall be arranged to turn in a clockwise direction to close the valve. The direction of rotation for opening and closing of the valve shall be indicated on the hand wheels.

All Sluice valves shall be open end tested. Bypasses for valves 400 mm and over shall be fitted with integral bypasses as follows.

400 mm nominal diameter valve - 50 mm diameter bypass

500 mm nominal diameter valve - 80 mm diameter bypass

800 mm nominal diameter valve - 100 mm diameter bypass

Each valve shall bear on their bodies as cast indications in raised letters showing.

- Size of Valve
- Year of Manufacture
- Manufacturer's Name
- Pressure rating
- Heat Number
- Valve Operating & Closing direction on hand wheel.

The serial number of valves shall be punched on the flanges distinctly and legibly on both side flanges of valve.

- (a) One spare spindle and nut shall be supplied. Spares supplied shall be new, unused, and interchangeable with the corresponding components they are intended to replace.
- (b) The material of construction of valve shall be as follows:

Item	Material of construction
Body, wedge and bonnet	SG Iron IS 1865 Gr 400/15
Spindle	SS Gr. 316
Extension spindle	SS Gr. 316
Seat rings	Bronze IS 318 Gr LTB2 / SS Gr. 316
Back seat bush	Bronze IS 318 Gr LTB2
Shoe and channel lining	SS Gr. 316 / Bronze IS 318 Gr LTB2

c. Non-Return Valve

Design requirements

- (a) Non-return valve shall be as per IS 5312. The valves shall be suitable for mounting on horizontal pipeline.
- (b) Valves shall be quick closing type with non-slam characteristics. Hydraulic passage and doors shall be designed to avoid cavitations. The pressure drop in the valve at design flow shall be limited to 0.3 mwc.
- (c) Valve body shall be designed for 1.5 times the rated pressure.
- (d) The face-to-face dimensions of valves shall conform to IS:5312.
- (e) All non-return valves shall be rated PN 1.0 as per IS:5312

Features of construction

- (a) Valves shall be of swing check type. Valves shall be quick closing type with non-slam characteristics. The non-slam characteristics shall be achieved by providing suitable combination of door and hydraulic passages without any external damping arrangement, or counterweights.
- (b) Valve flange faces shall be parallel to each other and shall be right angle to valve centerline.
- (c) Flange back shall be machined, or spot faced for proper seating of bolt head and nut. Flanges shall be drilled as per BS 4504
- (d) Valves shall be free from sharp projections, which are likely to get clogged with stringy materials. The internal parts shall be easily accessible for inspection through inspection hole.
- (e) Valves 450 mm and above shall be provided with supporting foot.
- (f) Swing door valves of size 600mm and above shall be of multidoor type.
- (g) Direction of the flow shall be clearly embossed on the valve body.
- (h) Maximum allowable leakage rate shall be 7cc/hr/mm diameter.
- (i) The material of construction of valve shall be as follows:

S. No	Component	Material of construction
1.	Body and Door	SG Iron IS 1865 Gr. 400/15
2.	Body Ring	SS AISI 316 / Bronze IS 318 Gr. LTB 2
3.	Door Ring	SS AISI 316 / EPDM Rubber / Bronze IS 318 Gr. LTB 2
4.	Bearings	Bronze/Teflon
5.	Hinge pin	High Tensile Brass/Stainless Steel

6.	External Hardware	SS 304

d. Butterfly Valve

Design Requirements

- (a) Butterfly valves shall be as per IS:13095 / equivalent international standard, tight shut off, with double eccentricity.
- (b) The time from fully open to fully closed position and vice versa shall be limited to about 2½ minutes. The valve shall be suitable for controlling flows by throttling.
- (c) Butterfly valves shall be suitable for bi-directional pressure testing with dead-tight shut off even after long period of operation of 5 years. The valves shall be of double flanged long body type.
- (d) The valves shall be electrically/pneumatically/manual operated to suit the requirement. The valve shall be free from induced vibrations. Valve shall be suitable for mounting in any position.
- (e) All butterfly valves shall be rated PN 1.0 as per IS:13095.

Features Of Construction

- (a) The disc shall be designed to withstand the maximum pressure differential across the valve in either direction of flow. The disc shall be contoured to ensure the lowest possible resistance to flow.
- (b) The valve seat shall be of integrally cast or replaceable design. When the valve is fully closed, the seal shall seat firmly so as to prevent leakage. The seat surfaces shall be machined smooth to provide a long life for the seal. All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve.
- (c) The shaft shall be designed to withstand the maximum torque that will be imposed by the operator. The shaft shall be stainless steel with stainless steel backed PTFE bearings. Disc pins shall be stainless steel. Rings shall be bi-directional self-adjusting suitable for pressure or vacuum service. Removal and replacement of seals shall be possible without removing the operating mechanism, valve shaft and without removing the valve from the pipeline. Valve shafts shall be a one-piece unit extending completely through the valve disc, or of the "stub shaft" type, which comprises two separate shafts inserted into the valve disc hubs.
- (d) All valve spindles and hand wheels shall be positioned to give good access for operational personnel.
- (e) All hand wheels shall be arranged to turn in a clockwise direction to close the valve, the direction of rotation for opening and closing being indicated on the hand wheels.

- (f) Valve shall be suitable for throttling purpose.
- (g) The valve seat shall be of integrally cast or replaceable design. When the valve is fully closed, the seal shall seat firmly so as to prevent leakage. The seat surfaces shall be machined smooth to provide a long life for the seal.
- (h) Valves shall be provided with position indicator to show the position of the disc, mounted on the driven shaft end.
- (i) All fasteners shall be set flush so as to offer the least resistance possible to the flow through the valve
- (j) Valves shall be provided with suitable stops to prevent movement of the shaft beyond the limits corresponding to fully open and fully closed position of the disc.
- (k) Valve of diameter 600 mm and above shall be provided with enclosed gear arrangement for ease of operation. The operation gear shall be such that they can be opened and closed by one man against an unbalanced head of 1.15 times the specified rating. Valve and any gearing shall be such as to permit manual operation in a reasonable time and not exceed a required rim pull of 400 N.
- (l) Rubber sealing ring shall preferably attached to disc edge by means of sectional retaining ring.
- (m) Flanges shall be as per BS 4504.

Materials of Construction

Item	Material of construction
Body	Ductile iron (S.G.Iron) (IS 1865 Gr.500/7)
Disc	Ductile iron (S.G.Iron) (IS 1865 Gr.500/7)
Shaft	Stainless Steel BS 970 Grade 431 S 29
Bearing	Stainless steel backed PTFE
Thrust pad	Ductile iron (S.G.Iron) (IS 1865 Gr.500/7)
Valve seal	EPDM
Seat ring	Stainless steel (ASTM A 240 type 316).
Gland plate / End cover	Carbon steel (IS 2062 Gr.B)
Clamping ring / segments	Stainless steel (ASTM A 240 type 316)
Gland seal & 'O' rings	EPDM
Internal & External Fasteners	Stainless steel AISI 316
Handwheel	SS AISI 304

e. Air valve

The valve shall be capable of exhausting air from pipework automatically when being filled, the air being released at a sufficiently high rate to prevent the restriction of the inflow rate. Similarly, the valve shall be capable of ventilating pipe work automatically when being emptied, the air inflow rate being sufficiently high to prevent the development of a vacuum

in the pipelines. The valve shall also automatically release air accumulating in pipe work during normal working conditions. The design shall be such that, higher the rate of flow the greater the resultant down thrust, keeping the ball 'glued' to its seat until the last drop of air is expelled from the pipe system.

Each air valve shall be provided with an isolating sluice valve with flanged end connection. The possible air velocity (inflow and outflow) must be at least 10 m/s.

Air valves shall thus be designed to automatically operate so that they will;

- (a) positively open under internal pressure less than atmospheric pressure to admit air in bulk during pipeline draining operation;
- (b) exhaust air in bulk and positively close as water, under low head, fills the body of the valve during filling operation;
- (c) not blow shut under high velocity air discharge; and
- (d) exhaust accumulated air under pressure while the pipe is flowing full of water.

All air valves shall be constructed so that internal working parts which may become necessary for repairs shall be readily accessible, removable, and replaceable without use of special tools and removing the valve from the line.

Air valves shall be of double orifice type and tamper proof unless otherwise directed by the Engineer. A buoyant rigid float shall seal the large orifice and the chamber housing shall be designed to avoid premature closing of the valve by the air whilst being discharged. Small orifice shall discharge small air volume during operation under full internal pressures.

All valve flanges shall be designed to withstand the stresses to which they would be subjected under hydraulic test. Flanges shall be machined flat with scurtings. The flanges shall be drilled in accordance with IS 1538 to suit the flanges of respective sluice valve.

Threaded connections shall conform to the specifications for tapered pipe threads for general use, National pipe threads (NPT) as per ANSI/ASME B 1.20.1.

The aperture of valves must be properly designed for which the Contractor shall submit design calculations for necessary approvals before the procurement of valves.

All air valves shall be rated PN 1.0.

All branched outlets including air valve tees will be provided with one ½" BSP coupling duly plugged for measurement of pressure in due course. The closing plug shall be in Stainless Steel (AISI 304 or equivalent) with Hex. Head and shall be provided with copper washer for sealing.

Material of construction of air valve shall comply with following requirement.

Sr. no.	Description	Material
1	Valve Body, orifice chamber cover & cowl	SG Iron IS 1865 Gr 400/15 / Epoxy coated internally
2	Small orifice floats	Stainless Steel SS 304 With rolling Seal mechanism preferred.
3	Large orifice floats	Stainless steel S.S. 304
4	Large orifice	Bronze or Stainless IS 318 – LTB-20 Steen or Gun metal IS6603-GR-04 GR-18 Ni-10
5	Small orifice plug	Stainless steel IS6603 Cr-18, Ni-10/Gun Metal BS 1400 LG
6	Large orifice seat ring	Neoprene with Gunmetal Impregnation
7	Guides for small orifice float	P.V.C.
8	Joint Ring	Rubber - Neoprene
9	Fasteners	SS 304
10	Flange	As per IS 1538

Bidders are encouraged to submit alternative design. Alternative design of air valve is subjected to approval by Engineer.

f. Dismantling joints:

Design requirements

- Dismantling joint shall be designed such that adequate space can be created by collapsing the dismantling joint, for removal and for reinstallation of adjacent valves. The Dismantling Joint shall be a self-contained flanged restrained joint fitting, including both flanged components and sufficient harness bars to withstand the imposed thrust.
- The Dismantling Joint will allow for up to 2” of longitudinal adjustment.
- All parts of dismantling joints shall be amply proportioned to take care of all stresses that may occur during installation and in operation. Dismantling joints shall have end, thrust and follower flanges and rubber sealing ring. Tie rods shall be provided for rigid fixing after installation to enable transmission of thrust. Tie rods shall be provided for minimum 30% of the holes. The Dismantling Joint shall comply with AWWA C.219.
- With the use of dismantling joints, it shall be possible to have an approximate clearance of 25 mm with the adjoining fittings.

Features of Construction

- Outside of inner sleeve and inside of outer sleeve shall be machined to close tolerances.
- Inner sleeve end shall be chamfered for easy introduction of rubber ring.

- Sleeves shall be of uniform bore and straight in axis. The flanges shall be square to the axis of sleeve. The faces of flanges shall be parallel. The bolt holes circle and outside periphery shall be concentric with the bore and bolt holes equally spaced. Bolt holes in one flange shall be located in line with those in other.
- Bolt holes on flanges shall be drilled with the help of drilling jig
- Flanges shall be machined flat faced and shall be full or spot faced on the back side. Flange thickness shall be uniform throughout. Flange periphery also shall be finished smooth. Flanges shall be as per relevant applicable standard corresponding to design pressure. The flanges of dismantling joints mating with valves shall have drilling stranded matching with that of the valve.

Materials of Construction

- (a) Body: CI IS: 210 Gr FG 200
- (b) Flanges: CI IS: 210 Gr FG 200
- (c) Seal ring: EPDM Rubber
- (d) Tie Rods, Bolts, Nuts, and washers: SS 304

Design parameters

Pressure ratings shall match the pressure rating of the pipe work in which they are installed.

g. Electric Actuator

The sluice valve on pump discharge lines and pumping main shall be operated by electric actuator and the operating mechanism shall consist of the following accessories:

- (a) AC Electric Motor.
- (b) Reduction gear unit.
- (c) Torque switch mechanism
- (d) Limit switch mechanism complete with set of limit switches and additional two spare sets for open/close position.
- (e) Hand wheel, for manual operation.
- (f) Valve position indicator.
- (g) Hand-auto lever with suitable locking arrangement.
- (h) 10 W single phase space heater in the switch compartment
- (i) Blinking light throughout the valve operation.
- (j) Junction box for terminating power and control cables.

The actuator shall be suitable for operation on 415V, 3 phase, 50 Hz power supply in the climatic conditions given in the Specification. The motor winding insulation shall confirm to class B as per relevant BS and motor shall be protected by suitable thermal overload relays. The actuator shall be capable of producing not less than 1 1/2 times the required operator torque at the required time cycle of valve operation. The transmission shaft connecting the actuator to the valve shall be provided with 2 bearings one at actuator end and one at valve end with universal couplings at suitable places. Adequate no. of switch/contacts shall be provided to meet following requirements.

Valve close/open/in operation indications

- (a) To prevent starting of motor if discharge valve is not fully closed.
- (b) To trip the motor, if the discharge valve fails to open within specified time.

Each motor shall be suitable for operation in the climatic conditions. They shall also be suitable for operating on the specified electric supply and shall satisfactorily open and close the valve under variations of electric supply specified.

The electric motors shall be of the squirrel cage type as per IS 325 with insulation to IS 1271 Class B. The windings shall be impregnated to render them non-hygroscopic and oil resistant. All internal metal parts shall be painted. The motor shall be rated for 30 minutes.

Motor shall be protected by suitable overload protection device.

The reversing contactor starter and local controls shall be integral with the valve actuator. The starter shall comprise mechanically, and electrically interlocked reversing contactors of appropriate rating fed from a 110 Volt control transformer. The common connection of the contactor coils at the transformer shall be grounded. HRC cartridge type primary and secondary fuses shall be provided.

Local control shall comprise pushbuttons for open, close and stop operations and a Lockable Local/Remote/off selector switch. The control schematics shall be subject to approval.

Internal wiring shall be of 650/1100-volt grade PVC insulated stranded copper conductor of minimum 1.5 sq. mm for control circuits and of minimum 4 sq.mm copper for the power circuit. Each wire shall be number identified at each end. The terminals shall be of stud type. Cable entries shall be suitable for PVC insulated/ sheathed, armoured cables. A separate terminal box shall be provided for the heater. A separate terminal box shall be provided for cabling to control circuits.

The actuator enclosure shall be fully weatherproof and hose proof to IP 67 and shall be fitted with an anti-condensation heater, which shall be switched off when the motor is running.

Reduction Gear Unit shall be of the totally enclosed oil bath lubricated type. The gear box shall be provided with the first charge of oil lubricants and appropriate filling and drain connections. Gearing shall be adequate to open and close the valves under full indicated maximum operating pressure differential at a speed sufficient to cover the full extent of travel.

The operator shall have a hammer-blow device to loosen stuck valve or retrieve jammed valve position. The torque switch mechanism shall function as follows to stop the motor on closing or opening of the valve, or upon actuation by the torque when the valve disc is restricted in its attempt to open or close.

The torque switch in the closing direction shall interrupt the control circuit if mechanical overload occurs during the closing cycle or when the valve is fully closed. The torque switch in the opening direction shall interrupt the control circuit if mechanical overload occurs during the opening cycle or when the valve is fully open.

The mechanism shall facilitate adjustment of the torque at which the switches are required to operate. Non-adjustable limit switches shall stop the motor and give indication when the gate has attained the fully open or closed position.

The adjustable limit switches shall have control rated 2A, 48 V DC for specified system interlock, at the desired valve position in both the opening and closing directions.

Motor operators shall be provided with clearly visible local valve position indicators mounted on the operator assembly to give an indication whether the valve is fully open, fully closed or in an intermediate position. A hand wheel of Stainless-Steel construction shall be provided for emergency operation. The handwheel drive shall be mechanically independent of the motor drive and any gearing should be such as to permit emergency manual operation in a reasonable time.

HORIZONTAL SPLIT CASE PUMPS

Pumps shall be single stage designed for continuous operation and shall have a continuously rising head characteristics without any zone of instability. The pump shall conform as per IS:1520-1980, IS:325-1996.

The pumps shall be capable of delivering not less than 150% of rated capacity at a head of not less than 65% of the rated head. The shut off head of pump shall not exceed 120% of the

rated head. The drive motor shall be continuous rising type and its rating shall be at least equivalent to the horsepower required to drive the pump at 150% of its rated discharge.

Pump casing shall be close-grained cast iron of heavy section, horizontally split, making possible complete servicing of rotating parts without breaking piping or motor connections.

Motor to pump connection shall be of the flexible coupling type. Suction passages shall be volute in form, promoting smooth entry to impeller and increased efficiency.

Impeller shall be made of bronze, double suction, enclosed type, hydraulically balanced and passages smooth-finished for minimum friction and maximum efficiency. Impeller rings shall be secured from relative movement by tongue and groove fittings.

Shaft shall be of stainless steel, protected by gunmetal sleeves extending through stuffing boxes. Stuffing boxes shall be extra deep, water sealed with renewable bushes. Shaft shall be supported in ball /journal bearings, grease lubricated, contained in easily removable housing. Pumps shall be fitted with mechanical seals, an air valve, two grease lubricators, drain plug and water seal drain connections.

Base shall be of a size suitable for the pump, motor and shaft and shall be constructed of cast iron or welded steel. Flexible coupling shall be protected by a guard mounted on the common inertia base.

The pumps shall be installed on a concrete foundation with vibration isolators as per Approved-for-Construction shop drawings.

Motor shall be energy efficient (EFF-1), totally enclosed, fan-cooled, class-F insulation. Motor shall be specially designed for quiet operation. The motor rating be such as to ensure that no overloading of the motor throughout its capacity range. Motor shall be suitable for 415±10% volts, 3 phase, 50 cycles AC, power supply.

Material construction for pumps

Sr.No	Description	MOC
1.	Casing	Cast Iron
2.	Impeller	Bronze
3.	Shaft	Stainless Steel
4.	Bearings	Heavy duty Ball/Roller Bearings
5.	Base Plate	Cast Iron/Fabricated M.S.

6.	Flanges	BS 4504
7.	Packing	Mechanical Seal
9.	Starter	DOL

Induction Motor

Performance and Characteristics

The motor shall conform to IS: 325/IS:9283 and the cable shall conform to IS:9968.

The motor shall be three phase dry induction type with non-overloading characteristics.

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

- Variation of supply voltage $\pm 10\%$
- Variation of supply frequency $\pm 5\%$
- Combined voltage and frequency variation $\pm 10\%$

The starting current of motor shall not exceed 200% of rated full load current for star/delta starting and 600% of rated full load current for DOL starting, under any circumstances.

Motors shall be suitable for full voltage direct-on-line starting or star-delta starting.

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding acceptable winding temperatures, when the supply voltage is in the range 85% of the rated motor voltage.

Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage, in either direction of rotation.

The motor vibrations shall be within the limits specified in the relevant standard.

Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

The enclosure for motor shall be IP-68.

Minimum three number thermistors in series are to be provided to sense the stator winding temperature.

Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

The power rating of the motor shall be larger of the following:

115% of the power input to the pump at duty point.

105% of the power input to the pump at 75% head.

Earthing

Earthing of the motor shall be done in accordance with the relevant provisions of IS: 3043:1966. For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

Insulation

The stator winding shall be made from high conductivity annealed copper conductor; winding insulation shall be of class-F insulation, conforming to IS: 325. The stator winding shall be of high conductivity annealed copper enamelled insulated wires conforming to IS: 4800 (Part-VII): 1970 for dry type motors.

Constructional Features

The motor shall be suitable for continuous duty as well as intermittent duty with or without full submergence of the motor.

Aluminium die cast rotor to be provided for better starting torque characteristics.

The electric motor shall be suitable for 10 starts & stops per hour.

Single phasing and overload protection system shall be provided.

The motor degree of protection shall be IP68.

Each motor shall be provided with minimum 25 m length of power & control cables and 15 m length of lifting chain.

Junction box (i.e.) for terminating power & control cables for each motor.

Induction Motor Characteristics

Performance and Characteristics

All motors shall comply with IEC 60034, 60072 and IS-325, 4029, 4722 including standards referred to therein.

Description	Unit	Particulars
Type		Squirrel cage Induction motor
Rating	kW	(*)
Rated voltage	kV	0.415
Synchronous speed	Rpm	(*)
Quantity	Nos.	(*)
Type of mounting		Horizontal/ Vertical (depending on application and process requirement)
Duty type		Continuous (S1)
Method of starting		Soft starter/ Star-Delta starter/ Direct on line (depending on application and process requirement) (#)
Type of system earthing		Effectively Earthed.
Class of insulation		F
Design ambient temperature	°C	50
Location		Indoor/ Outdoor (depending on application and process requirement)
Degree of Protection		IP55
Cooling designation		IC411
Terminal box		LHS – looking from NDE end
External cable details		1.1 kV, 3C x (*) sq. mm. Aluminium, XLPE, armoured
Space heater for motor		Required if motor rating is 30kW and above

(*) – To be furnished by Contractor. Contractor should ensure that all the equipment ratings are based on their system requirement and subject to Engineer approval.

(#) – Motors rating upto and including 5.5 KW shall be started by DOL starter ,Motor ratings above 5.5KW and upto or equal to 250 KW shall be started by Star-Delta Starter and above 250 KW shall be started by soft starter.

Motors shall be energy efficient (Category –2 or better) squirrel cage induction motors (TEFC type) with degree of protection for enclosure of IP 55. They shall be capable of starting and accelerating the load for the method of starting, as per SLD without exceeding acceptable winding temperatures, when the supply voltage is 80% of the rated voltage. Main conductor and insulation shall be non-hygroscopic and in accordance with Class F of IEC 60085.

Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

Variation in supply voltage	±10%
Variation in supply frequency	±5%
Combined voltage and frequency variation	±10%

Motors shall be capable of starting and accelerating the load with the applicable method of starting, without exceeding permissible winding temperatures, when the supply voltage is 80% of the rated voltage. Motors shall be capable of satisfactory operation at full load at a supply voltage of 80% of the rated voltage for 5 minutes, commencing from hot condition. The Power rating of the motor shall be the larger of the following:

115% of the power input to the pump at duty point.

105% of the power input to the pump between 110% to 75% head.

Motors shall withstand the voltage and torque stresses developed due to the vector difference between the motor residual voltage and the incoming supply voltage equal to 150% of the rated voltage, during fast changeover of buses. The duration of this condition is envisaged for a period of one second.

The locked rotor withstand time under hot conditions at 110% rated voltage shall be more than the starting time at minimum permissible voltage by atleast two seconds or 15% of the accelerating time, whichever is greater. The locked rotor current of motors shall not exceed 600% of full load current of motor which is inclusive of 20% tolerance. The motors shall be provided with class F insulation with temperature limited to that of class B insulation.

Motors when started with the drive imposing its full starting torque under the specified supply voltage variations shall be capable of withstanding atleast two successive starts from cold conditions and one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

Constructional Features

Motors weighing more than 25 kg shall be provided with eyebolts, lugs or other means to facilitate safe lifting.

The motor construction shall be suitable for easy disassembly and re-assembly. The enclosure shall be sturdy and shall permit easy removal of any part of the motor for inspection and repair.

The rotor bars shall not be insulated in the slot portion between the inner core laminations for squirrel cage motors.

All bearings shall be fitted with oil or grease lubricators. Motor bearings shall not be subjected to any external thrust load. Unless otherwise specified, motor bearings shall have an estimated life of at least 40,000 hrs. It shall be possible to lubricate the bearings without dismantling any part of the motor. All terminals shall be of the stud type of adequate size for the particular duty, marked in accordance with an approved standard and enclosed in a weatherproof box.

The equipment shall be thoroughly degreased, all rust, sharp edges and scale removed and treated with one coat of primer and finished with two coats of grey enamel paint.

Terminal Box

Terminal boxes shall be of weatherproof construction designed for outdoor service. To eliminate entry to dust and water, gaskets of neoprene or approved equivalent shall be provided at cover joints and between box and motor frame. It shall be suitable for bottom entry of cables. It shall be capable of being turned through 360 degrees in steps of 90 degree.

The terminals shall be of the stud type with necessary plain washers, spring washers and check-nuts. They shall be designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearances. Suitable cable glands and cable lugs shall be supplied.

Heating During Idle Period

For motors rated below 30 kW, during idle periods, the stator winding will be connected to required single phase, 50 Hz, AC supply for heating and elimination of moisture. The supply will be connected between any two terminals.

Motors rated 30kW and above shall have space heaters suitable for 230V, single phase, 50 Hz, AC supply. Space heaters shall have adequate capacity to maintain motor internal temperature above dew point to prevent moisture condensation during idle period. The space heaters shall be placed in easily accessible positions in the lowest part of the motor frame.

Earthing Pad

Two independent earthing pads of non-corrodible metal shall be welded or brazed at two locations on opposite sides complete with suitable bolt and washers for earthing. These earthing pads shall be in addition to earthing stud provided in the terminal box.

Rating Plate

The following details, in addition to those specified in applicable standards shall be included on the rating plate.

Rated voltage, kW rating, frequency, efficiency, power factor, temperature rise of windings in degree centigrade at rated load, and ambient conditions.

Type of bearings, recommended lubricant, lubricating interval & re-lubricating quantity.

Tests

Motor shall be subjected to all the type test (one from similar rating of each lot) and routine tests as per applicable standard in the presence of the Engineer. Copies of test certificates for all brought out items shall be furnished at the time of inspection for the Employer's approval. The Contractor shall ensure to use calibrated test equipment / instruments having valid calibration test certificates from standard laboratories traceable to National / International standards.

Sluice Gate

Design Requirements and Construction Features

The construction of sluice gates shall be in accordance with the specification and generally as per IS:13349-1992. All sluice gates shall be of the rising spindle type.

Frame

The frame shall be of the flange back type and shall be machined on the rear face to bolt directly to the machined face of the wall thimble.

Seating Faces

Seating faces shall be made of full width, solid section; dove-tail strips of stainless steel. They shall be secured firmly by means of counter sunk fixings in finished dove-tail grooves in the frame and slide faces in such a way as to ensure that they will remain permanently in place, free from distortion and loosening during the life of the sluice gates.

Wedging Devices

Sluice gates shall be equipped with adjustable side, top and bottom wedging devices as required providing contact between the slide and frame facing when the gate is in closed position.

Lifting Mechanism

- Sluice gate shall be operated through suitable lifting mechanism which shall incorporate suitable gearing if required, to keep the torque requirement within 7 kgf.m.
- Lifting mechanism shall incorporate a strong locking device suitable for use with a padlock or padlock and chain.
- Lift mechanism shall be provided with a suitable position indicator to always show the position of the gate.

Wall Thimbles

The cross section of the thimble shall have the shape of the letter 'F'.

Lifting Lugs

Adequate lifting lugs shall be provided for all gates.

Flush Bottom Seal

- When sluice gates are provided with flush bottom seals, the wedging device and facing along the bottom edge of the slide and frame shall be omitted.
- A solid square cornered; resilient rubber seal shall be provided on the bottom facing of slide. The seal shall be securely fastened to the bottom face of the slide by a retainer bar and corrosion resistant stainless-steel fasteners. The top surface of the bottom facing of frame shall be flush with invert of the gate opening. Bottom facing of the slide shall be accurately machined to make contact with the seal when the slide is closed.
- 1 No. of electric actuator for closing and opening of sluice gates shall be provided, so that the closing and opening operation time is minimised.
- Suitable arrangement shall be made on all the sluice gates or actuators such that the actuator is capable of operating all sizes of sluice gate, under this contract.
- The material of construction of sluice Gate shall be as follows:

Sr.No	Component	Material
1	Wall Thimble	Cast Iron: IS 210 Gr. FG 200

Sr.No	Component	Material
2	Frame and Slide	Cast Iron: IS 210 Gr. FG 200
3	Seating faces	Stainless Steel: ASTM Countersunk fixing A276 type 316
4	Wedge	Stainless Steel: ASTM A743 CF8M or SS316
5	Stem	Stainless Steel: ASTM extension A276 type 316
6	Stem nut	Stainless Steel: ASTM A743 CF8M
7	Stem Coupling	Stainless Steel: ASTM A276 type 316
8	Fasteners, anchor	Stainless Steel: ASTM bolts and nuts A276 type 316
9	Lifting mechanism, Pedestal gear house cover and stem guide	Cast Iron: IS 210 Grade FG 200
10	Lift nut	Bronze: ASTM B 148 (CA952, CA954 or CA958)

Electrically Operated Hoists

- Electric hoists shall be complete with hoisting motor, cross travel motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather & dust-proof push button station, contractor panel, all wiring, limit switches, etc.
- Electric hoists shall conform to IS:3938 and shall be suitable for outdoor application. All the parts of the hoist shall be designed to withstand surrounding atmospheric conditions without any deterioration.
- Rope drums shall be either cast iron, cast steel or mild steel to sustain concentrated loads and compressive strength caused by the wound rope resulting from rope pull. Drums shall be machine grooved right and left with grooves of a proper shape for the rope used.
- Gears shall be machine cut from solid cast or forged steel blanks or shall be of stress-relieved welded steel construction or built-up from steel billets and welded together to form one piece gear section. Hoist ropes shall be extra flexible, improved plough steel rope with a well lubricated hemp core and having six strands of 37 wires per strand with minimum ultimate tensile strength of 1.6×10^6 KN / m².
- Hooks shall be solid, forged, heat treated alloy or carbon steel of rugged construction of the single hook type and provided with a standard depress type safety latch. Swivelling hooks shall be mounted on thrust bearing & shall swivel freely through 360° with full lead.
- Hoisting motor shall be equipped with electrically released, spring set, friction shoe type brakes having torque capable of holding 125% of the full rated hook load. Brake shall apply when either the motor controller or the main power switch is in 'OFF' position or in the event of power failure/

- Drive motors shall be designed for frequent reversal, braking and acceleration and shall be as per IS:325. Pendant control switch, controllers and resistors, controls, electrical protective devices, cables and conductors, earthing guards etc. shall be as per IS:3938. Limit switches shall be provided for over-hoisting and over-lowering.
- The electric hoists shall be of Class II duty.
- 25% overload test, speed tests, limit switch tests and brake test shall be conducted for the hoist and trolley at manufacturer's works.

Fire Extinguishers

- Portable fire extinguishers are to be provided for all units/buildings as per the requirement of Tariff Advisory Committee (TAC) guidelines or meeting the requirement of local regulations whichever is more stringent.
- All the extinguishers shall be as per IS:15683.

Propeller Exhaust Fan

- The exhaust fan shall comply with IS 2312.
- The blades shall be of mild steel / carbon steel / cast aluminium and properly balanced so as to avoid noise and vibration.
- The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.
- Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.
- The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G carbon steel.

Ductile iron pipes and fittings

The DI pipes will be centrifugally cast (spun) Ductile Iron pipes for Water confirming to the IS 8329: 2000 / ISO 2531-2009 /BS EN 545 - 2010. The pipes used will be either with push on joints (Rubber Gasket Joints) or Flanged joints as required. The class of pipe to be used shall be of the class K-9 in pumping system and class K-7 in gravity system.

The pipes shall be externally coated with bitumen as per appendix C of IS 8329 and have factory provided cement mortar lining in the inside as per the provisions of Appendix B of the IS 8329. The pipes will be supplied in standard length of 5, 5.50 and 6 meters with suitably rounded or chamfered ends. Each pipe of the push on joint variety will also be supplied with a rubber / EPDM gasket. Any change in the stipulated lengths will be approved by the Engineer. The gaskets will conform to the IS 5382:1998/ISO Standard.

The specials and gaskets should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the pipe manufacturer. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his/subcontractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products. The flanged joints will conform to the Clause 6.2 of IS 8329/ISO Standard.

The pipes will be subjected to following tests for acceptance:

- Dimensional check as per Clause 13 and 15 of IS 8329
- Mechanical Test as per Clause 10 of IS 8329
- Hydrostatic Test as per Clause 11 of IS 8329
- The test reports for the rubber gaskets shall be as per acceptance tests of the IS: 5382 and will be in accordance to Clause 3.8.

The sampling of DI pipes shall be as per the provisions of the IS: 8329.

All pipes will be marked as per Clause 18 of IS 8329 and shown as below:

- Manufacturer name/ stamp
- Nominal diameter
- Class reference
- A white ring line showing length of insertion at spigot

The pipes should be preferably transported by road from the factory and stored as per the manufacturer specifications to protect damage. Factory test shall be as per IS:8329/ISO standard.

All the fittings for DI pipes shall be of class K-12 and conform to IS:9523-2000.

Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts. One rubber ring to be supplied for each socket, the rubber ring shall conform to IS:12820-2010 and IS: 5382. The lubricant for ductile iron pipes and specials has to have the following characteristics:

- must have a paste like consistency and be ready for use
- has to adhere to wet and dry surfaces of DI pipes and rubber rings to be applied in hot and cold weather; ambient temperature 0 - 50 °C , temperature of exposed pipes up to 70 °C
- must be non toxic
- must be water soluble
- must not affect the properties of the drinking water carried in the pipes
- must not have an objectionable odour
- has to inhibit bacterial growth
- must not be harmful to the skin
- must have a shelf life not less than 2 years

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

Puddle Flanges

Puddle flanges shall be fitted to pipes where the structure through which they pass is required to take thrust resulting from the pipe. Puddle flanges shall also be fitted where a water barrier is required. All puddle flanges shall be clearly shown on the drawing and the resultant thrust clearly indicated. Puddle flanges shall only be fitted with the Employer's Representative prior to approval.

Dewatering Pump

- The pump motor shall be suitable for working with or without submergence in water. The motor rating shall be more than the maximum power required by the pump.
- Pump shall be vertical, centrifugal, submersible, non-clog & single stage type. The pump set shall be portable with necessary hooks.
- The pump shall have double mechanical seals to prevent ingress of moisture in to the motor. The pump impeller shall be mounted on the extended shaft of the motor. The pump shall be supplied with flexible hose pipe of 80 mm dia. & 50 m length. Suitable cable of 50 M length shall be supplied with the pump.

Sump Drainage Pumps

Sump drainage pumps shall be of the open impeller centrifugal type vertically mounted close coupled to their fully submersible electric drive motors.

Sump pumps of 1.5 kW and under shall incorporate an integral level detector, control and motor starter and shall be powered only with a suitably fused three phase or single-phase low voltage supply and with supply isolation at the building distribution board.

Sump pumps over 1.5 kW shall be controlled and started from the building distribution board and be fed with a 3-phase supply. Control shall be via adjustable float level switches mounted adjacent to the pump.

The pumps shall be supplied with all necessary discharge pipe work, including non-return and isolating valves and suitable lifting gear for lowering and removing the pump from the sump. Pumps weighing 40 kg and more shall be lowered in the sump via guide rails and be located to their respective discharge pipe work with an angle flange connection and self-locating clamps.

The pump impeller shall be designed to pass solids of sizes which pass through the inlet ports of the pump and shall be capable of pumping solids of up to 20 mm diameter.

UNDERGROUND SERVICE RESERVOIR

Pipes and specials

All Pipes & specials for ground service reservoir shall be of Ductile Iron. The DI pipes will be centrifugally cast (spun) Ductile Iron pipes for Water confirming to the IS 8329: 2000 / ISO 2531-1998 /BS EN 545 (latest). The pipes used will be either with push on joints (Rubber Gasket Joints) or Flanged joints as required. The class of pipe to be used shall be of the class K-9.

The pipes shall be externally coated with bitumen as per appendix C of IS 8329 and have factory provided cement mortar lining in the inside as per the provisions of Appendix B of the IS 8329. The pipes will be supplied in standard length of 5-, 5.50- and 6-meters length with suitably rounded or chamfered ends. Each pipe of the push on joint variety will also be supplied with a rubber EPDM gasket. Any change in the stipulated lengths will be approved by the Engineer. The gaskets will conform to the IS 5382:1985/ISO Standard.

The specials and gaskets should also be supplied by the manufacturer of the pipes. They should preferably be manufactured by the manufacturer of the pipes. In case they are not, it will be the responsibility of the manufacturer of the pipes to have them manufactured from a suitable manufacturer under its own supervision and have it tested at his / subcontractors premises as per the contract. The pipe manufacturer will however be responsible for the compatibility and quality of the products.

The flanged joints will conform to the Clause 6.2 of IS 8329/ISO Standard.

The pipes will be subjected to following tests for acceptance:

- (a) Visual and dimensional check as per Clause 13 and 15 of IS 8329/ISO standard
- (b) Mechanical Test as per Clause 10 of IS 8329/ ISO standard
- (c) Hydrostatic Test as per Clause 11 of IS 8329/ ISO standard
- (d) The test reports for the rubber gaskets shall be as per
- (e) acceptance tests of the IS: 5382 and will be in accordance with Clause 3.8.

The sampling of DI pipes shall be as per the provisions of the IS: 8329 / ISO standard. All pipes will be marked as per Clause 18 of IS 8329 and shown as below:

- (a) Manufacturer name/ stamp
- (b) Nominal diameter
- (c) Class reference
- (d) A white ring line showing length of insertion at spigot

The pipes should be preferably transported by road from the factory and stored as per the manufacturer specifications to protect damage. Factory test shall be as per IS: 8329/ISO standard. All the fittings for DI pipes shall be of class K9 .Flanged fittings shall be supplied with one rubber gasket per flange and the required number of nuts and bolts. One rubber ring to be supplied for each socket, the rubber ring shall conform to IS: 12820 and IS: 5382. The lubricant for ductile iron pipes and specials has to have the following characteristics:

- (a) must have a paste like consistency and be ready for use
- (b) has to adhere to wet and dry surfaces of DI pipes and rubber rings to be applied in hot and cold weather; ambient temperature 0 - 50 °C , temperature of exposed pipes up to 70 °C
- (c) must be non toxic
- (d) must be water soluble
- (e) must not affect the properties of the drinking water carried in the pipes
- (f) must not have an objectionable odour

- (g) has to inhibit bacterial growth
- (h) must not be harmful to the skin
- (i) must have a shelf life not less than 2 years

All the DI fittings shall be properly packed with jute cloth. Rubber rings shall be packed in polyethylene bags. Rubber rings in PE bags and nuts, bolts etc. shall be supplied in separate jute bags.

Railings

Hand railing around the platforms, Balcony, stairs and landing shall be on both sides consisting of 50 mm diameter medium B class GI pipes in two rows (one at the top and other at middle level) and 1000 mm high vertical pipe at 1500 mm c/c (atleast two vertical pipes are to be provided whenever distance is less) with all accessories like elbows, tees etc. including welding, threading and embedding in cement concrete floor with two nos. of iron 65 X 65 X 6 mm size hold fasts. Railing shall be protected against corrosion after welding.

Ladder

MS iron ladder, 450 mm wide made up of 65mm X 65 mm X 6 mm MS angle iron and 20 mm MS bars welded at 300 mm c/c shall be provided. The ladder from top dome to the bottom of water retaining structure be 450 mm wide made up of 65 mm X 65 mm X 6 mm MS angle iron and 20 mm MS bars welded at 300 mm c/c.

Water level indicators

Water level indicator consists of an approved copper float and iron counterweight and connected by 4 mm thick steel flexible wire passing over aluminum pullies fixed on GI medium class pipe which is installed as indicated in the drawing shall have to be provided. The scale shall be calibrated in centimeters and should consist of MS sheet 20 gauge fixed over wooden plank with an MS angle iron frame of 35 mm X 35 mm X 5 mm and painted with white enamel bases, letters in black and red.

Ventilator

A ventilator of 1200 mm diameter and 600 mm height consisting of six nos. columns of 100 X 100 mm covered on the top with 100 mm to 75 mm thick c/c slab and 24-gauge square mesh on wire gauge of SS.

Water meter

Water meters of approved make and design shall be supplied and installed at required. The water meters shall meet with the approval of the local supply authorities. Suitable valves & chambers to house the meters shall also be provided along with the meters.

All meters shall conform to Indian Standard IS 779-1978 or IS 2273-1981 and of an approved manufacturer. Where called for water meter shall be located in masonry chamber of appropriate size as indicated.

Float valves

The design, materials, construction features, manufacture, inspection and testing of valves shall conform to the latest applicable codes and standards.

Mechanical float type valves will be at the inlet pipeline connection to the reservoir, which will close down once the full level of the reservoir has been reached. Also, it will get open once the level in the reservoir goes down from the preset level. The valve shall ensure tight closing with a upward movement of reservoir.

The auxiliary float valve shall be installed at the bottom of the inlet. It shall be of copper alloy, Corydon pattern with rough body and screwed male ends. The material of ball shall be copper and shall be installed at the bottom of the reservoir. The size of the float and the length of the lever must ensure a tight closing.

Material used in manufacture of valve shall be of tested quality. The materials of construction of main components of the valves shall be as follows.

Part No	Name of Part	Material	Specification
1.	Body	Cast iron	ISD 210, FG 200
2.	Valve	Cast iron	ISD 210, FG 200
3.	Bottom plate	Cast iron	ISD 210, FG 200
4.	Washer plate	Gun metal	IS 318
5.	Seat ring	Gun metal	IS 318
6.	Link	Gun metal	IS 318
7.	Liner	Brass	-
8.	Eye Bolt for Valve	Brass	-
9.	Lever fork	Mild steel	-
10.	Valve face	Synthetic rubber	-
11.	Float ball	Copper	-

ELECTRIC ACTUATOR

Electric actuator for closing and opening of each sluice gate shall be provided as per the process requirement mentioned elsewhere in this document, so that the closing and opening operation time shall be maximum of 10 minutes.

- The local control shall be protected by a Lockable cover.
- The Actuator shall be adequately sized to operate all the penstocks and be continuously rated to suit the modulating control required. The Gear box shall be Oil or Grease filled, and capable of installation in any position. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.
- The Actuator shall be capable of producing not less than one and half times the required torque and shall be suitable for at-least 15 minutes continuous operation.
- The Actuator starter shall be integrally housed with the Actuator in robustly constructed and totally enclosed weatherproof housing. The motor starter shall be capable of starting the motor under the most severe conditions.
- The starter housing shall be fitted with contacts and terminals for power supply, remote control and remote positional indication.
- Each starter shall be equipped as follows:
 - i 2No.Three phase magnetically operated line contactors with no-volt release and electrical and mechanical interlock.
 - ii 1 No. Three phase thermal cut-out device.
 - iii 1 No. control circuit transformer fully protected by fuses on primary and secondary circuits.
 - iv 1 No. Set of “open”, “close” and “stop” buttons.
 - v 1 No. Local-off-Remote switch with padlocking facilities.
 - vi 1 No. set of Torque and Limit switches for “open” and “Close” positions.
 - vii 3 No. sets of Auxiliary limit switches in each direction.
 - viii Gate position indicator and Hand wheel for Manual operation.
 - ix Reduction Gear unit.

D 5. SEWERAGE SYSTEM

CODES

Sr. No.	Code or Standard	Description
1.	Manual for Sewage collection system	CPHEEO Manual for sewerage, sewage treatment and Drainage- MoUD, GoI
2.	SP 7	National Building Code of India
3.	SP 35:1987	Handbook on water supply & drainage
4.	IS 1172 :1993	Code of Basic requirements for water supply, drainage and Sanitation
5.	IS 456-2000	Code of Practice for plain and reinforced concrete
6.	IS 13920-1993	Detailing of reinforced concrete structures subjected to seismic forces
7.	IS 1786-1985	High strength deformed steel bars and wires for concrete reinforcement
8.	IS: 8329-2000	Centrifugally Cast (spun) ductile iron pressure pipes for water, gas and sewage
9.	IS:12288-1987	Code of practice for use and laying of ductile iron pipes
10.	IS: 5382-1985	Specification for Rubber sealing rings for gas mains, water mains and sewers.
11.	IS: 8112	Specification for 43 Grade ordinary Portland cement.
12.	IS: 638	Specification for rubber and insertion jointing.
13.	IS: 3658-1981	Code of practice for liquid penetrant flaw detection
14.	IS 14845: 2000	Resilient Seated Cast Iron Air Relief. Valves for Water Works IS 14846Sluice valves for water works purpose (50 to 1200 mm size)
15.	I.S. 226-1975	Specification for Structural steel
16.	IS: 9523	Ductile iron fittings for pressure pipes for water, gas and sewerage
17.	IS: 1500	Code for Hardness test for DI pipes
18.	IS 7634 Part-2	Code of practice for plastic pipework for potable water supplies –Laying and jointing of polyethylene pipes
19.	IS 8360	Fabricated high Density polyethylene (HDPE) fittings for potable water supplies
20.	IS 8006	Injection-molded HDPE fittings for potable water supplies
21.	IS 1726: 1991	Cast iron manhole covers and frames -specification
22.	IS 3764-1966	Safety code of Excavation works and related Drilling Operations
23.	IS 14333- 1995	HDPE pipes for sewerage application
24.	IS 12592:2002	Specification for Precast RCC/ SFRC Manhole Frame & cover
25.	IS 4111-1986 Part 1 IS 5455-1997	Specifications for manholes

Sr. No.	Code or Standard	Description
	IS 4883-1988.	
26.	IS 8008	Injection-molded HDPE fittings for potable water supplies
27.	IS 10552:1983	Buckets to be used in power driven buckets type sewer cleaning machine
28.	IS 10595:1983	Requirement for power driven bucket type sewer cleaning machine
29.	IS 11117:1984	Requirement for power driven rodding machine for sewers
30.	IS 11387:1985	Requirement for high pressure jetting machine for sewer cleaning
31.	IS 11397:1985	Attachment tools for power driven rodding machine
32.	IS 11972:1987	Code of practice for safety precautions to be taken when entering a sewage system
33.	IS 14846:2000	Sluice valves for water works purposes (50 to 1200 mm size)
34.	IS 1726 (1991) Part I to Part VIII	Specification for cast iron manhole covers and frames
35.	IS 2685:1971	Codes of practice for selection, installation and maintenance of sluice valves
36.	IS 2906:1984	Specification for sluice valves for water works purposes (350 to 1200 mm size)
37.	IS 3950:1979	Surface boxes for sluice valves
38.	IS 5455: 1969	Specification for cast iron steps for manholes
39.	Advisory on "Recent trends in technologies in sewerage systems	Guidelines for preparation of DPRs for water supply system by MoUD, 2013
40.	Advisory note on improving Urban Water Supply & Sanitation Services	Guidelines for preparation of DPRs for water supply system by MoUD, 2013

Relevant International Standards for Design and Construction

Sr. No.	Code or Standards	Description
1	ISO: 10803-1997	Design method for ductile iron pipes
2	ISO: 2531-1991	Ductile iron pipes, fittings and accessories for pressure pipelines.
3	ISO: 4179-1985	Ductile iron pipes for pressure and non-pressure-Centrifugal cement mortar lining – General requirements.
4	BS: 3416	Bitumen based coatings for cold application, suitable for use in contact with Potable water.
5	ISO: 8179-1995	Ductile iron pipes-External coating-Part-1 Metallic Zinc with finishing layer.
6	ISO: 4633-1996	Rubber seals-Joint rings.

Sr. No.	Code or Standards	Description
7	AWWA C600	Installation of ductile iron water mains and their appurtenances
8	AWWA Manual M41	Ductile Iron Pipe and Fittings (Third Edition)

PARTICULAR SPECIFICATION

EXCAVATION

Before excavating the trench the alignment of pipeline shall be approved by Engineer. The excavation of trenches and pits for manholes / chambers shall be carried out in accordance with the specification specified in the earlier sections and shall be done such that it does not get far ahead of laying operation as approved by Engineer. For further details, detailed earthwork specifications, mentioned in earlier sections shall be referred to.

SAFETY MEASURES TO BE FOLLOWED WHILE EXCAVATION OF TRENCHES

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, red lanterns and guards as required shall be placed and maintained during the progress of construction work until it is safe for the traffic to use the roadways. The Contractor shall provide signboards at salient points in streets and keep men to guide the traffic at his own cost. The relevant Indian Standards and the rules and regulations of local authorities in regard to safety provisions shall be observed. Suitable fencing shall be provided along the sides of trenches and pits. The posts of fencing shall be of timber securely fixed in the ground not more than 3m apart and they shall not be less than 75 mm in diameter or less than 1.2 m above the surface of the ground. There shall be two rails, one near the top of the posts and the other about 50mm above the ground and each shall be of 50 mm to 70 mm in diameter and sufficiently long to run from post to post to which it shall be bound with rope. The method of projecting rails beyond the posts and tying them together where they meet will not be allowed on any account. All along the edges of the excavated trenches a bank of earth about 1.2 m high shall be formed where required by engineer for further protection.

The lighting, barricading, guarding of the trenches by watchmen shall be done by the contractor at his cost. At every 30 meters interval and at every change in the gradient, sight rails shall be provided and fixed by the contractor at his own cost. The sight rails and boning rods for checking the excavation and inverts of the pipes shall be of the quality approved by the Engineer. At every 15 meters interval, blank board shall be provided by the contractor at his own cost.

- Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than $[\text{External diameter of pipe in mm} + 600 \text{ mm}] + [400 \text{ mm for every 1500 mm Depth of cutting}]$ or as specified in the cross section Drawing in case there is any difference, the latter shall prevail).
- In case additional width is required it shall be provided only in the top portion from the ground level up to 300 mm above the crown of pipe. If any extra width is provided in the area below this portion, Contractor shall have to provide remedial measures in the form of lime concrete or rubble masonry or otherwise at the discretion and to the satisfaction of Engineer.

BEDDING

The pipe bedding should be placed so as to give complete contact between the bottom of the trench and the pipe. The bedding shall be provided as per the drawing. However, the bottom face / trench bed where pipe shall be placed shall be compacted to provide a minimum compaction corresponding to 95% of maximum dry density. The type of bedding viz. granular bedding, concrete cradle – PCC, RCC, concrete encasement, etc. shall be as per detail provided in the drawings and as per the directions of Engineer In Charge.

GRANULAR BEDDING

Where pipes are laid with a granular bed, appropriate bedding material shall be placed carefully over the full trench width without segregation. The material shall be spread and thoroughly compacted by approved mechanical means in successive uniform layers each not exceeding 150mm compacted thickness to produce a uniform bed to the required gradient. Where plate vibrators are used, there shall be a minimum of one pass for crushed stone and two passes for sands. Hand tamping will only be permitted where insufficient space is available to allow the use of mechanical plant. The minimum thickness of compacted granular material shall be as follows:-

150mm (minimum 100mm under sockets) for pipes not exceeding 300mm nominal diameter, except when trench is in rock.

200mm (minimum 100mm under sockets) for pipes greater than 300mm nominal diameter, or all pipes when trench is in rock.

The pipes shall then be set evenly on the bed, great care being taken to ensure uniform support for the entire length of the pipe. Pockets in the bedding shall be formed at each pipe joint to permit jointing to be carried out without the sleeve or socket of the pipe joint bearing on the bedding material and without bedding material entering the joint.

After the pipeline alignment and joints have been inspected and approved by the Engineer, the water testing of the pipeline satisfactorily completed, and, where appropriate, the annular gap at each pipe joint sealed, each joint pocket shall be carefully filled with granular material and thoroughly compacted up to the same level as the top of the bedding. Granular bedding material of the same type shall be placed on both sides of the pipeline in successive uniform layers not exceeding 150mm thick and compacted according to one of the methods given in below Table as agreed with or directed by the Engineer. Care shall be taken to ensure that no cavities remain under the pipe, and that the pipes are not displaced by differential pressure from either side. When placing and compacting surround material the Contractor shall take care not to displace or damage the pipes. The tipping of surround material from ground levels directly onto the pipes shall not be permitted.

Table showing Granular Surround - Compaction Requirements

Surround Material	Max. Layer Thickness mm	Alternative Methods (Number of Passes of Compaction Plant)		
		Hand Rammer	Vibrating Plate	100kg power Rammer*
Crushed Aggregate	150	2	1	2
Sand	75	3	2	4

* not to be used above springing level

Unless otherwise detailed on the Drawings for pipes with a full granular surround, the granular material shall extend up to a minimum height of 300mm over the crown of the pipes. For rigid pipes unless otherwise detailed, the granular material shall extend up to the springing level of the pipe. The surround shall be completed by careful placing of selected excavated material in layers not exceeding 150mm thick, thoroughly compacted on both sides of the pipeline to a level at least 300mm above the crown of the pipes.

For pipelines of 600mm diameter or greater the bed should be prepared ahead for approximately two pipe lengths whilst two pipes are being laid and the previous two pipes are receiving side filling. For pipelines less than 600 mm diameter the lengths of each stage shall be agreed with the Engineer. If the Contractor wishes to use any other method of laying pipes in granular bedding or surround he must submit his proposals in writing to and obtain the approval in writing from the Engineer well in advance of the date when he wishes to perform the work.

CONCRETE BEDDING

Concreting shall be carried out in accordance with specification given in the earlier sections. Concrete shall be of grade M15 unless otherwise detailed on the Drawings. The minimum

thickness of concrete between the bottom of the pipe and the trench shall be $0.25 \times$ nominal pipe diameter, subject to 150mm minimum, with a minimum 100mm beneath sockets.

The pipes shall be set to correct alignment as detailed below:-

The Contractor may use rectangular concrete blocks (two per pipe) made of grade M15 concrete, cast at least 7 days before use, together with pairs of approved hardwood wedges of the same width as the blocks in order to align and support the pipe before concreting. The blocks and wedges shall be of sufficient size and suitably founded on the bottom of the trench to support the pipe adequately without settlement or movement at any stage. The blocks and wedges should be placed near the end of each pipe length and should be left undisturbed during jointing of subsequent pipes and during construction, although the wedges should be removed during placing of concrete.

Blocks may have thin tie wires cast in to assist in holding down the pipe when the concrete surround is being mechanically vibrated. After approval of the joints and satisfactory testing of the pipeline a transverse flexible joint shall be formed by insertion of a template of compressible joint filler consisting of bitumen impregnated insulating board as per BS 1142 Part 3 or other equally compressible material shaped exactly to the pipe and full extent of the concrete cradle or surround. Unless otherwise detailed on the drawings the thickness of this flexible joint shall be a minimum of 25mm.

For spigot and socket pipes, the flexible joint in the concrete shall be aligned with the face of the socket. For sleeve type and flexible mechanical joints, the flexible joint shall be aligned with one end of the sleeve or mechanical joint. In certain cases, a flexible joint may be required at both ends of the sleeve or mechanical joint. These instances may be as shown on the Drawings or as directed by the Engineer in Charge. The concrete infill for flexible mechanical joints shall only be placed after the application of the specified protection materials to the joint. No steel reinforcement shall pass through the flexible joint.

Concrete for beddings, surrounds and joint infill shall be placed carefully and uniformly, suitable measures being adopted to ensure that the pipeline is not displaced by differential side pressure or by flotation. Concrete shall be properly compacted with particular care being taken to ensure that no cavities are left underneath the pipe.

The concrete shall provide a minimum cover to the pipe of 150mm for surrounds. Concrete beds to pipes of all diameters and surrounds to pipes of one metre diameter or less shall be poured in a single operation. Concrete surrounds to pipes over one metre diameter shall

normally be poured in two lifts, with a horizontal joint not more than 100mm below the crown of the pipe. Concrete shall be prevented from entering pipe joints. Formwork shall be used for all vertical faces and faces sloping more steeply than 1 vertically to 2 horizontally. Side forms should not normally be required, if trench widths specified are such that the concrete bedding / surround will extend the full width of the trench.

All formwork used for forming the concrete bedding shall be removed, unless the written approval of the Engineer is given to leave it in place for safety or similar reasons. Where side forms have been required backfilling shall be in accordance with the standard specifications. The bedding and surround shall be completed by careful placing of selected excavated material in layers not exceeding 150mm thick, thoroughly compacted by hand on both sides of the pipeline to a level at least 300mm above the crown of the pipes. As this material is placed and compacted in the trench, the supports to the sides of the trench shall be concurrently partly withdrawn so that there are no voids or un-compacted zones.

Except where otherwise specified or instructed by the Engineer, no traffic load may be imposed upon the trench within 72 hours of placing of concrete cradle or surround. If the Contractor wishes to use any other method of laying pipes in concrete cradle or surround, he must submit his proposals in writing to and obtain the approval in writing from the Engineer well in advance of the date when he wishes to perform the work.

COMPACTION

Vibratory methods shall be used for compaction. Compaction within distances of 15 cm to 45 cm from the pipe shall be usually done with hand tempers. The backfill material shall be compacted not less than 95% of maximum dry density.

BACK FILLING

Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipeline. The tamping around the pipe shall be done by hand or other hand-operated mechanical means. The water content of the soil shall be as near the optimum moisture content as possible. Filling of the trench shall be carried out simultaneously on both sides of the pipe in such a manner that unequal pressure does not occur. Backfilling shall be done in layers not exceeding 30 cm. Each layer shall be consolidated by watering, ramming, care being taken to avoid damage to the pipeline. In case of the mild steel pipes/specials, the spiders provided during assembly and

welding shall be retained until the trench is refilled and consolidated. Where timbers are placed under the pipeline to aid alignment, these timbers shall be removed before backfilling.

The contractor is requested to provide the method of Backfilling compaction test and evaluation value and obtain the approval from the engineer.

Backfilling should be placed in layers not exceeding 15cm thickness per layer, and should be compacted to a minimum of 95% maximum dry density. The refilling should be done on both sides of pipe together & height difference in earthfill on each side should not be more to cause lateral movement of pipe.

Most coarse-grained soils are acceptable. This may comprise of gravel or sand. However silty sand, clayey sand, silty and clayey gravel shall not be used unless proposed to be used in conjunction with gravel or clean sand.

It is very important that the pipe zone backfill material does not wash away or migrate in to the native soil. Likewise, potential migration of the native soil in to the pipe zone backfill must also be prevented.

Heavy earth moving equipment used for backfilling should not be brought until the minimum cover over the pipe is 90 cm in the case of wide tracked bulldozers or 120 cm in the case of wheeled roaders or roller compactors.

DEWATERING

During the excavation, if subsoil water is met with, CONTRACTOR shall provide necessary equipment and labourers for dewatering the trenches. The CONTRACTOR shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by the ENGINEER-IN-CHARGE. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer/drain, the CONTRACTOR shall take necessary permission from the local authorities.

RCC PIPES AND SPECIALS:

Reinforced cement concrete pipes used shall confirm to IS 458-1988 (with ISI mark as per IS 783:1985] with Spigot & socket ended pipes of NP-3 class. Rubber rings used for joining of these pipes shall be as per type 2 of IS: 5382

TOLERANCES:

The following tolerances shall be permitted:

SNo.	Dimensions	Tolerances
i)	Overall length	$\pm 1\%$ of standard length
ii)	Internal diameter of pipes:	
	a) Up to and including 300 mm	± 3 mm
	b) Over 300 mm and up to and including 600 mm	± 5 mm
	c) Over 600 mm	± 10 mm
iii)	Barrel wall thickness	
	a) Up to and including 30 mm	+2mm-1mm
	b) Over 30 mm up to and including 50 mm.	+3mm-1.5mm
	c) Over 50 mm up to and including 65 mm.	+4mm-2mm
	d) Over 65 mm up to and including 80 mm.	+5mm-2.5mm
	e) Over 80 mm up to and including 95 mm.	+6mm-3mm
	f) Over 95mm	+7mm-3.5mm

HANDLING AND LAYING OF PIPES:

- Pipes shall be laid and jointed in accordance with all relevant recommendations of the manufacturer. Any variations between the manufacturer's recommendations and this Specification shall be highlighted in the Contractor's Method Statements and a ruling will be given with the approval. All pipe laying shall be performed by experienced and competent pipe layers.
- The line of the pipe shall be set out and agreed with the Engineer well in advance of the excavation. Surface stripping, excavation, pipe laying, backfilling and reinstatement shall follow each other without undue delay or interval between these activities.
- Reasonable care shall be exercised in loading, transporting and unloading of concrete pipes. Handling shall be such as to avoid impact. Gradual unloading by inclined plane or by chain block is recommended.
- If the sides of the trench are not vertical, the toes of the side slopes shall end at the top the pipe, and practically vertical sided trench shall be dug from these down to the sub grade.
- Trench shall be of sufficient width to provide a free working space on each side of the pipe. The free working space shall be, preferably, not more than one third of the diameter of the pipe and not be less than 15cm on either side.
- Pipes shall be lowered into the trenches carefully. Mechanical appliances may be used.

- If concrete cradle bedding is used, the depth of concrete below the bottom of the pipe shall be at least one-fourth of the internal diameter of the pipe subject to a minimum of 10 cm and a maximum of 30 cm.
- The concrete shall extend up the sides of the pipe at least to a distance of one fourth of the outside diameter for pipes 30 cm and over in diameter. The pipe shall be laid in this concrete bedding before the concrete has set.
- Pipes laid in trench in earth shall be bedded evenly and firmly and as far up the haunches of the pipes as to safely transmit the load expected from the backfill through the pipe to the bed.
- This shall be done either by excavating the bottom to the trench to fit the curve of the pipe to form an even bed. Necessary provision shall be made for joints wherever required.
- Pipes shall be laid true to line and grade as specified.
- Laying of pipes shall always proceed upgrade on a slope. If the pipes have spigot and socket joints, the socket ends shall face upstream. In case of pipes, with joints to be made with loose collars, the collars shall be slipped on before the next pipe is laid. Adequate and proper expansion joints shall be provided wherever necessary.
- The sections of the pipe shall be joined together in such a manner that there shall be as little unevenness as possible along the inside of the pipe.

In case where the foundation conditions are unusual, such as in the proximity of trees or poles, the pipe shall be encased in concrete as directed by the Engineer in Charge.

In laying the pipes and fittings / specials, the centre for each manhole / chamber or pipeline shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 x 100 x 1800 mm) at each manhole / chamber or junction of pipelines at nearly equal distance from the peg and at sufficient distances there from to be well clear of all intended excavation, so arranged that a sight rail when fixed at a certain level against the post shall cross the centre line of the manhole/chamber or pipe lines. The sight rail shall not in any case be more than 30 m apart; intermediate rails shall be put up if directed by Engineer.

Boning staves of 75 mm x 50 mm size shall be prepared by Contractor in various lengths, each length being of a certain whole number of metres and with a fixed tee head and fixed intermediate cross pieces, each about 300 mm long. The top-edge of the cross piece must be fixed below the top-edge of the tee-head at a distance equal to the outside diameter of the pipe or the thickness of the concrete bed to be laid as the case may be. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of the pipe etc. as the case may be.

The sight rail of size 250 mm x 40 mm shall be screwed with the top edge resting against the level marks. The centre line of the pipe shall be marked on the rail and this mark shall denote also the meeting point of the centre lines of any converging pipes. A line drawn from the top edge of one rail to the top edge of the next rail shall be vertically parallel with the bed of the pipe, and the depth of the bed of pipe at any intermediate point may be determined by letting down the selected boning staff until the tee head comes in the line of sight from rail to rail.

The post and rails shall be perfectly square and planed smooth on all sides and edges. The rails shall be painted white on both sides, and the tee-heads and cross-piece of the boning staves shall be painted black. For the pipes converging to a manhole / chamber at various levels, there shall be a rail fixed for every different level. When a rail comes within 0.60M of the surface of the ground, a higher sight-rail shall be fixed for use with the rail over the next point. The posts and rails shall in no case be removed until the trench is excavated, the pipes are laid and Engineer gives permission to proceed with the backfilling.

MANHOLES

Manholes shall be constructed at places as per the drawings and as directed by Engineer.

- Excavation shall be done in accordance with specification provided earlier.
- The manholes shall be circular and constructed in brick masonry at the location as shown in the drawing/ directed by Engineer.
- The manhole spacing in general shall be 30m or more, as specified in the construction drawings and at every junction, change in direction or change in diameter of pipe or as per the directions of Engineer In Charge.
- The Manhole dimensions and other details shall be as per IS 4111.
- The Contractor, while constructing the manholes, shall suitably provide one or two (one each on either side) RCC NP3 pipe piece/s for the plot sewer connection, as directed by the Engineer along with the plot service connection chambers.
- The manhole cover and frame shall be heavy duty (HD-20) Steel Fibre Reinforced Concrete (SFRC) and shall be capable of withstanding Class A loading as per IRC and shall conform to IS: 12592 (Part I & II).
- The inspection and testing of manhole frames and covers shall be done at factory in presence of Engineer and the cost of such inspection shall be made by the contractor and shall be deemed part of the pipeline works.
- The entire height of the manhole shall be tested for water tightness by closing both the incoming and outgoing ends of the sewer and filling the manhole with water and drop in water

level not more than 50mm per 24 hours shall be permitted. The Contractor at his own cost shall arrange the required water for testing and other requirements.

CONNECTION OF PIPES AND MANHOLES

150 ID RCC NP3 pipes shall be used. Granular bedding shall be provided for RCC pipes. Bedding details are as per the drawings specified. Road side Chamber sizes as given below up to 0.60 metre average depth in cement mortar 1 :5 lime concrete with 40 per cent lime mortar 2:3 in foundation cement concrete 1 :2:4 benching 12mm thick cement plaster 1 :2 with a floating coat of 1 mm thick of neat cement R.C.C. 1 :2:4 slab 100 mm thick/cement concrete topping, 50mm thick with 455mmx455mm / 455mm x610mm inside light duty C.I. inspection chamber cover and frame weight as per 1.5.1. specification painted with 3 coats of black bitumastic superior paint complete as per standard design.

BRICK MANHOLES

This work shall consist of construction of structures with bricks jointed together by cement mortar in accordance with the details shown on the drawings or as approved by the Engineer in charge. The brick work shall be with first class bricks in cement mortar 1:3 (1cement: 3 coarse sand). The external joints of the brick masonry shall be finished smooth, and the joints of the pipes with the masonry shall be made perfectly leak proof.

Manholes shall be constructed as per the drawings and directions of engineer in charge. For detailed specifications pertaining to materials such as brick, sand, cement, water etc, earlier / relevant sections shall be referred to.

PIPE ENTERING OR LEAVING MANHOLE:

Whenever a pipe enters or leaves a manhole, bricks on edge must be out to a proper form and laid around the upper end of the pipe so as to form an arch. All around the pipes, there shall be a joint of cement mortar 1:2, 13mm thick between it and the bricks.

CEMENT PLASTER WORK

- Concrete surfaces to be rendered shall be kept dry. The wall should not be too wet but only damp at the time of plastering. The damping shall be uniform to get uniform bond between the plaster and the wall.
- The proportion of cement mortar shall be as specified on relevant Drawings. Cement shall be mixed thoroughly in dry condition and just enough water added to obtain workable consistency. The quality of water, sand and cement shall be as per relevant I.S codes. The

mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to stand for more than 25 minutes after mixing with water.

- Curing of plaster shall be started as soon as the applied plaster has hardened enough so as not to be damaged. The decision as to when the plaster has hardened will be given by Engineer. Curing shall be done by continuous applying water in a fine spray and shall be carried out for at least 7 days.
- Plastering shall be done on inside / both faces of concrete surface, as directed by the Engineer, in CM 1:3 and 12 mm thick for the manholes.
- 20 mm plastering work shall be carried out in 2 layers, the first layer being 10 mm (1:3) thick and the second layer being 10 mm (1:1) thick. The first layer shall be dashed against the prepared surfaces with a trowel to obtain even surfaces. The second layer shall then be applied and finished leaving an even and uniform surfaces, trowel finished unless otherwise directed by Engineer.

STEEL FIBRED REINFORCED CONCRETE COVERS (SFRC COVERS)

The steel fibred reinforced concrete covers shall be heavy duty and extra heavy duty as per IS 12592 (Part-I & II) with adequate steel reinforcement having thickness of 75 mm to 150 mm with other accessories for lifting. Suitable painting arrangements as per the relevant specifications shall be provided to the satisfaction of Engineer in Charge. The frame of manhole shall be firmly embedded to correct alignment and levels in R.C.C. slab or plain concrete as the case may be on the top of the masonry. After completion of the work, manhole covers shall be sealed by means of thick grease. 210mm thickness of concrete can be varied to flush manhole cover and frame with the road surface. The covers and frames shall conform to IS 1726 for cast Iron and IS 12592 for pre-cast concrete covers and shall be of the following grades and types. SFRC manhole covers of heavy duty (HD-20) are used. For manholes in the plots, RCC covers of M 200 frame (900mm X600mm) of medium duty shall be used as per the drawings, relevant specifications and as per the directions of engineer in charge.

PRE-CAST CONCRETE MANHOLE COVERS & FRAMES

Pre-cast reinforced cement concrete manhole covers intended for use in sewerage generally conform to IS 12592.

SHAPES AND DIMENSIONS

Shape, dimensions and tolerance of pre-cast concrete manhole covers and frames shall conform to IS 12592. Outside dimension of cover at top shall match with corresponding frame so that the maximum clearance at top between the frame and the cover all round the periphery

is not more than 5 mm and the top surface of the frame and covers, is in level within a tolerance of +5 mm. For facility of removing the cover from the frame, suitable taper matching with taper given for the frame shall be provided to the periphery of the cover.

LIFTING DEVICE

The minimum diameter of mild steel rod used as lifting device shall be 12 mm for light and medium duty covers and 16 mm for heavy and extra heavy duty covers. The lifting device shall be protected from corrosion by hot galvanizing or epoxy coating or any other suitable treatment as per relevant specifications and directions of engineer in charge.

FINISHING & COATING

To prevent any possible damage from corrosion of steel the underside of the covers shall be treated with anticorrosive paint. The top surface of the covers shall be given a chequered finish.

In order to protect the edges of the covers from possible damage at the time of lifting and handling it is necessary that the manhole covers shall be cast with a protective mild steel sheet of minimum 2.5 mm thickness around the periphery of the covers. Exposed surface of mild steel sheet shall be given suitable treatment with anticorrosive paint or coating. To prevent the top outer edge of frame from possible damages, it shall be protected by 25 mm X 3 mm mild steel flat as part of the frame.

Grades	Grade Designation	Type/shape of cover
Medium Duty	MD - 10	Rectangular, Circular and Square (for pre-cast concrete manhole covers)
Heavy Duty	HD - 20	Circular-Square, Rectangular, (Scraper Manhole)
Extra Heavy Duty	EHD - 35	Circular, Square, Rectangular, (Scraper Manhole)

M.S. STEPS

Provide and install mild steel (M.S.) footrests in manholes, using 20 mm x 20 mm square bars conforming to IS: 2062. The footrests shall be securely fixed into 20 cm x 20 cm x 10 cm cement concrete blocks with a mix ratio of 1:3:6 (1 part cement, 3 parts coarse sand, 6 parts graded stone aggregate of 20 mm nominal size), as per IS: 456. The installation should ensure that the footrests are set at specified intervals and locations, with the concrete blocks properly

embedded in the manhole walls or floor. The work must conform to the standard design approved by the engineer, with all materials and workmanship meeting the required IS standards for quality and safety. Ensure that footrests are free from sharp edges and are properly finished to prevent injury.

DROP MANHOLE

When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) of main line and the invert level of branch lines is more than 600 mm or a drop of more than 600 mm is required to be given in the same sewer line and it is uneconomical or impractical to arrange the connection within 600 mm, a drop connection shall be provided for which a manhole shall be constructed as per relevant drawing, incorporating a vertical drop pipe from the higher sewer to the lower one. This pipe shall be provided outside the shaft and encased in concrete. A continuation of the branch sewer should be built through the shaft wall to form a rodding and inspection eye, which should be provided with a half blank flange. The diameter of the back drop should be at least as large as that of the incoming pipe. The drop pipe should terminate at its lower end with a plain or duck-foot bend turned so as to discharge its flow at 45 degrees or less to the direction of the flow in the main sewer. The pipe, unless of cast iron, shall be surrounded with 150 mm thick concrete.

SCRAPER (SERVICE) TYPE MANHOLE

The square or rectangular manhole of size 1500 x 1500mm or 1500 x 1800 mm should have clear opening of 900 x 600 mm at top to facilitate lowering of buckets as per the drawings and directions of Engineer in Charge. A slab of plain cement concrete at least 150mm thick should be provided at the base to support the walls of the manhole and to prevent the entry of foul water. The thickness of the base shall be suitably increased up to 300mm, for manholes on large dia sewers, with adequate reinforcement provided to withstand excessive uplift pressures.

It is desirable to place the first pipe joint outside the manhole as close as practicable. The pipe shall be built inside the wall of the manhole flush with the internal periphery protected with an arch of masonry or cement concrete to prevent it from being crushed. The sidewalls of the manhole shall be constructed of cement brickwork 250mm thick and corbelled suitably to accommodate the frame of the manhole cover. The inside and outside of the brickwork should be plastered with cement mortar 1:3 (1cement: 3 coarse sand). Inside finished smooth with a coat of neat cement. Where subsoil water condition exist, a richer mix may be used and it shall further be water proofed with adequate quantity addition of approved water proofing compound as per manufacturer's specifications.

SEWER VENTILATORS-VENT SHAFTS

General: Precast RCC (M20) vent shafts shall be provided with an internal diameter of 125 mm and an external diameter of 225 mm at the top, and an internal diameter of 300 mm and an external diameter of 450 mm at the bottom, with an overall length of 9.0 meters. The bottom section shall be installed 1.175 meters below ground level in a pit measuring 900 mm x 900 mm x 1500 mm. Connections to sewer manholes shall be made with a 150 mm diameter NP4 RCC pipe (IS 458, amended up to date) including Type-A bedding. The shaft shall be finished with waterproofing cement of an approved brand, as per drawings and/or as directed by the Engineer.

- Concrete Work: The vent shaft shall be constructed from precast RCC with a mix of M20 grade. The base of the shaft shall be encased in PCC M15, with a 250 mm thick bed and a minimum of 200 mm all around, and a top layer of 150 mm thick PCC M15 with 20 mm nominal size graded stone aggregate. The junction of the vent shaft and surrounding concrete shall be grouted with cement mortar in a 1:1 ratio.
- Construction: The vent shaft shall have a cowl at the top, designed according to standard specifications. The shaft will be installed vertically in the prepared pit, ensuring it is securely fixed and aligned. The connection between the sewer manhole and the vent shaft shall be achieved using a 150 mm diameter NP4 RCC pipe, fully encased in concrete with Type-A bedding. The entire installation must be finished with waterproofing cement as specified by the Engineer.

CONCRETE ENCASEMENT:

Concrete encasements are generally provided in those places where the sewer lines cross the road or as per the drawing and directions of the engineer in charge. The pipe shall be encased all-around in 15 cm thick cement concrete 1:4:8 (1 cement: 4 fine sand: 8 graded stone aggregate 40 mm nominal size) with compacted sand or gravel. These can be constructed wherever required, as per the details given in drawings or as directed by the engineer in charge.

CHAMBER FOR PROPERTY CONNECTION

Property connection chambers (atleast 1 for each property) shall be constructed at the locations shown in the drawings or as shown by the engineer-in-charge.

Chamber shall be of rectangular brick masonry chamber of 0.9m x 0.6m in size and up to 2m in depth. RCC M20 of specified thickness shall be provided on the top which acts as a cushion

for seating of manhole covers. Precast concrete covers as per the drawings and reltype.t specifications shall be provided. 12mm thick plaster (1:3) shall be provided on both the sides of the chamber. 100mm thick PCC shall be provided at the bottom of the chamber. For detailed specifications on excavation, cement concrete works, brick works, CI footsteps, precast manhole covers and frames; earlier sections shall be referred to.

D 6. STORM WATER DRAINAGE

The following codes and standards unless specified herein shall be referred to, or equivalent to the approval of Engineer.

RELEVANT IS CODES

IS 783	Code of practice for laying of concrete pipes.
IS 3764	Excavation work-code of safety.
IS 2720	Methods of test for soils
(Part 1)	Part 1 Preparation of dry soil samples for various tests.
(Part 2)	Part 2 Determination of water content.
(Part 4)	Part 4 Grain size analysis.
(Part 5)	Part 5 Determination of liquid and plastic limit.
(Part 7)	Part 7 Determination of water content-dry density relation using light compaction.
Part (9)	Part 9 Determination of dry density - moisture content relation by constant weight of soil method.
(Part 14)	Part 14 Determination of density index (relative density) of cohesion less soils.
(Part 28)	Part 28 Determination of dry density of soils in place, by the sand replacement method.
(Part 33)	Part 33 Determination of the density in place by the ring and water replacement method.
(Part 34)	Part 34 Determination of density of soil in place by rubber balloon method.
(Part 38)	Part 38 Compaction control tests (Hilf Method).
IS 12592	Precast concrete manhole cover and frame-specification : 2002
IS 8112	43 grade ordinary Portland cement-specification :1989
IS 383	Specification for coarse and fine aggregates from natural sources for concrete:1970 (Reaffirmed 1997)
IS 5961	Specifications for cast iron grating for drainage purposes : (Reaffirmed 2003)
IS 1786	Specification for high strength deformed steel bars and wires for concrete reinforcement: 1985 (Reaffirmed 1990)
Manual on Sewerage and Sewage Treatment Systems	CPHEEO Manual on Sewerage and Sewage Treatment systems-2013- MoUD, GoI
Manual on Storm Water Drainage Systems	CPHEEO Manual on Storm Water Drainage Systems - 2019- MOHUA, GoI
IRC SP-50-1999	Guidelines on Urban Drainage
IS 12592: 2002	Precast Concrete Manhole Cover and Frame- Specification
IRC SP-42-1994	Guidelines on Road Drainage
IS 456:2000	Code of practice for plain and reinforced concrete
IS 458:2000	Code of practice for concrete pipes
SP 7 (Part-9 Section-1) 1983	National Building Code of India
SP 35:1987	Hand book on water supply & drainage
IS 1172 :1993	Code of Basic requirements for water supply, drainage and Sanitation

I.S. 3370 part I to IV	Code of practice for concrete structure for the storage of liquids
IS 1893-2002 part I to V	Criteria for earthquake –resistant design of structures
IS 1992-1969 / IS 6403-1971	Code for exploration to find the safe bearing capacity
IS 875 part I to III, 1987	Code of practice for design loads for building and structures
IS 7357	Code of practice for structural design of tanks
IS 1786-1985	High strength deformed steel bars and wires for concrete reinforcement

- Channel Shapes: Combination of Rectangular box type drains & Circular pipe.
- Material: RCC
 - o RCC (Concrete of M25 grade with minimum cement content of 330 kg /cum)
 - o PCC (1:2:4 (1 cement: 2 coarse sand (zone-III) derived from natural sources: 4 graded stone aggregate 20 mm nominal size derived from natural sources))
 - o RCC NP3 pipe in case of Circular pipe.
- Minimum and Maximum Velocities
 - o Minimum velocity: 0.6 m/s (CPHEEO manual)
 - o Maximum velocity: 3.0 m/s (CPHEEO manual)
- Minimum free board:
 - o Beyond 300mm bed width: 10 cm (CPHEEO manual)
 - o Beyond 300mm & up to 900mm bed width: 15 cm (CPHEEO manual)
 - o Beyond 900mm & up to 1500mm bed width: 30 cm (CPHEEO manual)
 - o Beyond 1500mm bed width: depends on discharge (CPHEEO manual)
- Inlet Chamber/ Catch basin
 - o Spacing at every 15m interval.
 - o As per the typical road section requirements for various ROW roads
 - o These chambers are of 500x450x600mm made of RCC concrete of grade M25 with 500x450mm Ductile iron horizontal grating as per relevant IS standards.
- Manhole and manhole covers for piped Drain
 - o RCC Manhole of grade M25 to be provided at every interval of 30m for piped drain.
 - o Heavy duty Precast concrete manhole covers & frame to be provided under the footpath.

- o Heavy duty Precast concrete manhole covers & frame with perforations to be provided under the carriageway.
 - o 20mm square bar foot rest shall be provided at every 0.5m interval (staggered) till the bed of the drain as per the relevant IS standards
- Manhole covers for Drain
 - o RCC Heavy duty manhole & frame to be provided at regular interval of 30m under the footpath.
 - o RCC Heavy duty manhole & frame with perforations to be provided at regular interval of 15m under the carriageway so as to allow road storm runoff to enter the drain..
 - o Clear size of 450mm x 450mm for smaller drain and size of 600mm x 600mm to be provided for drain maintenance purpose.
 - o Covers to be provided with hot dip galvanized lifting hooks.
- Plot connections

Minimum of one storm water drainage connections connecting to main road drains is to be provided from every individual plots to prevent the frequent cutting of service road. However, two or more stormwater drainage connections can be provided depending upon the size of the asset plot. HDPE pipes with RCC chambers are suggested for plot / courtyard connections. Provision of plot connection is under the scope of asset owner, However, provision of 200mm HDPE PE-100, PN-10 is kept to avoid the cutting of service road/ Footpath and necessary provision to be kept by the contractor for plot connections.

PARTICULAR SPECIFICATION

RCC STORM WATER DRAINS

The drains to collect storm water network shall be made of reinforced cement concrete with concrete cover slabs on the top. The grade of reinforced concrete to be M25 with minimum cement content of 330kg/cum. For the material specifications pertaining to reinforced cement concrete, technical specification of concrete and allied works to be referred. All storm water drains shall be constructed with proper excavation, construction of RCC drains to true lines and levels as per the relevant drawings etc as per the direction of Engineer in Charge. The top slab of the stormwater drain is proposed so as to take the vehicular load (In case of drain proposed under the carriage way). The stormwater drain is lowered 100mm down from road surface to provide a proper finishing of bituminous layer over it.

LAYING AND JOINTING CEMENT CONCRETE PIPES AND SPECIALS

RCC pipes shall be used for Stormwater drainage system for diameter ranging from 1400mm to 2400mm along with the combination of RCC box type drain. Earlier sections of RCC pipes and specials provided shall be referred to for material quality including the laying, joining, testing and commissioning etc for all pipeline related works. Reinforced cement concrete pipes used shall confirm to IS 458-2003 (with ISI mark as per IS 783:1985] with Spigot & socket ended pipes of NP-3 class. Rubber rings used for joining of these pipes shall be as per type 2 of IS: 5382.

Dimensions of pipes shall be as per details given in tables 12, 13, 14, 17, 18 and 19 of IS: 458/2003. Rubber rings use for joining of these pipes shall be as per type 2 of IS: 5382.

MANHOLES FOR PIPED DRAIN

Manholes shall be constructed at places as per the drawings and as directed by Engineer.

- Excavation shall be done in accordance with specification provided earlier.
- The manholes shall be rectangular in shape and constructed in minimum grade of concrete M-25 at the location as shown in the drawing/ directed by Engineer.
- The manhole spacing in general shall be 30m or more, as specified in the construction drawings and at every junction, change in direction or change in diameter of pipe or as per the directions of Engineer In Charge.
- The Manhole dimensions and other details shall be as per IS 4111.
- The manhole cover and frame shall be heavy duty (HD-20) of required shape and approved quality and shall be installed at the locations shown in the drawings or as per the directions of the Engineer In Charge.
- MS footsteps with 20mm diameter roundbar shall also be embedded in the drains at the manhole entry points for maintenance of the storm water drainage system.
- The inspection and testing of manhole frames and covers shall be done at factory in presence of Engineer and the cost of such inspection shall be made by the contractor and shall be deemed part of the pipeline works.
- The entire height of the manhole shall be tested for water tightness by closing both the incoming and outgoing ends of the sewer and filling the manhole with water and drop in water level not more than 50mm per 24 hours shall be permitted. The Contractor at his own cost shall arrange the required water for testing and other requirements.

INLET CHAMBER/ CATCHBASIN WITH HORIZONTAL GRATING:

The chamber shall be of concrete of minimum grade M25 with minimum cement content of 330kg/cum with Ductile iron horizontal grating having clear size of 500mm x 450mm capable of catering fire tender load i.e 40 M/T. The grating should be removable for maintenance purpose. The size of the chamber shall be 500mm x 450mm x 600mm and should be taken as the clear internal dimensions of the chamber. The chamber shall have a connection pipe from the chamber to the drain and shall be of 200mm PN10 PE-100 HDPE pipe material conforming to IS 14333:1996 as per the drawings. The chamber shall be built at the location finalised by the Engineer-in-Charge. Generally, the spacing of the chambers is at every 15m interval depending upon the grading of the road channel and the area of the drainage.

HORIZONTAL GRATING:

Horizontal Gully Grating shall be of Ductile Iron grating and frames suitable for fire tender load / AA class loading as per IRC 6. Horizontal grating to be provided for the inlet of the stormwater runoff for the drains proposed under the carriage way. The clear size of the grating is 500mm x 450mm and 600mm x 600mm. The gratings are provided with an outer frame having height of 100mm. The gratings are provided at the interval of every 15m or as per the directions of the Engineer in Charge. The gully grating cover shall be hinged to the frame to facilitate its opening for cleaning and repairs.

RCC MANHOLE COVER:

RCC Manhole covers to be provided at the interval of every 30m for the cleaning and maintenance purpose in the stormwater drain. Heavy duty manhole cover with minimum grade of concrete M-25 to be provided. The Manhole cover should be capable to cater the vehicular load of minimum 20 M/T. The clear of the cover is 450mm x 450mm for small drains and 600mm x 600mm for large sized drains. Covers to be provided with hot galvanized lifting hooks.

WEEP HOLES

Weep holes, with 75 mm PVC pipes as per specification shall be provided at 1.5 m vertically and horizontally unless otherwise specified in the entire length of storm water drain. The lowest weep hole shall be at about 50 cm above the invert level of stormwater drain. All weep holes shall be surrounded by loose stones and shall have sufficient fall to drain out the water quickly. These weep holes shall be of PVC pipe material as approved by the engineer in charge.

STORM WATER CULVERTS / ROAD CROSSINGS / BRIDGES

RCC Culverts shall be constructed at all the locations shown in the drawings or as per the directions of Engineer In charge. Care shall be taken to ensure that the bed of the culverts shall be constructed 0.3m below the existing natural bed levels of nala / drain. Suitable training of the nala in the upstream and downstream of the nala shall be carried out as per the drawings and directions of the Engineer In charge.

All culverts and bridges shall be constructed with Parapet walls as per the drawings and directions of the Engineer In charge. For details regarding earth work specifications, material specifications earlier sections shall be referred to.

D 7. CIVIL

SCOPE

This specification covers the general requirements of earthwork in excavation in different materials, site grading, filling in areas as shown in drawing, filling back around foundations and in plinths, conveyance and disposal of surplus soils or stacking them properly as shown on the drawings and as directed by the Engineer and all operations covered within the intent and purpose of this specification.

APPLICABLE CODES

The following codes in their latest revision shall be read in conjunction with and shall be part of Design Criteria. In case of conflict the most stringent shall apply.

IS 783	Code of practice for laying of concrete pipes.
IS 1200	Method of measurement of building and civil engineering works.
(Part 1)	Part 1 Earthwork
(Part 27)	Part 27 Earthwork done by mechanical appliances.
IS 3764	Excavation work-code of safety.
IS 2720	Methods of test for soils:
(Part 1)	Part 1 Preparation of dry soil samples for various tests.
(Part 2)	Part 2 Determination of water content.
(Part 4)	Part 4 Grain size analysis.
(Part 5)	Part 5 Determination of liquid and plastic limit.
(Part 7)	Part 7 Determination of water content-dry density relation using light compaction.
Part (9)	Part 9 Determination of dry density - moisture content relation by constant weight of soil method.
(Part 14)	Part 14 Determination of density index (relative density) of cohesionless soils.
(Part 28)	Part 28 Determination of dry density of soils in place, by the sand replacement method.
(Part 33)	Part 33 Determination of the density in place by the ring and water replacement method.
(Part 34)	Part 34 Determination of density of soil in place by rubber balloon method.
(Part 38)	Part 38 Compaction control test (Hilf Method).

DRAWINGS

The Engineer will furnish drawings wherever, in his opinion, such drawings are required to show areas to be excavated/ filled grade level, sequence of priorities etc. The Contractor shall follow strictly such drawings.

GENERAL

The Contractor shall furnish all tools, plants, instruments, qualified supervisory personnel, labour, materials any temporary works, consumables, any and everything necessary, whether or not such items are specifically stated herein for completion of the job in accordance with the specification requirements.

The Contractor shall carry out the survey of the site before excavation and set properly all lines and establish levels for various works such as earthwork in excavation for grading, basement, foundations, plinth filling, roads, drains, cable trenches, pipelines etc. Such survey shall be carried out by taking accurate cross sections of the area perpendicular to established reference/ grid lines at specified intervals or nearer as determined by the Engineer based on ground profile. These shall be checked by the Engineer and thereafter properly recorded.

The excavation shall be done to correct lines and levels. This shall also include, where required, proper shoring to maintain excavations and also the furnishing, erecting and maintaining of substantial barricades around excavated areas and warning lamps at night for ensuring safety.

The rates quoted shall also include for dumping of excavated materials in regular heaps, bunds, riprap with regular slopes as directed by the Engineer, within the lead specified and levelling the same so as to provide natural drainage. Rock/ soil excavated shall be stacked properly as directed by the Engineer. As a rule, all softer material shall be laid along the centre of heaps, the harder and more weather resisting materials forming the casing on the sides and the top. Rock shall be stacked separately.

CLEARING

The area to be excavated filled shall be cleared of fences, trees, plants, logs, stumps, bush, vegetation, rubbish, slush, etc. and other objectionable matter. If any roots or stumps of trees are met during excavation, they shall also be removed. The material so removed shall be burnt or disposed off as directed by the Engineer. Where earth fill is intended, the area shall be

stripped of all loose/ soft patches, top soil containing objectionable matter/ materials before fill commences.

PRECIOUS OBJECTS, RELICS, OBJECTS OF ANTIQUITY, ETC.

All gold, silver, oil, minerals, archaeological and other findings of importance, trees cut or other materials of any description and all precious stones, coins, treasures, relics, antiquities and other similar things which may be found in or upon the site shall be the property of the Owner and the Contractor shall duly preserve the same to the satisfaction of the Owner and from time to time deliver the same to such person or persons as the Owner may from time to time authorise or appoint to receive the same.

CLASSIFICATION

All materials to be excavated shall be classified by the Engineer, into one of the following classes and shall be paid for at the rate tendered for that particular class of material. No distinction shall be made whether the material is dry, moist or wet. The decision of the Engineer regarding the classification of the material shall be final and binding on the Contractor and not be a subject matter of any appeal or arbitration.

Any earthwork will be classified under any of the following categories:

Ordinary and Hard Soils

These shall include all kinds of soils containing kankar, sand, silt, murum and/ or shingle, gravel, clay, loam, peat, ash, shale, etc., which can generally be excavated by spade, pick axes and shovel, and which is not classified under "Soft and Decomposed Rock" and "Hard Rock" defined below. This shall also include embedded rock boulders not longer than 1 metre in any one direction and not more than 200 mm in any one of the other two directions.

Soft and Decomposed Rock

This shall include rock, boulders, slag, chalk, slate, hard mica schist, laterite and all other materials which in the opinion of Engineer is rock, but does not need blasting and could be removed with picks, hammer, crow bars, wedges, and pneumatic breaking equipment. The mere fact that the Contractor resorts to blasting for reasons of his own, shall not qualify for classification under 'Hard Rock'.

This shall also include excavation in macadam and tarred roads and pavements. This shall also include rock boulders not longer than 1 metre in any direction and not more than 500 mm

in any one of the other two directions. Masonry to be dismantled will also be measured under this item.

Hard Rock

This shall include all rock occurring in large continuous masses which cannot be removed except by blasting for loosening it. Harder varieties of rock with or without veins and secondary minerals which, in the opinion of the Engineer require blasting shall be considered as hard rock. Boulders of rock occurring in such sizes and not classified under (a) and (b) above shall also be classified as hard rock. Concrete work both reinforced and unreinforced to be dismantled will be measured under this item, unless a separate provision is made in the Schedule of Quantities.

EXCAVATION

All excavation work shall be carried out by mechanical equipment unless, in the opinion of the Engineer, the work involved and time schedule permit manual work.

Excavation for permanent work shall be taken out to such widths, lengths, depths and profiles as are shown on the drawings or such other lines and grades as may be specified by the Engineer. Rough excavation shall be carried out to a depth 150 mm above the final level. The balance shall be excavated with special care. Soft pockets shall be removed even below the final level and extra excavation filled up as directed by the Engineer. The final excavation if so instructed by the Engineer, should be carried out just prior to laying the mud-mat.

The Contractor may, for facility of work or similar other reasons excavate, and also backfill later, if so approved by the Engineer, at his own cost outside the lines shown on the drawings or directed by the Engineer. Should any excavation be taken below the specified elevations, the Contractor shall fill it up, with concrete of the same class as in the foundation resting thereon, upto the required elevation. No extra shall be claimed by the Contractor on this account.

All excavation shall be done to the minimum dimensions as required for safety and working facility. Prior approval of the Engineer shall be obtained by the Contractor in each individual case, for the method he proposes to adopt for the excavation, including dimensions, side slopes, dewatering, disposal, etc. This approval, however, shall not in any way relieve the Contractor of his responsibility for any consequent loss or damage. The excavation must be carried out in the most expeditious and efficient manner. Side slopes shall be as steep as will stand safely for the actual soil conditions encountered. Every precaution shall be taken to

prevent slips. Should slips occur, the slipped material shall be removed and the slope dressed to a modified stable slope. Removal of the slipped earth will not be paid for if the slips are due to the negligence of the Contractor.

Excavation shall be carried out with such tools, tackles and equipment as described herein before. Blasting or other methods may be resorted to in the case of hard rock; however not without the specific permission of the Engineer.

The Engineer may also direct that in some extreme case, the rock may be excavated by heating and sudden quenching for splitting the rock. Fire-wood shall be used for burning and payment shall be made for such work as called for in the schedule of quantities.

Trench excavation

The trench excavation of pipe line shall be in accordance with IS 12288. Pipe trenches shall be excavated to the lines and levels as shown in the drawings or as directed by the Engineer. The depth of the excavated trench shall be as given in the drawings or as directed by the Engineer. The width of the trench at bottom between the faces of sheeting shall be such as to provide 300mm clearance on either side of the DI pipe except where rock excavation is involved. No pipe shall be laid in a trench until the section of trench in which the pipe is to be laid has been approved by the Engineer.

The depth should be sufficient to provide a cover not less than 1000 mm. It may be necessary to increase the depth of pipeline to avoid land drains or in the vicinity of roads, railways or other crossings. Care should be taken to avoid the spoil bank causing an accumulation of rainwater.

The bottom of the trench shall be trimmed and levelled to permit even bedding of the pipes. It should be free from all extraneous matter which may damage the pipe or the pipe coating. Additional excavation shall be made at the joints of the pipes, so that the pipe is supported along its entire length.

All excavated material shall be stacked in such a distance from the trench edge that it will not endanger the work or workmen and it will avoid obstructing footpaths, roads and drive ways. Hydrants under pressure, surface boxes, fire or other utility controls shall be left unobstructed and accessible during the construction work. Gutters shall be kept clear or other satisfactory provisions made for street drainage, and natural water-courses shall not be obstructed.

To protect persons from injury and to avoid damage to property, adequate barricades, construction signs, torches, red lanterns and guards, as required, shall be placed and maintained during the progress of the work and until it is safe for traffic to use the roadways. All materials, piles equipment and pipes which may serve as obstruction to traffic shall be enclosed by fences or barricades and shall be protected by illuminating proper lights when the visibility is poor.

As far as possible, the pipe line shall be laid below existing services, like water and gas pipes, cables, cable ducts and drains but not below sewers, which are usually laid at greater depth. Where it is unavoidable, pipe line should be suitably protected. A minimum clearance of 500 mm shall be provided between the pipe line and such other services.

Trees, shrubbery fences, poles, and all other property and surface structures shall be protected. Tree roots shall be cut within a distance of 50 cm from pipe joints in order to prevent roots from entering them. Temporary support, adequate protection and maintenance of all underground and surface structures, drains, sewers and other obstructions encountered in the progress of the work shall be provided. The structures, which will be disturbed shall be restored after completion of the work.

Where water forms or accumulates in any trench the Contractor shall maintain the trench free of water during pipe laying.

Wherever necessary to prevent caving, trench excavations in soils such as sand, gravel and sandy soil shall be adequately sheeted and braced. Where sheeting and bracing are used, the net trench width after sheeting shall not be less than that specified above. The sides of the excavation shall be adequately supported at all times and, except where described as permitted under the Contract, shall be not battered.

The Engineer in co-operation with the Contractor shall decide about the sheeting/ bracing of the trench according to the soil conditions in a particular stretch and taking into account the safety requirements of the Contractor's and Engineer's staff. Generally, safety measures against caving have to be provided for trenches with vertical walls if they are deeper than 2.0m.

STRIPPING LOOSE ROCK

All loose boulders, semi-detached rocks (along with earthy stuff which might move therewith) not directly in the excavation but so close to the area to be excavated as to be liable, in the opinion of the Engineer, to fall or otherwise endanger the workmen, equipment, or the work,

etc., shall be stripped off and removed away from the area of the excavation. The method used shall be such as not to shatter, or render unstable or unsafe the portion, which was originally sound and safe.

Any material not requiring removal as contemplated in the work, but which, in the opinion of the Engineer, is likely to become loose or unstable later, shall also be promptly and satisfactorily removed as directed by the Engineer. The cost of such stripping will be paid for at the unit rates accepted for the class of materials in question.

FILL, BACK FILLING AND SITE GRADING

General

All fill material will be subject to the Engineer's approval. If any material is rejected by the Engineer, the Contractor shall remove the same forthwith from the site at no extra cost to the Owner. Surplus fill material shall be deposited/ disposed off as directed by the Engineer after the fill work is completed.

No earth fill shall commence until surface water discharges and streams have been properly intercepted or otherwise dealt with as directed by the Engineer.

Material

To the extent available, selected surplus soils from excavated materials shall be used as backfill. Fill material shall be free from clods, salts, sulphates, organic or other foreign material. All clods of earth shall be broken or removed. Where excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150 mm size, mixed with properly graded fine material consisting of murrum or earth to fill up the voids and the mixture used for filling.

If any selected fill material is required to be borrowed, the contractor shall make arrangements for bringing such material from outside borrow pits. The material and source shall be subject to prior approval of the Engineer. The approved borrow pit area shall be cleared of all bushes, roots of trees, plants, rubbish, etc. top soil containing salts/ sulphate and other foreign material shall be removed. The materials so removed shall be burnt or disposed off as directed by the Engineer. The Contractor shall make necessary access roads to borrow areas and maintain the same, if such access road does not exist, at his cost.

Filling In Pits and Trenches Around Foundations Of Structures, Walls, Etc.

As soon as the work in foundations has been accepted and measured, the spaces around the foundations, structures, pits, trenches, etc. shall be cleared of all debris, and filled with earth in layers not exceeding 15 cm., each layer being watered, rammed and properly consolidated, before the succeeding one is laid. Each layer shall be consolidated to the satisfaction of the Engineer. Earth shall be rammed with approved mechanical compaction machines. Usually no manual compaction shall be allowed unless the Engineer is satisfied that in some cases manual compaction by tampers cannot be avoided. The final backfill surface shall be trimmed and levelled to proper profile as directed by the Engineer or indicated on the drawings.

Plinth Filling

Plinth filling shall be carried out with approved material as described herein before in layers not exceeding 15 cm, watered and compacted with mechanical compaction machines. The Engineer may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours allowed to dry and then the surface again compacted as specified above to avoid settlements at a later stage. The finished level of the filling shall be trimmed to the level/ slope specified.

Where specified in the schedule of works, compaction of the plinth fill shall be carried out by means of 12 tonne rollers smooth wheeled, sheep-foot or wobbly wheeled rollers. In case of compaction of granular material such as sands and gravel, vibratory rollers shall be used. A smaller weight roller may be used only if permitted by the Engineer. As rolling proceeds water sprinkling shall be done to assist consolidation. Water shall not be sprinkled in case of sandy fill.

The thickness of each unconsolidated fill layer can in this case be upto a maximum of 300 mm. The Engineer will determine the thickness of the layers in which fill has to be consolidated depending on the fill material and equipment used.

Rolling shall commence from the outer edge and progress towards the centre and continue until compaction is to the satisfaction of the Engineer, but in no case less than 10 passes of the roller will be accepted for each layer.

The compacted surface shall be properly shaped, trimmed and consolidated to an even and uniform gradient. All soft spots shall be excavated and filled and consolidated.

At some locations/ areas it may not be possible to use rollers because of space restrictions etc. The Contractor shall then be permitted to use pneumatic tampers, rammers, etc. and he shall ensure proper compaction.

Sand Filling In Plinth and Other Places

At places backfilling shall be carried out with local sand if directed by the Engineer. The sand used shall be clean, medium grained and free from impurities. The filled-in-sand shall be kept flooded with water for 24 hours to ensure maximum consolidation. Any temporary work required to contain sand under flooded condition shall be to the Contractor's account. The surface of the consolidated sand shall be dressed to required level or slope. Construction of floors or other structures on sand fill shall not be started until the Engineer has inspected and approved the fill.

Back Filling Trenches

Back-filling and compaction shall be done by hand or approved mechanical methods in layers of 150 mm up to proctor density of 90%, special care shall be taken to avoid damage of the pipe and the coating or moving of the pipe.

Note: The Employer gives very high priority to proper compaction of the backfill as per specifications. It is mandatory that mechanical compaction device shall be used for compacting each layer. The compaction shall be tested as per stipulations of QA/QC document.

Where the excavation is made through permanent pavements, curbs, paved footpaths, or where such structures are undercut by the excavation, the entire back-fill to the subgrade of the structures shall be made with sand in accordance with IS 12288.

All excavations shall be backfilled to the level of the original ground surfaces unless otherwise shown on the drawings or ordered by the Engineer, and in accordance with the requirements of the specification. The material used for backfill, the amount thereof, and the manner of depositing and compacting shall be subject to the approval of the Engineer, but the Contractor will be held responsible for any displacement of pipe or other structures, any damage to their surfaces, or any instability of pipes and structures caused by improper depositing of backfill materials.

Trenches crossing a road shall be backfilled with selected material placed in layers not exceeding 15 cm in thickness after compacting, wetted and compacted to a density of not less

than 90 percent of the maximum dry density at optimum moisture content of the surrounding material. Any shortfall in the quantity of material for backfilling the trenches shall be supplied by the Contractor at his expense.

The Contractor shall at his own expense make good any settlement of the trench backfill occurring after backfilling and until the expiry of the defects liability period.

On completion of pressure and leakage tests exposed joints shall be covered with approved selected backfill placed above the top of the pipe and joints in accordance with the requirements of the above specifications. The Contractor shall not use backfilling for disposal of refuse or unsuitable soil.

GENERAL SITE GRADING

Site grading shall be carried out as indicated in the drawings and as directed by the Engineer. Excavation shall be carried out as specified in the specification. Filling and compaction shall be carried out as specified in PART B and elsewhere unless otherwise indicated below.

If no compaction is called for, the fill may be deposited to the full height in one operation and levelled. If the fill has to be compacted, it shall be placed in layers not exceeding 225 mm and levelled uniformly and compacted as indicated in PART B before the next layer is deposited.

To ensure that the fill has been compacted as specified, field and laboratory tests shall be carried out by the Contractor at his cost.

Field compaction test shall be carried out at different stages of filling and also after the fill to the entire height has been completed. This shall hold good for embankments as well.

The Contractor shall protect the earthfill from being washed away by rain damaged in any other way. Should any slip occur, the Contractor shall remove the affected material and make good the slip at his cost.

The fill shall be carried out to such dimensions and levels as indicated on the drawings after the stipulated compaction. The fill will be considered as incomplete if the desired compaction has not been obtained.

If specifically permitted by the Engineer, compaction can be obtained by allowing loaded trucks conveying fill or other material to ply over the fill area. Even if such a method is permitted, it will be for the Contractor to demonstrate that the desired/ specified compaction has been obtained. In order that the fill may be reasonably uniform throughout, the material should be

dumped in place in approximately uniform layers. Traffic over the fill shall then be so routed to compact the area uniformly throughout.

If so specified, the rock as obtained from excavation may be used for filling and levelling to indicate grades without further breaking. In such an event, filling shall be done in layers not exceeding 50cms approximately. After rock filling to the approximate level, indicated above has been carried out, the void in the rocks shall be filled with finer materials such as earth, broken stone, etc. and the area flooded so that the finer materials fill up the voids. Care shall be taken to ensure that the finer fill material does not get washed out. Over the layer so filled, a 100 mm thick mixed layer of broken material and earth shall be laid and consolidation carried out by a 12 tonne roller. No less than twelve passes of the roller shall be accepted before subsequent similar operations are taken up.

FILL DENSITY

The compaction, only where so called for, in the schedule of quantities/ items shall comply with the specified (Standard Proctor/ Modified Proctor) density at moisture content differing not more than 4 percent from the optimum moisture content. The Contractor shall demonstrate adequately at his cost, by field and laboratory tests that the specified density has been obtained.

Disposal

Excess excavated earth shall be disposed by contractor at a suitable site on his own responsibility.

CONCRETE & ALLIED WORKS

SCOPE

This Specification covers the general requirements for ready mixed concrete and for concrete using on-site production facilities including requirements in regard to the quality, handling, storage of ingredients, proportioning, batching, mixing, transporting, placing, curing, protecting, repairing, finishing and testing of concrete; formwork; requirements in regard to the quality, storage, bending and fixing of reinforcement; grouting.

It shall be very clearly understood that the specifications given herein are brief and do not cover minute details. However, all works shall have to be carried out in accordance with the relevant standards and codes of practices or in their absence in accordance with the best accepted current engineering practices or as directed by ENGINEER from time to time. The

decision of ENGINEER as regards the specification to be adopted and their interpretation and the mode of execution of work shall be final and binding on CONTRACTOR and no claim whatsoever will be entertained on this account.

APPLICABLE CODES AND SPECIFICATION

The following specifications, standards and codes, including all official amendments/revisions and other specifications & codes referred to therein, should be considered a part of this specification. In all cases the latest issue/edition/revision shall apply. In case of discrepancy between this specification and those referred to herein below or other specifications forming a part of this bid document, this specification shall govern.

Materials

IS:269	Specification for 33 grade ordinary portland cement.
IS:455	Specification for Portland slag cement.
IS:1489	Specification for Portland pozzolana cement(Parts 1 & 2)
IS:8112	Specification for 43 grade ordinary portland cement.
IS:12330	Specification for sulphate resisting Portland Cement.
IS:383	Specification for coarse and fine aggregates from natural sources for concrete.
IS:432	Specification for mild steel and medium tensile (Parts steel bars and hard drawn steel wires for 1 & 2) concrete reinforcement.
IS:1786	Specification for high strength deformed steel bars and wires for concrete reinforcement.
IS:1566	Specification for hard drawn steel wire fabric for (Parts II) concrete reinforcement.
IS:9103	Specification for admixtures for concrete.
IS:2645	Specification for integral cement waterproofing compounds.
IS:4900	Specification for plywood for concrete shuttering work.
IS:4926	Ready mixed concrete
IS:12269	Specification for 53 grade ordinary portland cement.
IS:8041	Specification for rapid hardening cement.
IS:12600	Specification for low heat cement.
IS:6909	Specification for supersulphated cement.
IS:12089	Specification for granulated ground blast furnace slag.
BS:6699	Specification for granulated ground blast furnace slag.

BS:6073	Specifications for precast concrete masonry units (Part 1) Methods for specifying precast concrete masonry (Part 2)

Material Testing

IS:4031	Methods of physical tests for hydraulic cement. (Parts 1 to 15)
IS:4032	Method of chemical analysis of hydraulic cement.
IS:650	Specification for standard sand for testing of cement.
IS:2430	Methods for sampling of aggregates for concrete.
IS:2386	Methods of test for aggregates for concrete (Parts 1 to 8)
IS:3025	Methods of sampling and test (physical and chemical) water used in industry.(Part 1 to 51)
IS:6925	Methods of test for determination of water soluble chlorides in concrete admixtures.

Material Storage

IS:4082	Recommendations on stacking and storing of construction materials at site.

Concrete Mix Design

IS:10262	Recommended guidelines for Concrete Mix Design.

Concrete Testing

IS:1199	Method of sampling and analysis of concrete.
IS:516	Method of test for strength of concrete.
IS:9013	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
IS:8142	Method of test for determining setting time of concrete by penetration resistance.
IS:9284	Method of test for abrasion resistance of concrete.
IS:2770	Methods of testing bond in reinforced concrete.

Equipment

IS:1791	Specification for batch type concrete mixers.
IS:2438	Specification for roller pan mixer.
IS:4925	Specification for concrete batching and mixing plant.

IS:5892	Specification for concrete transit mixer and agitator.
IS:7242	Specification for concrete spreaders.
IS:2505	General Requirements for concrete vibrators: Immersion type.
IS:2506	General Requirements for screed board concrete vibrators.
IS:2514	Specification for concrete vibrating tables.
IS:3366	Specification for pan vibrators.
IS:4656	Specification for form vibrators for concrete.
IS:11993	Code of practice for use of screed board concrete vibrators.
IS:7251	Specification for concrete finishers.
IS:2722	Specification for portable swing weigh batchers for concrete (single and double bucket type).
IS:2750	Specifications for steel scaffoldings.

Codes Of Practice

IS:456	Code of practice for plain and reinforced concrete.
IS:457	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
IS:3370	Code of practice for concrete structures for storage of liquids (Parts 1 to 4)
IS:3935	Code of practice for composite construction.
IS:2204	Code of practice for construction of reinforced concrete shell roof.
IS:2210	Criteria for the design of reinforced concrete shell structures and folded plates.
IS:2502	Code of practice for bending and fixing of bars for concrete reinforcement.
IS:5525	Recommendation for detailing of reinforcement in reinforced concrete works.
IS:2751	Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
IS:9417	Specification for welding cold worked bars for reinforced concrete construction.
IS:3558	Code of practice for use of immersion vibrators for consolidating concrete.
IS:3414	Code of practice for design and installation of joints in buildings.

IS:4326	Code of practice for earthquake resistant design and construction of buildings.
IS:4014	Code of practice for steel tubular scaffolding. (Parts 1 & 2)
IS:2571	Code of practice for laying in situ cement concrete flooring
IS:7861	Part1 - Recommended practice for hot weather concreting Part2 – Recommended practice for cold weather concreting
IS:3370	Code of practice for concrete structures for the storage of liquid (Part I to IV)

Construction safety

IS:3696	Safety code for scaffolds and ladders.(Parts 1 & 2)
IS:7969	Safety code for handling and storage of building materials.
IS:8989	Safety code for erection of concrete framed structures.

Measurement

IS:1200 (Part 1 to 12)	Method of measurement of building and engineering works (Part 2 and 5)

GENERAL

ENGINEER shall have the right at all times to inspect all operations including the sources of materials, procurement, layout and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged, and ENGINEER's approval obtained, prior to starting of concrete work. This shall, however, not relieve CONTRACTOR of any of his responsibilities. All materials, which do not conform to this specification, shall be rejected.

Materials should be selected so that they can satisfy the design requirements of strength, serviceability, safety, durability and finish with due regards to the functional requirements and the environmental conditions to which the structure will be subjected. Materials complying with codes/standards shall only be used. Other materials may be used after approval of the ENGINEER and after establishing their performance suitability based on previous data, experience or tests.

MATERIALS

Cement

Unless otherwise specified or called for by ENGINEER/OWNER, cement shall be ordinary Portland cement conforming to IS: 269, IS: 8112 or IS: 12269.

The Portland pozzolana cement shall conform to IS: 1489 and it shall be used as directed by ENGINEER. Where Portland pozzolana or slag cements are used, it shall be ensured that consistency of quality is maintained and there will be no adverse interactions between the materials and the finish specified is not marred.

Only one type of cement shall be used in any one mix unless specifically approved by ENGINEER. The source of supply, type or brand of cement within the same structure or portion thereof shall be approved from ENGINEER prior to its use.

Cement, which is not used within 90 days from its date of manufacture, shall be tested at a laboratory approved by ENGINEER and until the results of such tests are found satisfactory, it shall not be used in any work.

Aggregates

Aggregates shall consist of naturally occurring stones and gravel (crushed or uncrushed) and sand. They shall be chemically inert, strong, hard, clean, durable against weathering, of limited porosity, free from dust/silt/organic impurities/deleterious materials and conform to IS: 383. Aggregates such as slag, crushed over burnt bricks, bloated clay ash, sintered fly ash and tiles shall not be used.

Aggregates shall be washed and screened before use where necessary or if directed by the ENGINEER.

Aggregates containing reactive materials shall be used only after tests conclusively prove that there will be no adverse affect on strength, durability and finish, including long term effects, on the concrete.

The fineness modulus of sand shall neither be less than 2.2 nor more than 3.2. If use of sand having fineness modulus more than 3.2 is unavoidable then it shall be suitable blended with crusher stone dust.

The maximum size of coarse aggregate shall be as stated on the drawings, but in no case greater than 1/4 of the minimum thickness of the member, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill the corners of the form. For most work 20mm aggregate is suitable. Where there is no restriction to the flow of concrete into sections, 40mm or larger size is permitted.

In concrete elements with thin sections, closely spaced reinforcements or small cover, consideration should be given to the use of 10mm nominal maximum size.

Plums 160 mm and above of a reasonable size may be used where directed. Plums shall not constitute more than 20% by volume of concrete unless specified by ENGINEER.

Water

Water used for both mixing and curing shall conform to IS:456. Potable water is generally satisfactory. Water containing any excess of acid, alkali, sugar or salt shall not be used.

The pH value of water shall not be less than 6.

Seawater shall not be used for concrete mixing and curing.

The proposed admixtures shall comply with requirements of latest IS codes.

Reinforcement

Reinforcement bars shall conform to IS:432 and/ or IS:1786 and welded wire fabric to IS:1566 as shown on the drawing.

All reinforcement shall be clean, free from pitting, oil, grease, paint, loose mill scales, rust, dirt, dust or any other substance that will destroy or reduce bond.

Special precaution like coating of reinforcement may be provided with the prior approval of ENGINEER.

Samples And Tests

All materials used for the works shall be tested before use. The frequency of such confirmatory tests shall be decided by ENGINEER.

Manufacturer's test certificate shall be furnished for each batch of cement/steel and when directed by ENGINEER samples shall also be got tested by the CONTRACTOR in a laboratory approved by ENGINEER at no extra cost to OWNER. However, where material is supplied by OWNER, all testing charges shall be borne by OWNER, but transportation and preparation of material samples for the laboratory shall be done by CONTRACTOR at no extra cost.

Sampling and testing of aggregates shall be as per IS:2386 under the supervision of ENGINEER. The cost of all tests, sampling, etc. shall be borne by CONTRACTOR. For coarse aggregate crushing value shall be tested.

Water to be used shall be tested to comply with clause 5.4 of IS:456.

CONTRACTOR shall furnish manufacturer's test certificates and technical literature for the admixture proposed to be used. If directed, the admixture shall be got tested at an approved laboratory at no extra cost.

Storing Of Materials

All material shall be stored in a manner so as to prevent its deterioration and contamination, which would preclude its use in the works. Requirements of IS:4082 shall be complied with.

CONTRACTOR will have to make his own arrangements for the storage of adequate quantity of cement even if cement is supplied by OWNER. If such cement is not stored properly and has deteriorated, the material shall be rejected. Cost of such rejected cement, where cement is supplied by OWNER, shall be recovered at issue rate or open market rate whichever is higher. Cement bags shall be stored in dry weatherproof shed with a raised floor, well away from the outer walls and insulated from the floor to avoid moisture from ground. Not more than 15 bags shall be stacked in any tier. Storage arrangement shall be approved by ENGINEER. Storage under tarpaulins shall not be permitted. Each consignment of cement shall be stored separately and consumed in its order of receipt. CONTRACTOR shall maintain record of receipt and consumption of cement.

Each size of coarse and fine aggregates shall be stacked separately and shall be protected from dropping leaves and contamination with foreign material. The stacks shall be on hard, clean, free draining bases, draining away from the concrete mixing area.

CONTRACTOR shall make his own arrangements for storing water at site in tanks of approved capacity. The tanks shall be cleaned at least once a week to prevent contamination.

The reinforcement shall be stacked on top of timber sleepers to avoid contact with ground/ water. Each type and size shall be stacked separately.

CONCRETE

General

Concrete grade shall be as designated on drawings. Concrete in the works shall be "DESIGN MIX CONCRETE" OR "NOMINAL MIX CONCRETE". All concrete works of upto grade M15 shall be NOMINAL MIX CONCRETE whereas all other grades, M20 and above, shall be DESIGN MIX CONCRETE.

Design Mix Concrete

Design Mix Concrete are classified in three categories, viz. "Normal Concrete (M)", "Heavy Concrete (H)", "Super Heavy Concrete (SH)". Each class of concrete shall be identified by a prefix and two numbers. Prefix "M" would denote Normal Concrete, prefix "H" would denote heavy concrete and prefix "SH" would denote super heavy concrete. The two numbers e.g. 25 - 40 would denote the crushing strength of cube at 28 days in N/sq.mm and maximum size of the coarse aggregates in millimetres respectively.

Normal concrete shall have a net dry unit weight of not less than 25 kN/cum, for the finished structure after curing, Heavy concrete shall have a net dry unit weight of not less than 36.30 kN/cum, for the finished structure after curing and special heavy concrete shall have a net dry unit weight of not less than 41 kN/cum for the finished structure after curing.

Mix Design & Testing

For Design Mix Concrete, the mix shall be designed as per any of four methods given in SP: 23 to provide the grade of concrete having the required workability and characteristic strength not less than appropriate values given in IS: 456. The design mix shall in addition be such that it is cohesive and does not segregate during placement and should result in a dense and durable concrete capable of giving the specified finish. For liquid retaining structures, the mix shall also result in watertight concrete. The CONTRACTOR shall exercise great care while designing the concrete mix and executing the works to achieve the desired result.

The minimum grade of concrete shall be as per Table 5 of IS: 456 for various exposure conditions of concrete. For various environmental conditions, refer Table 3 of IS: 456.

The minimum cement content for Design Mix Concrete shall be as per Table 5 of IS: 456 or as given below, whichever is higher.

Table. Grade of Concrete and Minimum Cement Content

Grade of Concrete	Minimum Cement Content in kg/cum. of Concrete
M 20	300
M 25	300
M 30	320
M 35	340

The minimum cement content stipulated above shall be adopted irrespective of whether the CONTRACTOR achieves the desired strength with less quantity of cement. The CONTRACTOR's quoted rates for concrete shall provide for the above eventuality and nothing extra shall become payable to the CONTRACTOR on this account. Even in the case where the quantity of cement required is higher than that specified above to achieve desired strength based on an approved mix design, nothing extra shall become payable to the CONTRACTOR.

It shall be CONTRACTOR's sole responsibility to carry out the mix designs at his own cost. He shall furnish to ENGINEER for approval at least 30 days before concreting operations, a statement of proportions proposed to be used for the various concrete mixes and the strength results obtained. The strength requirements of the concrete mixes ascertained on 150 mm cubes as per IS:516 shall comply with the requirements of IS:456.

Table. Grade of Concrete and Compressive Strength

Grade of Concrete M	Minimum Compressive Strength N/Sq.mm at 7 days	Specified Characteristic compressive strength N/sq.mm at 28 days
15	10.0	15.0
20	13.5	20.0
25	17.0	25.0
30	20.0	30.0
35	23.5	35.0

A range of slumps recommended for various types of construction, unless otherwise instructed by the ENGINEER, shall be as given below:

Table. Recommended Slump

Structure/Member	Slump in millimetres	
	Maximum	Minimum
Reinforced foundation walls and footings	75	25
Plain footings, caissons and substructure walls	75	25
T. G. and massive compressor foundations	50	25
Slabs, Beams and reinforced walls	50	25
Pumps & miscellaneous Equipment Foundations	75	25
Building columns	50	25
Pavements	50	25
Heavy mass construction	50	25
Liquid retaining/ conveying structures	50	25

(NOTE: These values are not meant for pumped concrete placed using slip formed technique.)

Where single size graded coarse aggregate are not available, aggregates of different sizes shall be properly combined. The contractors mix design shall show that combined grading of coarse aggregate meets the requirements of Table 2 of IS: 383 for graded aggregates.

Batching & Mixing of Concrete

Proportions of aggregates and cement, as per approved concrete mix design, shall be by weight. These proportions shall be maintained during subsequent concrete batching by means of weigh batchers capable of controlling the weights within $\pm 2\%$ for cement and $\pm 3\%$ for aggregate. The batching equipment shall be calibrated at the frequency decided by ENGINEER.

Amount of water added shall be such as to produce dense concrete of required consistency, specified strength and satisfactory workability and shall be so adjusted to account for moisture content in the aggregates. Water- cement ratio specified for use by ENGINEER shall be maintained. Each time the work stops, the mixer shall be cleaned out, and while recommencing, the first batch shall have 10% additional sand and cement to allow for sticking in the drum.

Arrangement should be made by CONTRACTOR to have the cubes tested at his own expense in an approved laboratory or in field with prior consent of ENGINEER. Sampling and testing of strength and workability of concrete shall be as per IS:1199, IS:516 and IS:456. It is preferable to cast additional cubes (minimum 3 specimen) for testing at 7 days and 14 days.

Nominal Mix Concrete

Mix Design & Testing

Mix Design and preliminary tests are not necessary for Nominal Mix Concrete. However works tests shall be carried out as per IS:456. Proportions for Nominal Mix Concrete and w/c ratio may be adopted as per Table 9 of IS:456. However, it will be CONTRACTOR's sole responsibility to adopt appropriate nominal mix proportions to achieve the specified characteristic strength.

Batching & Mixing of Concrete

Based on the adopted nominal mixes, aggregates shall be measured by volume. However cement shall be by weight only. Appropriate correction shall be made for bulking of sand after testing.

Ready mixed concrete

All specification as per IS:4926 – "Specification for ready mixed concrete" shall be used.

The Contractor shall identify at least two sources of ready mix concrete supplier and get it approved by ENGINEER prior to start of the Works. Any change in the source of the RMC, shall be got approved by the ENGINEER.

The design mix prepared by the RMC supplier shall be the responsibility of the Contractor. The testing of concrete as per Codal provisions and the specifications shall be done by the Contractor same as the normal concreting works.

PRECAST CONCRETE

General

Precast concrete shall comply with the preceding Sections relating to Concrete as far as they are applicable. Precast concrete blocks shall comply with the requirements and recommendations of BS 6073.

Precasting bed

All precast units shall be cast on, or their shutters supported from a suitably prepared level unyielding paved area.

Marking

All units shall be suitably marked in a clean and legible manner with a reference number and the date of casting, which information shall be clearly visible when units are stacked. Reinforced precast members shall be clearly marked to indicate the upper face.

Formwork

The formwork shall be either steel or lined with steel, waterproof / laminated board or such other material as directed and approved by the ENGINEER. Forms shall be strongly constructed, closely jointed and smooth and shall be such as to ensure true sharp arises and a perfect surface. Forms shall be so designed that they can be taken apart and reassembled readily.

Casting tolerance

The casting tolerance, unless otherwise ordered or directed, shall be within +3mm of true dimensions.

Striking forms

The method and time of striking the side shutters after casting the units will normally be left to the discretion of the CONTRACTOR, but the ENGINEER may specify minimum time in which case the CONTRACTOR must comply with the ENGINEER'S directions. In the event of any damage resulting from premature removal of shutters, or from any other cause, the unit will be liable to rejection and replacement by the Contractor at his own cost, whether the Engineer has specified a minimum striking time or not.

Lifting, stacking and removal

Precast units shall not be lifted, transported or used in the Works until they are sufficiently mature. The crushing tests on the test cubes, which are to be kept along with relevant the precast units, will be used to assess the maturity of the units.

Lifting, stacking and removal of precast units shall be undertaken without causing shock, vibration or undue stress to or in the units. The CONTRACTOR shall satisfy the ENGINEER

that the methods he proposes for lifting, transporting and setting precast units will not overstress or damage the units in any way. In the event of overstress or damage due to whatever cause, the unit or units concerned will be liable to rejection. Rejected units shall be immediately broken up and removed from the site. The CONTRACTOR shall replace such rejected units at his own cost.

Curing

The top and sides of all precast units shall be kept covered constantly and in a damp condition with clean, potable fresh water for at least seven days after casting or for such further period as the ENGINEER may direct. It is preferable to have a curing pond for this purpose.

Precasting records

Complete records shall be maintained of all precast work. Every unit shall have a reference number, date of casting, date of removal from bed and date and position of placing shall be recorded together with corresponding test cube reference number and results.

CONTRACTOR shall submit a method statement to ENGINEER for approval, furnishing details of each stage of operation.

Formwork

Formwork shall be all inclusive and shall consist of but not limited to shores, bracings, sides of footings, walls, beams and columns, bottom of slabs, etc. including ties, anchors, hangers, inserts, false work, wedges, etc.

The design and engineering of the formwork as well as its construction shall be the responsibility of CONTRACTOR. However, if so directed by ENGINEER, the drawings and calculations for the design of the formwork shall be submitted to ENGINEER for approval.

Formwork shall be designed to fulfil the following requirements:

Sufficiently rigid and tight to prevent loss of grout or mortar from the concrete at all stages and appropriate to the methods of placing and compacting.

Capable of providing concrete of the correct shape and surface finish within the specified tolerance limits.

Capable of withstanding without deflection the worst combination of selfweight, reinforcement and concrete weight, all loads and dynamic effects arising from construction and compacting activities, wind and weather forces.

Capable of easily striking without shock, disturbance or damage to the concrete

Soffit forms capable of imparting a camber if required.

Soffit forms and supports capable of being left in position if required.

Capable of being cleaned and/or coated if necessary, immediately prior to casting the concrete; design temporary openings where necessary for these purposes and to facilitate the preparation of construction joints.

The formwork may be of lined timber, waterproof / plastic coated plywood, steel, plastic depending upon the type of finish specified. Sliding forms and slip form may be used with the approval of ENGINEER. Timber for formwork shall be well seasoned, free from sap, shakes, loose knots, worm holes, warps and other surface defects. Joints between formwork and formwork and between formwork and structure shall be sufficiently tight to prevent loss of slurry from concrete using foam and rubber seals.

The faces of formwork coming in contact with concrete shall be cleaned and two coats of approved mould oil applied before fixing reinforcement. All rubbish, particularly chippings, shavings, sawdust, wire pieces, dust etc. shall be removed from the interior of the forms before the concrete is placed. Where directed, cleaning of forms shall be done by blasting with a jet of compressed air at no extra cost.

Forms intended for reuse shall be treated with care. Forms that have deteriorated shall not be used. Before reuse, all forms shall be thoroughly scraped, cleaned, nails removed, holes suitably plugged, joints repaired and warped lumber replaced to the satisfaction of ENGINEER. CONTRACTOR shall equip himself with enough quantity of shuttering to allow for wastage so as to complete the job in time.

Permanent formwork shall be checked for its durability and compatibility with adjoining concrete before it is used in the structure. It shall be properly anchored to the concrete.

Wire ties passing through beams, columns and walls shall not be allowed. In their place bolts passing through sleeves may be used. Formwork spacers left in situ shall not impair the

desired appearance or durability of the structure by causing spalling, rust staining or allowing the passage of moisture.

For liquid retaining structures sleeves shall not be provided for through bolts nor shall through bolts be removed if provided. The bolts, in the latter case, shall be cut at 25 mm depth from the surface and the hole made good by cement mortar of the same proportion as the concrete just after striking the formwork.

Where specified or shown on drawings all corners and angles exposed in the finished structure shall have chamfers or fillets of 20 mm x 20 mm size.

Forms for substructure may be omitted when, in the opinion of ENGINEER, the open excavation is firm enough (in hard non-porous soils) to act as a form. Such excavation shall be slightly larger, as directed by ENGINEER, than that required as per drawing to compensate for irregularities in excavation.

CONTRACTOR shall provide adequate props of adjustable steel pipes carried down to a firm bearing without overloading any of the structures.

The shuttering for beams and slabs shall be so erected that the side shuttering of beams can be removed without disturbing the bottom shuttering. If the shuttering for a column is erected for the full height of the column, one side shall be built up in sections as placing of concrete proceeds or windows left for placing concrete from the side to limit the drop of concrete to 1.5 m or as directed by ENGINEER. CONTRACTOR shall temporarily and securely fix items to be cast (embedment/inserts) in a manner that will not hinder the striking of forms or permit loss of grout.

Formwork showing excessive distortion, during any stage of construction, shall be removed. Placed concrete affected by faulty formwork, shall be entirely removed and formwork corrected prior to placement of new concrete at CONTRACTOR's cost.

The striking time for formwork shall be determined based on the following requirements:

- a) Development of adequate concrete strength;
- b) Permissible deflection at time of striking form work;
- c) Curing procedure employed - its efficiency and effectiveness;
- d) Subsequent surface treatment to be done;
- e) Prevention of thermal cracking at re-entrant angles;

- f) Ambient temperatures; and Aggressiveness of the environment (unless immediate adequate steps are taken to prevent damage to the concrete).

Before removing formwork of soffit of slabs/ beams compressive strength at 7/14/21 days shall be checked.

Under normal circumstances (generally where temperatures are above 20 Deg. C) forms may be struck after expiry of the period given in IS: 456 unless directed otherwise by ENGINEER. For Portland Pozzolana/slag cement the stripping time shall be suitably modified as directed by the ENGINEER. It is the CONTRACTOR's responsibility to ensure that forms are not struck until the concrete has developed sufficient strength to support itself, does not undergo excessive deformation and resists surface damage and any stresses arising during the construction period.

Reinforcement Fabrication And Placement

Reinforcing bars supplied in the form of bent coils shall be straightened cold without damage at no extra cost. No bending shall be done when ambient temperature is below 5 Deg.C. Suitable preheating may be permitted if steel bar bending is to be done at below 0 Deg.C. Bars supplied in bent coils shall be straightened only by machine.

All bars shall be accurately bent gradually and according to the sizes and shapes shown on the drawings/ schedules or as directed by ENGINEER. Bar bending machines shall be used to achieve desired accuracy.

Re-bending or straightening incorrectly bent bars shall not be done without approval of ENGINEER.

Reinforcement shall be accurately fixed and maintained firmly in the correct position by the use of blocks, spacers, chairs, binding wire, etc. to prevent displacement during placing and compaction of concrete. The tied in place reinforcement shall be approved by ENGINEER prior to concrete placement. Spacers (PVC or Concrete) shall be of such material and design as will be durable, not lead to corrosion of the reinforcement and not cause spalling of the concrete cover.

Binding wire shall be 16 gauge soft annealed wire. Ends of the binding wire shall be bent away from the concrete surface and in no case encroach into the concrete cover.

Substitution of reinforcement, laps/splices not shown on drawing shall be proposed by CONTRACTOR and approved by ENGINEER.

If permitted by ENGINEER, welding of reinforcement shall be done in accordance with IS: 2751, IS: 9417 and SP: 34 as applicable.

Tolerance on placement of reinforcement shall be as per Cl. 12.3 of IS: 456.

Tolerances

Tolerance for formed and concrete dimensions shall be as per IS: 456 and/ or ACI-117-90, ACI-347 unless specified otherwise.

Tolerance specified for horizontal or vertical building lines or footings shall not be construed to permit encroachment beyond the legal boundaries.

Tolerance for top of concrete of equipments and structural steel foundations shall be as under:

- a) Where grout thickness is less than or equal to 25mm: +5mm and –10mm.
- b) Where grout thickness is more than 25mm: ± 15 mm.

Preparation Prior To Concrete Placement

Before concrete is actually placed in position, the inside of the formwork shall be cleaned and mould oil applied, inserts and reinforcement shall be correctly positioned and securely held, necessary openings, pockets, etc. provided.

All arrangements-formwork, equipment and proposed procedure, shall be approved by ENGINEER. CONTRACTOR shall maintain separate Pour Card for each pour as per the format enclosed.

Transporting, Placing And Compacting Concrete

Concrete shall be transported from the mixing plant to the formwork with minimum time lapse by methods that shall maintain the required workability and will prevent segregation, loss of any ingredients or ingress of foreign matter or water.

In all cases concrete shall be deposited as nearly as practicable directly in its final position. To avoid segregation, concrete shall not be rehandled or caused to flow. For locations where direct placement is not possible and in narrow forms, CONTRACTOR shall provide suitable drops and “Elephant Trunks”. Concrete shall not be dropped from a height of more than 1.5 m.

Concrete shall not be placed in flowing water. Under water concrete shall be placed in position by tremie or by pipeline from the mixer and shall never be allowed to fall freely through the water.

While placing concrete the CONTRACTOR shall proceed as specified below and also ensure the following:

Continuously between construction joints and predetermined abutments.

- a) Without disturbance to forms or reinforcement.

- b) Without disturbance to pipes, ducts, fixings and the like to be cast in; ensure that such items are securely fixed. Ensure that concrete cannot enter open ends of pipes and conduits, etc.
- c) Without dropping in a manner that could cause segregation or shock.
- d) In deep pours only when the concrete and formwork is designed for this purpose and by using suitable chutes or pipes.
- e) Do not place if the workability is such that full compaction cannot be achieved.
- f) Without disturbing the unsupported sides of excavations; prevent contamination of concrete with earth. Provide sheeting if necessary. In supported excavations, withdraw the linings progressively as concrete is placed.
- g) If placed directly onto hardcore or any other porous material, dampen the surface to reduce loss of water from the concrete.
- h) Ensure that there is no damage or displacement to sheet membranes.
- i) Record the time and location of placing structural concrete.

Concrete shall normally be compacted in its final position within thirty minutes (Initial setting time) of leaving the mixer. Concrete shall be compacted during placing with approved vibrating equipment without causing segregation until it forms a solid mass free from voids, thoroughly worked around reinforcement and embedded fixtures and into all corners of the formwork. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn slowly till air bubbles cease to come to the surface, leaving no voids. When placing concrete in layers advancing horizontally, care shall be taken to ensure adequate vibration, blending and melding of the concrete between successive layers. Vibrators shall not be allowed to come in contact with reinforcement, formwork and finished surfaces after start of initial set. Over-vibration leads to segregation and shall be avoided.

Concrete may be conveyed and placed by mechanically operated equipment after getting the complete procedure approved by ENGINEER. The slump shall be held to the minimum necessary for conveying concrete by this method. When concrete is to be pumped, the concrete mix shall be specially designed to suit pumping. Care shall be taken to avoid stoppages in work once pumping has started.

CONTRACTOR shall submit a method statement to ENGINEER for approval, furnishing details of pour sequence, thickness of each layer, mixing and conveying equipment proposed etc. preferably with a sketch.

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for at least 24 hours after the final set of concrete before the start of subsequent placement. Placing shall stop when concrete reaches the top of the opening in walls or bottom

surface of slab, in slab and beam construction, and it shall be resumed before concrete takes initial set but not until it has had time to settle as determined by ENGINEER. Concrete shall be protected against damage until final acceptance.

Placing Of Concrete by Pumping Methods

General

Placing of concrete by pumping will be as specified or authorised by Engineer to achieve the required speediness of construction and maintain targeted schedules.

Pumping of concrete shall be done only after conducting pumpability trials to ascertain the performance of fresh concrete on pumping in presence of the Engineer as per approved procedure. During pumping, concrete shall be conveyed either through rigid pipe or through flexible hose and discharged directly into the desired area. A steady supply of pumpable concrete is necessary for satisfactory pumping. Pumpable concrete requires properly graded aggregates, material uniformity, consistent batching and thorough mixing. Concrete pumps used shall be able to deliver concrete over a horizontal distance of about 400 m or of about 100 m in a vertical direction, (with intermediate figures for a combination of horizontal and vertical movements). They shall be used for concreting densely reinforced structures, internal structural elements of buildings and for large pours of concrete.

Placement of normal concrete by pumping will be permitted as specified or authorised by the Engineer. The decision, whether or not to pump any particular mix shall rest entirely with the Engineer and no extra claims for payment on this account will be entertained. The pumping equipment, pipe lines and accessories as well as proportioning of pumpable concrete shall generally confirm to the recommendations of ACI-304.2 (latest revision) – Placing of concrete by pumping method - Proportioning of pumpable mixes gives certain guide lines on concrete mix. However, final selection of mix shall be as instructed by the Engineer.

Pumping Equipment

Requisite numbers of modern dependable concrete pumps capable of pumping concrete of specified quality at a rate required to meet the construction schedules, together with a balanced complement of pipelines, accessories, spare parts, power-controlled placing booms, and experienced pump operators and maintenance staff shall be provided at locations and in a manner approved by the Engineer.

The pumping plant shall be completely installed on each occasion, with preliminary mock operation for a sufficient length of time prior to scheduled placement of a particular concrete

pour, to enable the Engineer to conduct pumpability tests and necessary adjustments for the concrete mix, prior to use of the pumping for placement of concrete.

Type Of Pump

The selection of the concrete pump shall be done as per the project requirement. The Contractor shall submit the concrete pump data sheets proving the suitability for the given project to ENGINEER for approval.

The concrete pump shall be selected on its best pumping capacity and the speediness to be achieved in the project. The piston pumps of a net horizontal pumping capacity of 30 m³/ hr or 20 m³/ hr or 15 m³/ hr or 10 m³/ hr can be utilised. The combination of various pumps to be used shall be decided by Contractor and shall submit the necessary documents and targeted progress to be achieved in line with the Time Period and Milestones.

These pumps shall have capacity to pump the concrete up to at a horizontal distance of 400 m and capable of generating a minimum pressure of 80 bar. These parameters shall depend upon the building sizes, manoeuvrability and other construction features. These pumps shall consist of a receiving hopper with a bolted grill at top of capacity not less than 600 litres. The hoppers shall be provided with hydraulically driven re-mixing blades or other agitating devices to keep the concrete mixed continuously and maintain consistency and uniformity. The pumps shall be provided with two cylinders with max. diameter not less than 150 mm, stroke of about 1200 mm and the number of strokes not exceeding 25 per minute. The outlet valves shall be located on the discharge lines. Type of inlet and outlet valves may vary depending on the manufacturer, but they shall preferably be of sliding-rod-flat-gate type. The piston shall be hydraulically driven. Primary power shall be supplied by gasoline, diesel or electric motor of requisite power rating. Care shall be taken by the Contractor to ensure uninterrupted operation of the pumps during the entire period of concreting by providing adequate standby arrangements. The primary power and pump equipment shall be either truck or trailer mounted, and not skid mounted.

Pipelines And Accessories

Rigid pipelines

Concrete transported to the placement area by pumping methods shall be pumped thorough rigid pipes or a combination of rigid and heavy-duty flexible hoses. Rigid pipe shall be made available in minimum 125 mm diameter size. Aluminium alloy lines shall not be used for delivery of concrete. Rigid pipes shall be furnished in such lengths as can be manually handled by a single person.

Flexible conduit (hose)

Flexible conduit shall be made of rubber, or spirally wound flexible metal, and plastic flexible conduits generally present greater resistance to movement of concrete and their performance is not the same as that of a rigid pipe and also larger sizes (100 mm to 123 mm) have a tendency to leak. Flexible conduits provided, shall be interchangeable with rigid pipes and their use restricted to curves, difficult placement areas, and as connection to moving cranes or to water borne lines.

Couplings

The couplings provided to connect both flexible and rigid pipe sections shall be adequate in strength to withstand handling during erection of the pipe system, misalignments, and poor support along the lines. They should be nominally rated for at least 3.45 MPa and greater for rising over 30m. The strength and tightness of joints shall be guaranteed. Couplings shall be designed to allow replacement of any pipe section without moving other pipe sections and shall provide a full internal cross-section with no obstructions or crevices to disrupt the smooth flow of concrete.

Accessories

The pump and the distribution system for a particular concreting job shall use the accessories as listed below and they shall be approved by the Engineer.

- a) Rigid and flexible pipes in varying lengths, such as 3, 1.5, 0.9, 0.6 and 0.3 m lengths.
- b) Curved sections of rigid pipes such as large radius elbows at angles of 90 deg., 45 deg., 22 deg. 30 min. and 11 deg. 15 min.
- c) Swivel joints and rotary distributors.
- d) Pin and gate valves to prevent back-flow in the pipe line.
- e) Switch valve to direct flow into another pipe line.
- f) Connection devices to fill form the bottom up.
- g) Temporary supports, rollers and other devices for protection of conduit over rock, concrete, reinforcement steel and forms. Lifting and leashing points.
- h) Extra strong coupling for vertical runs in inaccessible areas.
- i) Transition for connecting different sizes of pipes.
- j) Air vents for downhill pumping

k) Clean-out equipment

- l) Adequate numbers of separate placement booms of various radius and reach, either stationary steel column mounted or tower crane mast mounted moving on rail tracks, or truck mounted shall be provided by the Contractor to match within concrete placement schedule and pumps. For maximum flexibility of operation the separate placement boom shall be such that they can be easily lifted by the tower cranes provided. Their mounting arrangements shall be quick connecting type and interchangeable between tower crane masts, steel columns and truck mountings etc. The placement booms shall consist of three hinged parts incorporating a concrete pipe line with articulated inserts at boom joints and ending in a flexible hose. The boom shall be remote controlled.

The concrete pumping plant apart from the receiving hopper and the pump shall also be provided with a water pressure valve, connecting pipes with needle valve, cleaning rods, outlets for drainage water and a high pressure pumps for flushing out the concrete in pipe line.

The shortest way shall be selected in planning the direction of the concrete pipeline, and the number of bends (elbows) shall be as small as possible. Should a change be made of the direction in plan of the pipe lines or a change of their vertical profile, these shall be arranged with easy transitions.

Before the pipeline is assembled all pipe flanges shall be tested and carefully cleaned, packing rings cleaned or replaced, and the internal surfaces of all pipe section cleaned. Horizontal lengths of concrete pipe lines shall be laid on supports, wooden trestles, scaffolding, staging etc. Vertical and inclined lengths of pipe shall be fastened by clamp irons or stirrups to masts, or to the frame of the structure being erected. It is recommended to replace vertical sections of the pipeline by inclined sections where possible. Sharp turns and bends at an angle of 90 deg. shall be avoided. Pipes shall be supported in such a manner that they do not disturb the forms during concreting.

A vertical section of the concrete pipeline shall not be arranged closer than 8 to 9 m from the concrete pump. Before a vertical section a valve shall normally be placed, to prevent back flow of the concrete when the pump stops or when the pipe is cleaned or replaced. When pumping vertically through the placer boom, a thrust block shall be provided at the base of the vertical riser to resist the forces in the pipeline due to the pumping of concrete.

When pumping downwards, 15 m or more, it is desirable to provide an air release valve at the middle of the top bend.

Line Resistance And Lubrication

When concrete is pumped through a straight section of a pipe or hose, it moves as a cylinder riding on a thin lubricant film of a grout or mortar. At changes in direction or cross-section some re-mixing occurs. In all cases at the start of pumping operation lubricating mortar is required, and this shall be a properly designed mortar of cement-sand grout (1:1) or a batch of the regular concrete with the coarse aggregate omitted. Except for a small portion of this mortar which may be used for bedding at the construction joint, it shall be wasted and not used in the concrete placement. It can be assumed that about 0.35 cu. m of mortar will lubricate a 125 mm diameter horizontal pipeline of about 300 m length and the lubrication shall be maintained as long as the pumping continues. For vertical or smaller lines less mortar will be required. The mortar shall have the same cement content as that of the concrete. The water cement ratio shall be determined by the placing condition and finally decided by the Engineer. In order to ensure that only minimum quantity of grout mortar is used to lubricate the pipeline, a rubber sponge ball shall be allowed to pass through the pipeline immediately before the first batch of grout mortar is pumped. This rubber ball shall be pushed by the following mortar along the pipeline slowly and allowed to emerge at the open end. The cost of the lubricating mortar to be used, shall be deemed to have been included in the general rate structure for works in the schedule of items and nothing extra shall be payable.

It shall be taken into account when planning the pipeline that, in straight horizontal and vertical section of pipe and at bends the resistance to the movements of concrete differ. For convenience in calculating the resistance of a concrete pipeline experimental co-efficient of equivalent length shall be used by means of which the equivalent length of a horizontal concrete pipeline is to be obtained. In absence of the pump manufacturer's data, equivalent lengths of concrete pipeline as indicated in **Error! Reference source not found.** may be used.

Table: EQUIVALENT LENGTH OF CONCRETE PIPELINES

Characteristics of a length of concrete	Equivalent length of horizontal pipeline Concrete pipeline in meter
Bend in pipeline at an angle of 90 deg.	12
Bend in pipeline at an angle of 45 deg.	7
Bend in pipeline at an angle of 22 deg. 30 min.	4
1 m of vertical concrete pipeline	8

The equivalent length of the concrete pipeline must be less than or equal to the range of feed in horizontal direction as specified by the pump manufacturer for the same rate of pumping. To obtain the least line resistance, the layout of the pipeline system shall contain a minimum number of bends and preferably with no change in pipe size. If two sizes of pipes are required to be used, the smaller diameter shall be used at the pump end and the larger at the discharge end. The contractor shall exercise care in handling of the pipeline, during assembly, cleaning and dismantling so as to lower the line resistance by preventing the formation of rough surfaces, dents in pipe section and crevices in couplings. If any pipe, bend, coupling and other accessories are considered to be defective or damaged by the Engineer, the same shall not be used in the concrete pipeline till such time the defect has been removed and the damage repaired to the entire satisfaction of the Engineer. Qualified chemical admixtures shall be used effectively to get workable concrete.

Proportioning Pump Able Concrete

Basic Consideration

Although the ingredients of concrete to be placed both by pumping and by other means are the same, more emphasis shall be laid on the quality control and proportioning of a dependable pumpable mix. Dependability is effected by the equipment and the operator, with the control of all of the ingredients in the mixture, the batching and mixing operations, and the knowledge and experience of all the personnel from beginning to end.

Concrete mixes for pumping shall be “plastic” at all times. Stiff mixes shall not be used for pumping as they do not pump well. Particular attention shall be given to the mortar (cement, sand and water) and the amounts and sizes of coarse aggregates.

Normal Weight Aggregates

Coarse normal weight aggregates

The maximum size of angular coarse aggregate shall be limited to one-third of the smallest inside diameter of the hose or pipe based on simple geometry of cubical shape aggregates. For well-rounded aggregates, the maximum size shall be limited to 40% of the pipe or hose diameter. Adequate provisions shall be made to eliminate over size particles in the concrete by screening or by careful selection of aggregate. Gradation of sizes of coarse aggregates shall correspond to Grades A and B of **Error! Reference source not found.** and shall meet IS: 2386 requirements. If required certain fractional sizes shall be combined and blended to

produce the required gradation. Greater emphasis shall be laid on uniformity of gradation throughout the entire job.

The maximum size of the coarse aggregate has a significant effect on the volume or amount of coarse aggregate that may be effectively used in a mix. As will be seen from **Error! Reference source not found.** the quantity of coarse aggregate must be substantially reduced as the maximum size become smaller. Mixes consisting of too large a portion of coarse aggregate with less cement shall be avoided.

Table. GRADING REQUIREMENT OF COARSE AGGREGATES FOR PUMPED CONCRETE

Grade - A (Maximum Size 40 mm)		Grade –B (Maximum Size 20 mm)	
Sieve Size(mm)	Percent Passing	Sieve Size(mm)	Percent Passing
50	100	25	100
40	95 to 100	20	90 to 100
20	35 to 70	12.5	20 to 55
10	10 to 30	10	0 to 15
4.75	0 to 5	4.75	0 to 5

Table. VOLUME OF COARSE AGGREGATE PER UNIT OF VOLUME OF CONCRETE

Max. size	Volume of Dry-rodded Coarse Aggregate per Unit volume of aggregates of concrete for different fineness moduli of sand			
	FMS =2.40	FMS =2.60	FMS =2.80	FMS =3.00
10	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
20	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
40	0.76	0.74	0.72	0.70
50	0.78	0.76	0.74	0.72

Note:

Volume is based on aggregates in dry-rodded condition.

These volumes are selected from empirical relationships to produce concrete with a degree of workability suitable for usual reinforced construction. When placement is to be by pump, they shall be reduced by about 10 percent.

FMS = Fineness Modulus of Sand.

Fine normal weight aggregate

Fine aggregate shall consist of natural sand, manufactured sand or a combination thereof and shall be graded within the following limits.

Sieve Size	Percent passing by weight
9.5 mm	100
4.75 mm	95 to 100
2.36 mm	80 to 100
1.18 mm	50 to 85
600 microns	25 to 60
300 microns	10 to 30
150 microns	2 to 10

Fine aggregates shall conform to the requirements of IS: 2386. Particular attention shall be given to those passing through finer screen sizes. For small line system (less than 150 mm) 15 to 30 percent shall pass 300 micron sieve and 5 to 10 percent shall pass 150 micron sieve. Sands which are deficient in either of these two sizes shall be blended with selected finer sands or inert material such as quarry dust to produce these desired percentages.

The fineness modulus of sand meeting the above grading limits will fall between 2.13 and 3.37 with the median being 2.75. Pumpability of mixes will generally improve with a decrease in the fineness modulus value or in other words with the use of finer sands. Sands having a fineness modulus between 2.40 and 3.00 are generally satisfactory provided that the percentages passing 300 micron and 150 micron sieves meet the previously stated requirements. It shall also be emphasized that for uniformity, the fineness modulus of the sand shall not vary more than 0.20 from the average value used in proportioning.

Table above is suggested as a guide to determine the amounts of coarse aggregate to be combined with sand of different fineness modulus.

Although in practice it may not be possible to duplicate this recommended sand gradation exactly, sands having a gradation closer to the upper limit (fine sand) are more desirable for

pumping than those near the lower limit (coarse sand). The fineness modulus of sand according to the recommended curve is 2.68 and the gradation meets all the requirements stated earlier.

Water And Slump

Water requirements and slump control for pumpable normal weight concrete are interrelated and extremely important considerations. The mixing water requirements for a particular mix shall be determined by the Engineer and modified to suit the fineness of sands, quality of admixtures, additives, cement replacements or other special materials being used in the concrete.

The Contractor shall establish the optimum slump jointly with the Engineer for a pumpable mix at the discharge hose end and shall maintain control of that particular slump throughout the course of a job. Excess water shall not be added in the receiving hopper to make the concrete mix pumpable, instead attempt shall be made to obtain 'truly plastic mix' by proper proportioning.

Slump of concrete may undergo change between initial mixing and final placement. If the slumps at the discharge hose end are to be maintained within specified limits, it will be necessary for the concrete to enter the pump at a higher slump to give the required mobility during transport. Slump adjustments by re-proportioning of the constituents as may be required shall be carried out by the Contractor jointly in consultation with the Engineer for every type of mix and for every new placement and set up of pump and pipelines.

Cement Content

- The determination of the cement content for a normal weight pump mix shall follow the same basic principles used for conventionally placed concrete. The water cement ratio shall be established by the Engineer on the basis of exposure conditions, strength requirements or minimum cement consumption, whichever governs. However, because of slightly higher ranges of slump and ratios of fine to coarse aggregates, the pump mix may require an increase in the amount of cement above those pumpable concrete mass. The total quantity of fines passing through the 300 micron sieve including cement, fine sand, stone dust etc shall be in the range of 380 to 450 kg/cu.m. of concrete.
- Cement content in case of M-50 shall be maximum 425 kg/m³, and shall be a mix with high range of workability i.e. 175 mm +/- 25 mm. All the contents shall be mixed based on the mix design & trial studies.
- While establishing the cement content for normal weight trial mixes, it will be necessary to take into account the capabilities of the particular pump and its operator for over strength proportioning in the laboratory to provide for field variations.

- In case of pumping difficulties, it is desirable and economical to correct any deficiencies in the aggregates, especially in the sand instead of using extra quantities of sand. With well graded coarse and fine aggregates properly combined, the cement requirement for pumpable mixes shall closely resemble to those used in conventionally placed concrete.

Admixtures

The use of poor aggregate grading or aggregate with continuous change in overall grading of the 'combinations' during concreting operation will make special admixtures quite useful in overcoming the main difficulty like blockage in pumping. These admixtures shall be incorporated in pumpable concrete to aim the following.

- Increase in the range of mix designs which may be successfully pumped using water reducing admixtures/Super plasticizers with the approval of the Engineer.
- Reducing the risk of pipeline blockages by preventing segregation of concrete mix.
- To have satisfactory/specified performance both in fresh and hardened state.
- Any admixture that increases workability in normal weight concrete may usually improve pumpability. The choice of type of admixture and the advantage gained from its use in concrete to be pumped will depend on the characteristics of the pump mix and will be finally decided by the Engineer in consultation with the admixture manufacturer.

For improvement of pumpability the following admixtures are generally recommended. Such admixtures used shall conform to ASTM C-494/IS 9103.

Water Reducing Admixtures/Super Plasticizers

These cause reduction in water requirements at constant slump or an increase in slump at constant water-cement ratio. They can be designed to have no apparent effect on setting time, or alternately to achieve varying degrees of acceleration or retardation in rate of hardening of the mixture. Most water reducing admixtures increase the pumpability of the concrete mix through plasticising action.

- **Air Entraining Admixtures**

Air entrained concrete is considerably plastic and more workable than non air entrained concrete. It can be pumped with less coarse aggregate segregation and has fewer tendencies for concrete to bleed. Start-up after shut down is also generally easier due to reduced bleeding. For pumped concrete these limits shall be obtained at the point of placement in the structure. To compensate for air content loss in the air entrained concrete higher entrainment of air may be required at the batching plant. The required adjustment of admixture dose shall be carried out by the Engineer after carrying out necessary air loss tests. An air content in the range of 3 to 5 % shall be preferred as higher ranges reduces the delivery capacity of pump

systems due to increased compressibility of the concrete and also reduces strength of concrete.

If air-entraining plasticizer is used, typically 13 % minimum water reduction is possible. Therefore, strength loss due to air entrainment will be compensated by using such air-entraining plasticizer.

- **Finely Divided Mineral Admixtures**

Contractor, if specifically approved by the engineer, can use mineral admixture. In concrete mixtures, deficient in fines, the addition of a finely divided inert mineral admixture generally improves workability, pumpability, reduces the amount of bleeding and increases the strength. The effect on strength depends on the type of mineral admixture used, conditions under which the concrete is cured, and the amount of admixture used. Water soluble polymers obtained from cellulose derivations may also be used as an admixture with a small dose of 60 to 150 gms/cu.m to increase viscosity of the mixing water and reduce the frictional resistance to flow and bleeding in the pipe system.

Trial Mixes

The trial mixes for pumping shall be prepared and tested in the Site laboratory by contractor in accordance with specification. The ingredients, particularly the coarse and fine aggregates shall also be checked for the conformance to the desired properties described, by the contractor. Above table may be used to select the volume of coarse aggregate per cu. m. of concrete. In using this table it is recommended that the highest probable fineness modulus of sand be used rather than the average fineness modulus to ensure consistent performance during pumping. For additional plasticity, 10 % reduction in coarse aggregate quantities shall be considered. Experience with the use of local aggregate and their uniformity shall also be considered in the proportioning concepts.

Mix Design For Pumpable Concrete

Taking the above factors into account, the concrete shall first be designed for normal placement conditions and then modified as necessary to suit pumping. The following procedure shall be adopted:

- Design the mix for specified characteristic strength and workability.
- Check and ensure combined grading of aggregates i.e. as uniform grading as possible. This requirement is vital as gaps or partial gaps are the basic reasons for poor water retention property and segregation under pressure.

- Determine the optimum sand content for the required workability and increase sand content by reducing volume of coarse aggregate per unit volume of concrete by about 10 % as a degree of protection against under sanding due to batch variations.
- Recheck the minimum cement content for durability.
- Examine the total fines content i.e. cement and fine aggregates passing through 300 micron sieve and readjust the mix, if necessary. A very rich mix with fine sand will be as problematic as coarse sand with lean mix.
- Re-appraise the grading if the particle shape of any particular fraction is such as may cause excessive voids. Re-adjust as required, if necessary examining the void ratio of various combinations, using void meter to achieve minimum voids at the expense of 'sufficient fines' content.
- If dissatisfied with (a) to (f) as above, consider what remedial action may be taken to overcome the troublesome factor. For example, the following two situations may occur :
- If the sand has more coarser fraction it is worth considering the addition of a proportion of finer sand, or alternately if the sand has finer fraction, the addition of coarse fraction may be considered. Addition or reduction of cement may help, but the correct solution is to overcome the gap in overall grading as stated above.
- In a 20 mm aggregate max size, if there is an excess of 10 to 4.75 mm fraction, and this fraction is flaky with unduly large surface area, either increase the sand content to reduce the possibility of segregation and to reduce the inter-practical stresses, or (better) re-grade using single sized aggregates.
- At the trial mix stage small variations can be made preferably in the light of the pressures registered and observed performances through the pump. In certain cases admixtures may be economically and beneficially used to improve or eliminate circumstances that cannot readily be overcome by other means

Testing For Pumpability

No mix shall be accepted for use on a pumping job until an actual test under field condition has been completed. Testing a mix for pumpability involves duplication of the anticipated job condition from beginning to end. The batching and conveying by truck mixers shall be the same as will be used, the same pump and operator shall be present. The pipe and hose layouts shall simulate the actual condition as far as practicable. Prior use of a mix on another job may furnish evidence of pumpability but only if conditions are duplicated. Before commencing a new concreting job, the contractor shall carry out pumpability tests in consultation with the Engineer. Concrete used in such tests shall not be used in the actual construction, unless specifically permitted by the Engineer.

Following parameter shall be established by pumpability trials:

- Insitu compressive & split tensile strength of concrete by
- Curing the sample at Site by sprinkling water.
- Curing the sample at Laboratory in curing tanks.
- Wet sieve analysis of concrete to ensure that proportions of ingredients before and after pumping are same.

Field Practices

- Proper planning of concrete supply, pump location, line layout, placing sequence and the entire pumping operation shall be done by the Contractor and got approved by the Engineer on every occasion before commencement of concreting job. The pump shall be as near the placing area as practicable, and the entire surrounding area must have adequate bearing strength to support the concrete delivery trucks, thus assuring a continuous supply of concrete. For important concrete placements and large jobs, adequate standby power and pumping equipment shall be provided as replacement, should break down occur.
- Direct communications shall be maintained between the pump operator, concrete placing crew and batching plant. The placing rate shall be estimated so that concrete can be operated at an appropriate delivery rate. As a final check, the pump shall be started and operated without concrete to ascertain that, all moving parts are operating properly. As stated previously, the grout mortar shall be pumped into the line to provide initial lubrication for the concrete. As soon as concrete is received, the pump shall be run slowly until the lines are completely full and the concrete is slowly moving. Once the pumping is started, the operator shall ensure that the hopper of the pump is not emptied beyond a certain level, as air may enter the pipeline and cause choking. Continuous pumping should be ensured. If a delay occurs because of concrete delivery, form repairs, or other factors, the pump shall be slowed down to maintain some movement of the concrete till normal supply is resumed. For longer delays, the concrete in the receiving hopper shall be made to last as long as possible by moving the concrete in the lines occasionally with one stroke of the pump. In confined areas, attempt shall be made by the Contractor to run a return line back to the pump, so that concrete can be re-circulated during delays.
- The Contractor shall ensure that obstructions are not found in the pipe due to interruption in the feed of the concrete by more than 30 to 45 minutes.
- Minor blockages shall be cleared by operating a few strokes of the pump in reverse momentarily and then by returning to normal forward pumping. If this fails, a succession of reverse and forward strokes shall be carried out to remove the blockage. Should this fail also, the blockage may be due to air-lock and the entrapped air has to be removed.

- Attempt to push through the obstructions by repeatedly starting the pump will result in compaction of the concrete and complicate the removal of the concrete in the pipe. Blockages in the pipe are usually discovered by the sound when the pipe is struck. To remove the obstruction, the concrete pipe shall be taken apart at the assured position and cleaned. Then the pumping process shall be started all over again.
- This method of checking the blockage and setting it right shall be done with great speed as excessive delay will cause setting of concrete in the pipeline downstream of the choke and will lead to further blockage. When the blockage is being found out and remedied, the pump shall periodically be given one or two strokes forward to keep the concrete in motion. If blockage occurs in the placer boom, a pipe joint near the base of the placer boom shall be opened and the boom made vertical to drain the pipeline by gravity.
- Cleaning blockages are time consuming and as such major blockages shall best be avoided by ensuring a pumpable mix. Concrete that is either under or over sanded, short of fines, gap graded, has an excess of a particular size, or excessively wet or dry will be rejected by the pump either by blockage or by hard pumping involving excessive pressures.
- The termination of pumping operations shall be carefully planned to utilize the concrete dormant in the pipeline and the hopper when the pump is stopped and to avoid wastage.
- When the form is nearly full, and there is enough concrete in the line to complete the placement, the pump shall be stopped and a go-devil be inserted and forced through the line to clear it out. Water under pressure shall be used to push the go-devil. The go-devil shall be stopped about one metre from the end of the line, so that the water in the line will not spill over into the placement area. After flushing, water in the pipe shall be removed by drain cock which shall be located for this purpose in the lowest part of the line. After all concrete has been removed from the lines, all lines and equipment shall be immediately cleaned thoroughly.

Quality Control

- Contractor shall ensure that workmanship and plant shall be maintained at peak efficiency. Degree of control on all the concrete operation from selection of the ingredients to the final testing of specimen shall be in line with the assumptions made in mix design with respect to the standard deviation and co-efficient of variation.
- The Contractor shall ensure that any compromise in quality is not done for the pumped concrete. To be pumpable, a high level of quality control for the assurance of uniformity must be maintained. Sampling at both the truck discharges and point of final placement shall be done by the Contractor and the Engineer jointly, as frequently as the Engineer desires to determine, if any change in the slump air content, and other significant mix characteristics occur take necessary corrective actions.

- The Contractor shall engage experienced supervision at all levels. The placing crew shall be experienced and qualified and each operation shall be well planned and properly scheduled.
- All the crew engaged in each of the concrete activities shall demonstrate in the presence of the Engineer, their skills and capabilities to produce the final product as specified.

Mass Concrete Works

Sequence of pouring for mass concrete works shall be as approved by ENGINEER. CONTRACTOR shall exercise great care to prevent shrinkage cracks and shall monitor the temperature of the placed concrete if directed.

Placing temperature of concrete

Placing temperature of concrete should be maintained as specified in Bill of Quantities or as directed by ENGINEER, to avoid shrinkage cracking.

Mixing water shall be kept cool by storing it under cover. Chilled water or crushed ice as part of the mixing water to achieve the specified placing temperature shall be used. For chilled water, it is recommended that the contractor install and maintain refrigeration facility of required capacity. The contractor shall also build and maintain well insulated adequate capacity storage tank for cold water with insulated connected piping. To supplement this refrigeration facility, the contractor will have to have ice plant or use commercial ice subject to approval of the ENGINEER. The full quantity of crushed ice shall be stored in cold storage 24 hours in advance of the start of concreting. The temperature in cold storage shall not be more than -20°C . The contractor should study the placing temperature condition and work out plant capacity commensurate with the construction schedule requirements and submit his scheme along with the tender.

Ice when used as replacement for a portion or all the mixing water shall be produced from water which meets the requirements of specification. Ice when used shall be in flakes of size 3mm or below or crushed condition and the crushed ice shall be such as to pass completely, 10mm sieve.

Curing

Curing and protection shall start immediately after the compaction of the concrete to protect it from:

- Premature drying out, particularly by solar radiation and wind;
- leaching out by rain and flowing water;
- rapid cooling during the first few days after placing;

- high internal thermal gradients;
- low temperature or frost;
- Vibration and impact which may disrupt the concrete and interfere with its bond to the reinforcement.

All concrete, unless directed otherwise by ENGINEER, shall be cured by use of continuous sprays or ponded water or continuously saturated coverings of sacking, canvas, hessian or other absorbent material for the period of complete hydration with a minimum of 7 days. The quality of curing water shall be the same as that used for mixing.

Where a curing membrane is directed to be used by the ENGINEER, the same shall be of a non-wax base and shall not impair the concrete finish in any manner. The curing compound to be used shall be got approved from the ENGINEER before use and shall be applied with spraying equipment capable of a smooth, even textured coat.

Curing may also be done by covering the surface with an impermeable material such as polyethylene, which shall be well sealed and fastened.

Extra precautions shall be exercised in curing concrete during cold and hot weather as per Clause no. 8.3 of IS: 7861(Part II) and Clause no. 8.2 of IS:7861(Part I) respectively.

Curing arrangement shall be subjected to ENGINEER's approval.

Construction Joints And Keys

Construction joints (location and type) shall be as shown on the drawing or as approved by ENGINEER. Concrete shall be placed without interruption until completion of work between construction joints. If stopping of concreting becomes unavoidable anywhere, a properly formed construction joint shall be made with the approval of ENGINEER.

Dowels for concrete work, not likely to be taken up in the near future, shall be coated with cement slurry and encased in lean concrete as indicated on the drawings or as directed by ENGINEER.

Before resuming concreting on a surface which has hardened all laitance and loose aggregates shall be thoroughly removed by wire brushing and/ or hacking, the surface washed with high pressure water jet and treated with thin layer of cement slurry for vertical joints and a 15 mm thick layer of cement sand mortar for horizontal joints, the ratio of cement and sand being the same as in the concrete mix.

When concreting is to be resumed on a surface, which has not fully hardened, all laitance shall be removed by wire brushing, the surface wetted, free water removed and a coat of cement slurry applied. On this a layer of concrete not exceeding 150 mm thickness shall be placed and well rammed against the old work. Thereafter work shall proceed in the normal way.

Approved epoxy Bonding agent, for bond between old (say 28 days or more) and new concrete shall be used as per manufacturer's specifications.

Foundation Bedding

All earth surfaces upon which or against which concrete is to be placed, shall be well compacted and free from standing water, mud or debris. Soft or spongy area shall be cleaned out and back filled with either soil-cement mixture, lean concrete or clean sand compacted as directed by ENGINEER. The surfaces of absorptive soils shall be moistened.

Concrete shall not be deposited on large sloping rock surfaces. The rock shall be cut to form rough steps or benches by picking, barring or wedging. The rock surface shall be kept wet for 2 to 4 hours before concreting.

Base Concrete

The thickness and grade of concrete and reinforcement shall be as specified in the item of work.

Before placing the blinding concrete as per the item of work, the sub-base of rubble packing shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

Finishes

General

The formwork for concrete works shall be such as to give the finish as specified. The CONTRACTOR shall make good as directed any unavoidable defects consistent with the type of concrete and finish specified; defects due to bad workmanship (e.g. damaged or misaligned forms, defective or poorly compacted concrete) will not be accepted. CONTRACTOR shall construct the formwork using the correct materials and to meet the requirements of the design and to produce finished concrete to required dimensions, plumbs, planes and finishes.

Integral Cement Finish On Concrete Floor

In all cases where integral cement finish on a concrete floor has been specified, the top layer of concrete shall be screeded off to proper level and tamped with tamper having conical projections so that the aggregate shall be forced below the surface. The surface shall be finished with a wooden float and a trowel with pressure. The finish shall be continued till the concrete reaches its initial set. No cement or cement mortar finish shall be provided on the surface. Where specified, a floor hardener of appropriate thickness as approved by the ENGINEER shall be supplied and used as recommended by the manufacturer.

Repair And Replacement Of Unsatisfactory Concrete

Immediately after the shuttering is removed, all the defective areas such as honeycombed surfaces, rough patches, etc. shall be brought to the notice of ENGINEER who may permit patching of the defective areas or reject the concrete work. ENGINEER'S decision on rejection of concrete work shall be final.

All through holes for shuttering shall be filled with non shrink cement mortar for full depth and neatly plugged flush with surface.

Rejected concrete shall be removed and replaced by CONTRACTOR at no additional cost to OWNER.

For patching of defective areas all loose materials shall be removed and the surface shall be prepared as directed by the ENGINEER.

Bonding between hardened and fresh concrete shall be done either by placing cement mortar or by applying epoxy. The decision of the ENGINEER as to be the method of repairs to be adopted shall be final and binding on the CONTRACTOR and no extra claim shall be entertained on this account. The surface shall be saturated with water for 24 hours before patching is done with 1:5 cement sand mortar. The use of epoxy for bonding fresh concrete shall be carried out as directed by ENGINEER.

CONTRACTOR shall submit a method statement for such repairs to ENGINEER for approval.

Vacuum Dewatering Of Slabs

Where specified floor slabs, either on grade or suspended, shall be finished by vacuum dewatering including all operations such as poker vibration, surface vibration, vacuum processing, floating and trowelling as per equipment manufacturer's recommendation. The equipment to be used shall be subject to ENGINEER'S approval.

Hot Weather Requirement

Concreting during hot weather shall be carried out as per IS:7861 (Part I).

Adequate provisions shall be made to lower concrete temperatures which shall not exceed 40 °C at the time of placement of fresh concrete.

Where directed by ENGINEER, CONTRACTOR shall spray non-wax based curing compound on unformed concrete surface at no extra costs.

Cold Weather Requirements

Concreting during cold weather shall be carried out as per IS:7861 (PART 2).

The ambient temperature during placement and upto final set shall not fall below 5 deg.c.

Approved anti-freeze/accelerating additive shall be used where directed.

For major and large scale concreting works the temperature of concrete at times of mixing and placing, the thermal conductivity of the formwork and its insulation and stripping period shall be closely monitored.

Liquid Retaining Structures

The CONTRACTOR shall take special care for concrete of liquid retaining structures, underground structures and those other specifically called for to guarantee the finish and water tightness.

The minimum level of surface finish for liquid retaining structures shall be of smooth type. All such structures shall be hydro-tested.

The CONTRACTOR shall include in his price hydro-testing of structure, all arrangements for testing such as temporary bulk heads, pressure gauges, pumps, pipe lines, etc.

Any temporary arrangements that may have to be made to ensure stability of the structures shall also be considered to have been taken into account while quoting the rates.

Any leakage that may occur during the hydro-test or subsequently during the defects liability period or the period for which the structure is guaranteed shall be effectively stopped either by cement/epoxy pressure grouting, guniting or such other method as may be approved by the ENGINEER. All such rectification shall be done by the CONTRACTOR to the entire satisfaction of the OWNER/ENGINEER at no extra cost to the OWNER.

Testing Concrete Structures for Leakage

Hydro-static test for water tightness shall be done at full storage level or soffit of cover slab, as may be directed by ENGINEER, as described below:

In case of structures whose external faces are exposed, such as elevated tanks, the requirements of the test shall be deemed to be satisfied if the external faces show no sign of leakage or sweating and remain completely dry during the period of observation of seven days after allowing a seven day period for absorption after filling with water.

In the case of structures whose external faces are submerged and are not accessible for inspection, such as underground tanks, the structures shall be filled with water and after the expiry of seven days after the filling; the level of the surface of the water shall be recorded. The level of water shall be recorded again at subsequent intervals of 24 hrs over period of seven days. Backfilling shall be withheld till the tanks are tested. The total drop in surface level over a period for seven days shall be taken as an indication of the water tightness of the structure. The ENGINEER shall decide on the actual permissible nature of this drop in the surface level, taking into account whether the structures are open or closed and the corresponding effect it has on evaporation losses. Unless specified otherwise, a structure whose top is covered shall be deemed to be water tight if the total drop in the surface level over a period of seven days does not exceed 40 mm.

Each compartment/segment of the structure shall be tested individually and then all together. For structures such as pipes, tunnels, etc. the hydrostatic test shall be carried out by filling with water, after curing as specified, and subjecting to the specified test pressure for specified period. If during this period the loss of water does not exceed the equivalent of the specified rate, the structure shall be considered to have successfully passed the test.

Optional Tests

If ENGINEER feels that the materials i.e. cement, sand, coarse aggregates, reinforcement and water are not in accordance with the specifications or if specified concrete strengths are not obtained, he may order tests to be carried out on these materials in laboratory, to be approved by the ENGINEER, as per relevant IS Codes. OWNER shall pay only for the testing of material supplied by the OWNER; otherwise CONTRACTOR shall have to pay for the tests. Transporting of all material to the laboratory shall however be done by the CONTRACTOR at no extra cost to OWNER.

In the event of any work being suspected of faulty material or workmanship requiring its removal or if the works cubes do not give the stipulated strength, ENGINEER reserves the right to order the CONTRACTOR to take out cores and conduct tests on them or do ultrasonic testing or load testing of structure, as per relevant IS specifications. All these tests shall be carried out by CONTRACTOR at no extra cost to the OWNER. Alternately ENGINEER also reserves the right to ask the CONTRACTOR to dismantle and re-do such unacceptable work at the cost of CONTRACTOR.

If the structure is certified by ENGINEER as having failed, the cost of the test and subsequent dismantling/reconstruction shall be borne by CONTRACTOR.

The quoted unit rates/prices of concrete shall deemed to provide for all tests mentioned above.

Grouting

Quality Control

CONTRACTOR shall submit his detailed Quality Assurance Plan along with the bid. This would be reviewed, appropriately modified and approved by engineer after the award of contract.

Inspection

All materials, workmanship and finished construction shall be subject to continuous inspection and approval of ENGINEER. Materials rejected by ENGINEER shall be expressly removed from site within 3 working days and shall be replaced by CONTRACTOR immediately at no extra cost to OWNER.

Clean-Up

Upon the completion of concrete work, all forms, equipment, construction tools, protective coverings and any debris, scraps of wood, etc. resulting from the work shall be removed and the premises left clean.

Acceptance Criteria

Any concrete work shall satisfy the requirements given below individually and collectively for it to be acceptable.

- properties of constituent materials;
- characteristic compressive strength;
- specified mix proportions;
- minimum cement content;
- maximum free-water/cement ratio;
- workability;
- temperature of fresh concrete;
- density of fully compacted concrete;
- cover to embedded steel;
- curing;
- tolerances in dimensions;
- tolerances in levels;
- durability;
- surface finishes;

- special requirements such as :
- Water tightness
- resistance to aggressive chemicals
- resistance to freezing and thawing
 - o very high strength
 - o improved fire resistance
 - o wear resistance
 - o resistance to early thermal cracking

ENGINEER's decision as to the acceptability or otherwise of any concrete work shall be final and binding on the CONTRACTOR.

For work not accepted, ENGINEER may review and decide whether remedial measures are feasible so as to render the work acceptable. ENGINEER shall in that case direct the CONTRACTOR to undertake the remedial measures. These shall be expeditiously and effectively implemented by CONTRACTOR. Nothing extra shall become payable to CONTRACTOR by OWNER for executing remedial measures.

PRECAST REINFORCED CONCRETE

General Requirements

Precast reinforced concrete units such as columns, fencing posts, door and window frames, lintels, chajjas, copings, sills, shelves, slabs, louvers etc. shall be of grade of mix as specified and cast in forms or moulds. The forms/ moulds shall be of fibre glass or of steel sections for better finish. Provision shall be made in the forms and moulds to accommodate fixing devices such as nibs, clips, hooks, bolts and forming of notches and holes. The contractor may precast the units on cement or steel platform which shall be adequately oiled provided the surface finish is of the same standard as obtained in form. Each unit shall be cast in one operation.

CONCRETE USED FOR PRECASTING THE UNITS SHOULD BE WELL PROPORTIONED, MIXED, PLACED and thoroughly compacted by vibrations or tamping to give a dense concrete free from voids and honey combing.

Precast articles shall have a dense surface finish showing no coarse aggregate and shall have not cracks or crevices likely to assist in disintegration of concrete or rusting of steel or other defects that would interfere with the proper placing of the units. All angle of the precast units with the exception of the angles resulting from the splayed or chamfered faces shall be true right angles. The arises shall be clean and sharp except those specified or shown to be

rounded. The wearing surface shall be true to the lines. On being fractured, the interior of the units should present a clean homogeneous appearance.

The longitudinal reinforcement shall have a minimum cover of 12 mm or twice the diameter of the main bar, whichever is more, unless otherwise directed in respect of all items except fencing posts or electric posts where the minimum cover shall be 25 mm.

Curing

After having been cast in the mould or form the concrete shall be adequately protected during setting in the first stages of hardening from shocks and from harmful effects of frost, sunshine, drying winds and cold. The concrete shall be cured at least for 7 days from the date of casting. The precast articles shall be matured for 28 days before erection or being built in so that the concrete shall have sufficient strength to prevent damage to units when first handled.

Marking

Precast units shall be clearly marked to indicate the top of member and its location and orientation in the structure.

Precast units shall be stored, transported and placed in position in such as manner that they will not be overstressed or damaged.

GENERAL BUILDING WORKS

APPLICABLE CODES AND SPECIFICATIONS

The more important Codes, Standards and Publications applicable to this section are listed hereinafter:

Code Reference	Description
IS: 110	Ready mixed paint, brushing, grey filler, for enamels for use over primers
IS: 269	Specification for 33 grade Ordinary Portland Cement
IS: 280	Specification for mild steel wire for general engineering purposes
IS: 287	Recommendations for maximum permissible moisture content of timber used for different purposes
IS: 383	Specification for coarse and fine aggregates from natural sources for concrete
IS: 456	Code of practice for plain and reinforced concrete

Code Reference	Description
IS: 712	Specification for building limes
IS: 1077	Specification for common burnt clay building bricks
IS: 1124	Method of test for determination of water absorption, apparent specific gravity and porosity of natural building stones
IS: 1200	Methods of measurement of building and Civil engineering works
IS: 1489 (Part 1)	Portland Pozzolana Cement: Flyash based
IS: 1489 (Part 2)	Portland Pozzolana Cement: Calcined clay based
IS: 1542	Specification for sand for plaster
IS: 1597	Code of practice for construction of stone masonry: Part 1 Rubble stone masonry
IS: 1661	Code of practice for application of cement and cement-lime plaster finishes
IS: 1834	Specification for hot applied sealing compound for joint in concrete
IS: 2074	Ready mixed paint, air drying, red oxide-zinc chrome, priming
IS: 2116	Specification for sand for masonry mortars
IS: 2185	Specification for concrete masonry units (Parts 1 & 2)
IS: 2212	Code of practice for brickwork
IS: 2250	Code of practice for preparation and use of masonry mortars
IS: 2395 (Parts 1 & 2)	Code of practice for painting concrete, masonry and plaster surfaces (Parts 1 & 2)
IS: 2402	Code of practice for external rendered finishes
IS: 2572	Code of practice for construction of hollow concrete block masonry
IS: 2645	Specification of integral cement waterproofing compounds
IS: 2691	Specification for burnt clay facing bricks
IS: 2750	Steel Scaffoldings
IS: 3620	Specification for laterite stone block for masonry
IS: 3696	Safety code of scaffolds and ladders (Parts 1 & 2)
IS: 4082	Recommendation of Stacking and Storage of construction materials

Code Reference	Description
IS: 5410	Cement paint, colour, as required
IS: 6041	Code of practice construction of autoclaved cellular concrete block masonry
IS: 6042	Code of practice for construction of light weight concrete block masonry
IS: 8042	Specification for white Portland cement
IS: 8112	Specification for 43 grade Ordinary Portland Cement
IS: 12269	Specification for 53 grade Ordinary Portland Cement
Legend	IS = Indian Standards

QUALITY ASSURANCE AND QUALITY CONTROL

- The work shall conform to high standards of design and workmanship, shall be structurally sound and aesthetically pleasing. Quality standards prescribed shall form the backbone for the Quality Assurance and Quality Control system.
- At the site level the Contractor shall arrange the materials, their stacking/ storage in appropriate manner to ensure the quality. Contractor shall provide equipment and manpower to test continuously the quality of materials, assemblies, etc., as directed by the Engineer. The tests shall be conducted continuously and the results of tests maintained. In addition, the Contractor shall keep appropriate tools and equipment for checking alignments, levels, slopes and evenness of the surface.
- The Engineer shall be free to carry out such tests as may be decided by him at his sole discretion, from time to time, in addition to those specified in this document. The Contractor shall provide the samples and labour for collecting the samples. Nothing extra shall be payable to the Contractor for samples or for the collection of the samples.
 - o The test shall be conducted at the Site laboratory that may be established by the Contractor or at any other Standard Laboratory selected by the Engineer.
 - o The Contractor shall transport the samples to the laboratory for which nothing extra shall be payable. In the event of Contractor failing to arrange transportation of the samples in proper time Engineer shall have them transported and recover two times the actual cost from the Contractor's bills.
 - o The testing charges shall be borne by the Contractor.
 - o Testing may be witnessed by the Contractor or his authorised representative. Whether witnessed by the Contractor or not, the test results shall be binding on the Contractor.

BRICKWORK

Materials

Bricks used in the works shall conform to the requirements laid down in IS: 1077. The class of the bricks shall be as specifically indicated in the respective items of work.

The nominal size of the modular brick shall be 200 mm x 100 mm x 100 mm with the permissible tolerances over the actual size of 190 mm x 90 mm x 90 mm as per IS: 1077. The nominal thickness of one brick and half brick walls using modular bricks shall be considered as 200 mm and 100 mm respectively. In the event of use of traditional bricks of nominal size 230 mm x 115 mm x 75 mm with tolerance up to ± 3 mm in each dimension, one brick and half brick walls shall be considered as 230 mm and 115 mm respectively.

Bricks shall be sound, hard, homogenous in texture, well burnt in kiln without being vitrified, hand/ machine moulded, deep red, cherry or copper coloured, of regular shape and size and shall have sharp and square edges with smooth rectangular faces. The bricks shall be free from pores, cracks, flaws and nodules of free lime. Hand moulded bricks shall be moulded with a frog and those made by extrusion process may not be provided with a frog. Bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 5 N/mm² unless otherwise specified in the items of work.

The average water absorption shall not be more than 20% by weight up to class 12.5 and 15% by weight for higher classes. Bricks which do not conform to this requirement shall be rejected. Over or under burnt bricks are not acceptable for use in the works.

Sample bricks shall be submitted to the Engineer for approval and bricks supplied shall conform to approved samples. If demanded by Engineer, brick samples shall be got tested as per IS: 3495 by Contractor. Bricks rejected by Engineer shall be removed from the site of works within 24 hours.

Mortar for brick masonry shall consist of cement and sand and shall be prepared as per IS: 2250. Mix shall be in the proportion of 1:5 for brickwork of thickness one brick or above and 1:4 for brickwork of thickness half brick or below, unless otherwise specified in the respective items of work. Sand for masonry mortar shall conform to IS: 2116. The sand shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by Engineer. If so directed by the Engineer, sand shall be screened and washed till it satisfies the limits of deleterious materials.

For preparing cement mortar, the ingredients shall first be mixed thoroughly in dry condition. Water shall then be added and mixing continued to give a uniform mix of required consistency. Mixing shall be done thoroughly in a mechanical mixer, unless hand mixing is specifically permitted by the Engineer. The mortar thus mixed shall be used as soon as possible,

preferably within 30 minutes from the time water is added to cement. In case, the mortar has stiffened due to evaporation of water, this may be re-tempered by adding water as required to restore consistency, but this will be permitted only up to 30 minutes from the time of initial mixing of water to cement. Any mortar, which is partially set shall be rejected and shall be removed forthwith from the site. Droppings of mortar shall not be re-used under any circumstances.

The Contractor shall arrange for test on mortar samples if so directed by the Engineer.

Workmanship

Workmanship of brick work shall conform to IS: 2212. All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. The cement mortar for brick masonry work shall be as specified in the respective item of work. Brick work 200 mm/ 230 mm/ 250 mm thick and over shall be laid in English Bond unless otherwise specified. 100 mm/ 115 mm/ 125 mm thick brickwork shall be laid with stretchers. For laying bricks, a layer of mortar shall be spread over the full width of suitable length of the lower course. Each brick shall be slightly pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Only full size bricks shall be used for the works and cut bricks utilised only to make up required wall length or for bonding. Bricks shall be laid with frogs uppermost. All brickwork shall be plumb, square and true to dimensions shown. Vertical joints in alternate courses shall come directly one over the other and be in line. Horizontal courses shall be levelled. The thickness of brick courses shall be kept uniform. In case of one brick thick or half brick thick wall, at least one face should be kept smooth and plane, even if the other is slightly rough due to variation in size of bricks. For walls of thickness greater than one brick both faces shall be kept smooth and plane. All interconnected brickwork shall be carried out at nearly one level so that there is uniform distribution of pressure on the supporting structure and no portion of the work shall be left more than one course lower than the adjacent work. Where this is not possible, the work shall be raked back according to bond (and not saw toothed) at an angle not exceeding 45°. But in no case the level difference between adjoining walls shall exceed one metre. Brick work shall not be raised more than one metre per day. Bricks shall be so laid that all joints are well filled with mortar. The thickness of joints shall not be less than 6 mm and not more than 10 mm. The face joints shall be raked to a minimum depth of 10 mm/ 15 mm by raking tools during the progress of work when the mortar is still green, so as to provide a proper key for the plastering/ pointing respectively to be done later. When plastering or pointing is not required to be done, the joints shall be uniform in thickness and be struck flush and finished at the time of laying. The face of brickwork shall be cleaned

daily and all mortar droppings removed. The surface of each course shall be thoroughly cleaned of all dirt before another course is laid on top.

During inclement weather conditions, newly built brick masonry works shall be protected by tarpaulin or other suitable covering to prevent mortar being washed away by rain.

Brickwork shall be kept constantly moist on all the faces for at least seven days after 24 hrs of laying. The arrangement for curing shall be got approved from the Engineer.

Double scaffolding having two sets of vertical supports shall be provided to facilitate execution of the masonry works. The scaffolding shall be designed adequately considering all the dead, live and possible impact loads to ensure safety of the workmen, in accordance with the requirements stipulated in IS: 2750 and IS: 3696 (Part I). Scaffolding shall be properly maintained during the entire period of construction. Single scaffolding shall not be used on important works and will be permitted only in certain cases as decided by the Engineer. Where single scaffolding is adopted, only minimum number of holes, by omitting a header shall be left in the masonry for supporting horizontal scaffolding poles. All holes in the masonry shall be carefully made good before plastering/ pointing.

In the event of usage of traditional bricks of size 230 mm x 115 mm x 75 mm or local bricks of size 250 mm x 125 mm x 75 mm, the courses at the top of the plinth and sills as well as at the top of the wall just below the roof/ floor slabs and at the top of the parapet shall be laid with bricks on edge.

A rendering of cement mortar 1:4 rough coat plaster shall be applied on Reinforced Cement Concrete (RCC) surfaces, which are in contact with masonry before starting masonry. All brickwork shall be built tightly against columns, floor slabs or other structural members.

To overcome the possibility of development of cracks in the brick masonry following measures shall be adopted.

RCC/ steel beams resting on masonry wall shall be provided with reinforced concrete bed blocks of minimum 50 mm thickness, duly finished on top with 2 layers of Kraft paper Grade 1 as per IS: 1397 or 2 layers of 50 micron thick polyethylene sheets.

PVC mesh fabric shall be provided at the junction of brick masonry and concrete before taking up plastering work.

Bricks for partition walls shall be stacked adjacent to the structural member to pre-deflect the structural member before the wall is taken up for execution. Further, the top most course of half or full brick walls abutting against either a deshuttered slab or beam shall be built only after any proposed masonry wall above the structural member is executed to cater for the deflection of the structural element.

Reinforced cement concrete transoms and mullions of dimensions as indicated in the construction drawings are generally required to be provided in the half brick partition walls.

Where the drawings indicate that structural steel sections are to be encased in brickwork, the brick masonry shall be built closely against the steel section, ensuring a minimum of 20 mm thick cement-sand mortar 1:4 over all the steel surfaces. Steel sections partly embedded in brickwork shall be provided with bituminous protective coating to the surfaces at the point of entry into the brick masonry.

Contractor shall note that the unit rates quoted for the masonry work shall be deemed to include for the installation of miscellaneous inserts such as pipe sleeves, bolts, steel sections with anchors, etc. and provide pockets, leaving openings, cutting chases, etc. in accordance with the construction drawings. Miscellaneous inserts shall be either supplied free by the Owner or to be furnished by the Contractor as per item description or as shown in drawings. Any of the miscellaneous inserts which are required to be fabricated and supplied by the Contractor and cement concrete to be provided in the pockets for holdfasts of door/ window frames, etc. shall however, be measured and paid for separately under the respective items of work.

Facing bricks of the type specified conforming to IS: 2691 shall be laid in the positions indicated on the drawings and all facing brickwork shall be well bonded to the backing bricks/ RCC surfaces. The level of execution of the facing brick work shall at any time be lower by at least 600 mm below the level of the backing brickwork.

Facing bricks shall be laid over 10 mm thick backing of cement mortar. The mortar mix, thickness of joint and the type of pointing to be carried out shall be as specified in the item of works. The pattern of laying the bricks shall be as specifically indicated in the drawings.

For facing brickwork, double scaffolding shall be used.

Faced works shall be kept clean and free from damage, discoloration, etc., at all times.

UNCOURSED RANDOM RUBBLE MASONRY IN FOUNDATION, PLINTH AND SUPERSTRUCTURE

Materials

Stones for the works shall be of the specified variety which is hard, durable, fine grained and uniform in colour (for superstructure work) free from veins, flaws and other defects. Quality and work shall conform to the requirements specified in IS: 1597 (Part-I). The percentage of water absorption shall not exceed 5% as per test conducted in accordance with IS: 1124. The Contractor shall supply sample stones to the Engineer for approval. Stones shall be laid with its grains horizontal so that the load transmitted is always perpendicular to the natural bed.

Cement-sand mortar for stone masonry works shall be in the proportion of 1:6. Materials and preparation of mortar shall be as specified or as directed by ENGINEER. , no stone grit powder shall be allowed for the mortar

Workmanship

For all works below ground level the masonry shall be random rubble un-coursed with ordinary quarry dressed stones for the hearting and selected quarry dressed stones for the facing.

For all works above ground level and in superstructure the masonry shall be random rubble un-coursed, well bonded, faced with hammer dressed stones with squared quoins at corners. The bushings on the face shall not be more than 40 mm on an exposed face and on the face to be plastered it shall not project by more than 12 mm nor shall it have depressions more than 10 mm from the average wall surface.

Face stones shall extend back sufficiently and bond well with the masonry. The depth of stone from the face of the wall inwards shall not be less than the height or breadth at the face. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three-fourths the thickness of wall nor less than 150 mm. The height of stone may be up to a maximum of 300 mm. Face stones or hearting stones shall not be less than 150 mm in any direction.

Chips and spalls shall be used wherever necessary to avoid thick mortar joints and to ensure that no hollow spaces are left in the masonry. The use of chips and spalls in the hearting shall not exceed 20% of the quantity of stone masonry. Spalls and chips shall not be used on the face of the wall and below hearting stones to bring them to the level of face stones.

The maximum thickness of joints shall not exceed 20 mm. All joints shall be completely filled with mortar. When plastering or pointing is not required to be done, the joints shall be struck flush and finished as the work proceeds. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of the work while the mortar is still green. Through or bond stones shall be provided in walls up to 600 mm thick and in case of walls above 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back. In case of highly absorbent types of stones (porous lime stone and sand stone, etc.) the bond stone shall extend about two-thirds into the wall and a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. Each bond stone or a set of bond stones shall be provided for every 0.5 sq.m. of wall surface.

All stones shall be sufficiently wetted before laying to prevent absorption of water from the mortar. All connected walls in a structure shall be normally raised uniformly and regularly.

However, if any part of the masonry is required to be left behind, the wall shall be raked back (and not saw toothed) at an angle not exceeding 45°. Masonry work shall not be raised by more than one metre per day.

Green work shall be protected from rain by suitable covering. Masonry work shall be kept constantly moist on all the faces for a minimum period of seven days for proper curing of the joints.

Type of scaffolding to be used shall be as specified in **Error! Reference source not found.** of PART B.

RUBBLE SUB-BASE

Materials

Stones used for rubble packing under floors on grade, foundations, etc., shall be clean, hard, durable rock free from veins, flaws, laminations, weathering and other defects. Stones shall generally conform to the requirements stipulated in IS: 1597 (Part I).

Stones shall be as regular as can be obtained from quarries. Stones shall be of height equal to the thickness of the packing proposed with a tolerance of ± 10 mm. Stones shall not have a base area neither less than 250 cm² nor more than 500 cm², and the smallest dimension of any stone shall not be less than half the largest dimension. The quality and size of stones shall be subject to the approval of the Engineer.

Workmanship

Stones shall be hand packed carefully and laid with their largest base downwards resting flat on the prepared sub-grade and with their height equal to the thickness of the packing. Stones shall be laid breaking joints and in close contact with each other. All interstices between the stones shall be wedged-in by small stones of suitable size, well driven in by crow bars and hammers to ensure tight packing and complete filling-in of the interstices. The wedging shall be carried out simultaneously with the placing in position of rubble packing and shall not lag behind. After this, any interstices between the smaller wedged stones shall be filled with clean hard sand by brooming so as to fill the joints completely.

The laid rubble packing shall be sprinkled with water and compacted by using suitable rammers.

BASE CONCRETE

The thickness and grade of concrete and reinforcement shall be as specified in items of work.

Before placing the blinding concrete, the sub-base of rubble packing shall be properly wetted and rammed. Concrete for the base shall then be deposited between the forms, thoroughly tamped and the surface finished level with the top edges of the forms. Two or three hours after the concrete has been laid in position, the surface shall be roughened using steel wire brush to remove any scum or laitance and swept clean so that the coarse aggregates are exposed. The surface of the base concrete shall be left rough to provide adequate bond for the floor finish to be provided later.

DAMP - PROOF COURSE

Materials And Workmanship

Where specified, all the walls in a building shall be provided with damp-proof course cover plinth to prevent water from rising up the wall. The damp-proof course shall run without a break throughout the length of the wall, even under the door or other openings. Damp-proof course shall consist of 50 mm thick cement concrete of 1:2:4 nominal mix with approved water-proofing compound admixture conforming to IS: 2645 in proportion as directed by the manufacturer. Concrete shall be with 10 mm downgraded coarse aggregates.

The surface of brick work/stone masonry work shall be levelled and prepared before laying the cement concrete. Side shuttering shall be properly fixed to ensure that slurry does not leak through and is also not disturbed during compaction. The upper and side surface shall be made rough to afford key to the masonry above and to the plaster.

Damp-proof course shall be cured properly for at least seven days after which it shall be allowed to dry for taking up further work.

CEMENT PLASTERING WORK

Materials

The proportions of the cement mortar for plastering shall be 1:4 (one part of cement to four parts of sand). Cement and sand shall be mixed thoroughly in dry condition and then just enough water added to obtain a workable consistency. The quality of water and cement shall be as per relevant IS standards. The quality and grading of sand for plastering shall conform to IS: 1542. The mixing shall be done thoroughly in a mechanical mixer unless hand mixing is specifically permitted by the Engineer. If so desired by the Engineer, the sand for internal and external plaster shall be machine washed to restrict silt content of sand to less than 2% by volume of sand to meet the Specifications. The mortar thus mixed shall be used as soon as possible preferably within 30 minutes from the time water is added to cement. In case the

mortar has stiffened due to evaporation of water this may be re-tempered by adding water as required to restore consistency, but this will be permitted only up to 30 minutes from the time of initial mixing of water to cement. Any mortar, which is partially set shall be rejected and removed forthwith from the site. Droppings of plaster shall not be re-used under any circumstances.

Workmanship

Preparation of surfaces and application of plaster finishes shall generally conform to the requirements specified in IS: 1661 and IS: 2402.

Plastering operations shall not be commenced until installation of all fittings and fixtures such as door/ window panels, pipes, conduits, etc. are completed.

All joints in masonry shall be raked as the work proceeds to a depth of 10 mm/ 20 mm for brick/ stone masonry respectively with a tool made for the purpose when the mortar is still green. The masonry surface to be rendered shall be washed with clean water to remove all dirt, loose materials, etc. Concrete surfaces to be rendered shall be roughened suitably by hacking or bush hammering for proper adhesion of plaster and the surface shall be evenly wetted to provide the correct suction. Hacking of concrete surfaces shall be about 144 hacks of 8-10 mm deep per square feet of surface area to be hacked. Excess bulges and uneven surfaces must be removed and chipped properly to line and level and no additional payment shall be made for this work. The masonry surfaces should not be too wet, but only damp at the time of plastering. The dampness shall be uniform to get uniform bond between the plaster and the masonry surface.

Interior plain faced plaster - This plaster shall be laid in a single coat of 12 mm thickness. The mortar shall be dashed against the prepared surface with a trowel. The dashing of the coat shall be done using a strong whipping motion at right angles to the face of the wall or it may be applied with a plaster machine. The coat shall be trowelled hard and tight forcing it to surface depressions to obtain a permanent bond and finished to smooth surface. Interior plaster shall be carried out on jambs, lintel and sill faces, etc. as shown in the drawing and as directed by the Engineer. In case more than 12 mm/ 10 mm thick plaster has to be rendered to the RCC surface then, the same has to be rendered in layers of maximum 15 mm thick each. This plaster has to be cured for at least 3 days before applying the subsequent or final neeru layer. Contractors quoted rate for plastering is deemed to include for above provision. Plain Faced Ceiling plaster - This plaster shall be applied in a single coat of 6 mm thickness. Application of mortar shall be as stipulated in above paragraph.

Exterior plain faced plaster - This plaster shall be applied in 2 coats. The first coat or the rendering coat shall be approximately 14 mm thick. The rendering coat shall be applied as

stipulated above except finishing it to a true and even surface and then lightly roughened by cross scratch lines to provide bond for the finishing coat. The rendering coat shall be cured for at least two days and then allowed to dry. The second coat or finishing coat shall be 6 mm thick. Before application of the second coat, the rendering coat shall be evenly damped. The second coat shall be applied from top to bottom in one operation without joints and shall be finished leaving an even and uniform surface. The mortar proportions for the coats shall be as specified in the respective item of work. The finished plastering work shall be cured for at least 7 days.

Interior plain faced plaster 20 mm thick if specified for uneven faces of brick walls or for random/ coursed rubble masonry walls shall be executed in 2 coats similar to the procedure stipulated in above paragraph.

Exterior Sand Faced Plaster - This plaster shall be applied in 2 coats. The first coat shall be approximately 14 mm thick and the second coat shall be 6 mm thick. These coats shall be applied as stipulated above. However, only approved quality white sand shall be used for the second coat and for the finishing work. Sand for the finishing work shall be coarse and of even size and shall be dashed against the surface and sponged. The mortar proportions for the first and second coats shall be as specified in the respective items of work.

Wherever more than 20 mm thick plaster has been specified, which is intended for purposes of providing beading, bands, etc. this work shall be carried out in two or three coats as directed by the Engineer duly satisfying the requirements of curing each coat (rendering/ floating) for a minimum period of 2 days and curing the finished work for at least 7 days.

In the case of pebble faced finish plaster, pebbles of approved size and quality shall be dashed against the final coat while it is still green to obtain as far as possible a uniform pattern all as directed by the Engineer.

Where specified in the drawings, rectangular grooves of the dimensions indicated shall be provided in external plaster by means of timber battens when the plaster is still in green condition. Battens shall be carefully removed after the initial set of plaster and the broken edges and corners made good. All grooves shall be uniform in width and depth and shall be true to the lines and levels as per the drawings.

Curing of plaster shall be started as soon as the applied plaster has hardened sufficiently so as not to be damaged when watered. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.

For waterproofing plaster, the Contractor shall provide the water-proofing admixture as specified in manufacturer's instructions while preparing the cement mortar.

For external plaster, the plastering operations shall be commenced from the top floor and carried downwards. For internal plaster, the plastering operations for the walls shall

commence at the top and carried downwards. Plastering shall be carried out to the full length of the wall or to natural breaking points like doors/ windows, etc. Ceiling plaster shall be completed first before commencing wall plastering.

Double scaffolding to be used shall be as specified in specification.

The finished plaster surface shall not show any deviation more than 4 mm when checked with a straight edge of 2 m length placed against the surface.

To overcome the possibility of development of cracks in the plastering work following measures shall be adopted:

Plastering work shall be deferred as much as possible so that fairly complete drying shrinkage in concrete and masonry works takes place.

PVC fabric shall be provided at the junction of brick masonry and concrete to overcome reasonably the differential drying shrinkage/ thermal movement.

Ceiling plaster shall be done, with a trowel cut at its junction with wall plaster. Similarly trowel cut shall be adopted between adjacent surfaces where discontinuity of the background exists.

CEMENT POINTING

Materials

The cement mortar for pointing shall be in the proportion of 1:3 (one part of cement to three parts of fine sand). Sand shall conform to IS: 1542 and shall be free from clay, shale, loam, alkali and organic matter and shall be of sound, hard, clean and durable particles. Sand shall be approved by Engineer and if so directed it shall be washed/ screened to meet specification requirements.

Workmanship

Where pointing of joints in masonry work is specified, the joints shall be raked at least 15 mm/ 20 mm deep in brick/ stone masonry respectively as the work proceeds when the mortar is still green.

Any dust/ dirt in the raked joints shall be brushed out clean and the joints shall be washed with water. The joints shall be damp at the time of pointing. Mortar shall be filled into joints and well pressed with special steel trowels. The joints shall not be disturbed after it has once begun to set. The joints of the pointed work shall be neat. The lines shall be regular and uniform in breadth and the joints shall be raised, flat, sunk or 'V' as may be specified in the respective items of work. No false joints shall be allowed.

The work shall be kept moist for at least 7 days after the pointing is completed. Whenever coloured pointing has to be done, the colouring pigment of the colour required shall be added

to cement in such proportions as recommended by the manufacturer and as approved by the Engineer.

IRONITE FLOORING

It shall consist of an underbed and a topping (incorporating iron particles) laid over an already laid and matured concrete base.

Thickness

Unless otherwise specified the total thickness of the finish shall be minimum 50 mm for horizontal surface of which topping shall not be less than 12 mm. While topping shall be of uniform thickness, the under bed may vary in thickness to provide necessary slope. The vertical surface shall project 6 mm from adjacent plaster or other finishes. Necessary cutting into the surface receiving the finish shall be done to accommodate the specified thickness.

Material

The hardening compound shall be uniformly graded iron particles, free from nonferrous metal impurities, oil, grease, sand, soluble alkaline compounds or other injurious materials. When desired by the Engineer-In-Charge, actual samples shall be tested.

Mix

The under bed for floor and similar horizontal surfaces shall consist of a mix of 1 part of cement, 1 part of sand and 2 parts of stone aggregates by volume. The stone aggregates shall be 10 mm down well graded. Just sufficient water shall be added to give workable consistency.

Proportion of metallic hardener shall be as specified or as indicated by the manufacturer.

However, in absence of any such direction 1 part metallic hardener shall be mixed dry with 4 parts cement, by weight. To this mixture 6 mm nominal size stone aggregates shall be added in proportion of 1 part cement mixed with hardener to 2 parts of stone aggregates by volume and uniformly mixed. Minimum quantity of water shall be added to make it workable.

Laying

The concrete floor shall be laid in panels of 1m x 1m or as directed by the Engineer. Alternate panels shall be laid on one day followed by the other group of alternate panels the next day. The position property. The concrete floor shall be laid upto the required grade. The forms if any shall remain sufficiently projecting to take the finish. The surface shall be roughened by wire brush as soon as possible.

The junction of floor and walls, floors and dado or skirting shall be rounded off as directed. Wooden strips or flat iron pieces shall be removed from their places before the succeeding alternate layers are laid. The finish shall be laid while the concrete underbed is still very 'green' within about 3 hours of laying of the later. The finish shall be of uniform thickness and even dense surface without trowel marks, pinhole etc. The topping layer shall be pressed firmly and worked vigorously and quickly to secure full bond with the concrete base. Just when the initial set starts the surface shall be finished and smoothened with steel trowel. The finish floor shall be cured for 7 days by keeping it wet.

Posts and Struts—R.C.C.

All posts and struts shall be of standard size, the length of posts being 1.8 m or as specified and that of struts being minimum of 2.0 m. These shall be cast in cement concrete 1:1 ½ :3 (1 cement : 1 ½ coarse sand : 3 graded stone aggregate 12.5 mm nominal size) reinforced with 10 mm diameter tor steel bars as directed and finished smooth with cement mortar 1:2 (1 cement: 2 fine sand).

The specifications for R.C.C. work shall apply. The posts and struts shall be free from cracks, twists and such other defects. G.I. staples on wooden plugs or 6 mm bar nibs will be provided as directed by Engineer-in- Charge while casting the posts. Quantity of RCC post, struts, Rails and Pales to be measured in cubic content.

G.I. Barbed Wire

The barbed wire shall be of galvanised steel as specified and it shall conform to IS 278. The sampling criteria is given in **Error! Reference source not found..** The wire shall be manufactured from steel by any process and shall not contain sulphur and phosphorous exceeding 0.065 per cent. The galvanised steel barbed wires shall be of two types:

Type A (Lowa Type) and

Type B (Glidden Type).

Type A (Lowa Type) : The barbs shall have four points and shall be formed by twisting two point wires, each two turns, tightly around both line wires making altogether four complete turns.

Type B (Glidden Type) : The barbs shall have four points and shall be formed by twisting two point wires, each two turns, tightly around one line wire making altogether four complete turns.

Details of G.I. Barbed wire

The galvanised steel barbed wire shall be of the size designations given in Table Below

TABLE SIZE DESIGNATIONS

Size Designation	Nominal dia. of wire				Mass of completed Barbed Wire		Distance between two barbs	No. of lays between the two consecutive barbs
	Line Wire		Point Wire Max Min					
	Nom (mm)	Tol (mm)	Nom (mm)	Tol (mm)	(g/m)		(mm)	(mm)
1.	2.50	± 0.08	2.50	± 0.08	155	136	75 ± 12	2 to 7
2.	2.50	± 0.08	2.50	± 0.08	120	108	150 ± 12	2 to 7
3.	2.50	± 0.08	2.00	± 0.08	125	108	75 ± 12	2 to 7
4.	2.50	± 0.08	2.00	± 0.08	103	89	150 ± 12	2 to 7
5.	2.24	± 0.08	2.00	± 0.08	106	97	75 ± 12	2 to 7
6.	2.24	± 0.08	2.00	± 0.08	85	78	150 ± 12	2 to 7

Note : The mass in g/m shall be obtained by dividing the total mass of the reel by the linear length in metres.

The number of lays between the two consecutive barbs shall vary between 2 to 7.

The barbed wire shall be formed by twisting together two line wires, one or both containing the barbs. The size of the line and point wires and barb spacing shall be as specified. The permissible deviation from the nominal diameter of the line wire and the point wire shall not exceed ±0.08mm. The line and point wires shall be circular in section, free from scales and other defects and shall be uniformly galvanised. The line wire, shall be in continuous lengths, and shall not contain any welds other than those in the rod before it is drawn. The distance between two successive splices shall not be less than 15metres. It shall have the tensile properties as specified in Table

Table Tensile Properties

Size of Line Wire	Tensile Strength of line wire	Minimum Breaking Load of Completed Barbed Wire
mm	kgf/sq. mm	Kgf
2.50	40 to 60	375
2.24	40 to 60	300

The number of reels to be selected at random for this purpose shall be in accordance with table.

Table Sampling Criteria

No. of Reels in the Lot	No. of Reels to be selected
Up to 25	3

26 to 50	4
51 to 150	5
151 to 300	7
301 and above	10

FENCING WITH G.I. BARBED WIRE AND RCC POSTS

Materials

R.C.C. posts and struts shall be as specified in above specifications in part B. GI Barbed wire shall be as specified in above specifications in part B.

Spacing of Posts and Struts

The spacing of posts shall be three metres centre to centre, unless otherwise specified, or as directed by the Engineer-in-Charge to suit the dimensions of the area to be fenced. Every 15th, last but one end post and corner posts shall be strutted on both sides and end posts on one side only.

Fixing of Posts and Struts

Pits 45 x 45 cm and 75 cm deep or as directed shall first be excavated true to line and level to receive the posts. In the case of struts, pits 70 x 45 x 75 cm deep or as directed shall be excavated to suit the inclination of the strut so that it is surrounded by concrete by not less than 15 cm at any point.

The pits shall be filled with a layer of 15 cm thick cement concrete 1:3:6 (1 cement: 3 fine sand: 6 graded stone aggregate 40 nominal size). The posts and struts shall then be placed in the pits, the posts projecting 1.2 m or to the specified height above ground, true to line and position. The cement concrete 1:3:6 shall be filled in upto 15 cm for posts and 25 cm for struts below ground level at the base of the concrete so that the posts are embedded in the cement concrete block of size 45 x 45 x 60 cm and strut in block of size 70 x 45 x 50 cm. The concrete in foundations shall be watered for at least 7 days to ensure proper curing. The remaining portions of pits shall be filled up with excavated earth and the surplus earth disposed off as directed by the Engineer-in-Charge and site cleared.

Fixing G.I. Barbed Wire

The barbed wire shall be stretched and fixed in specified number of rows and two diagonals. The bottom row shall be 14cm above ground and the rest at 12.5cm centre to centre. The

diagonals shall be stretched between adjacent posts from top wire of one post to the bottom wire of the second post.

The diagonal wires will be interwoven with horizontal wires by fixing the odd-rows of wires first, then the diagonal cross wires and lastly the even rows of wires. The barbed wire shall be held to the R.C.C. posts by means of G.I. staples fixed to wooden plugs or G.I. binding wire tied to 6mm barnibs fixed while casting the posts. Turn buckles and straining bolts shall be used at the end posts, if so specified.

G.I. BARBED WIRE FENCING WITH ANGLE IRON POSTS

Materials

G.I. Barbed wire shall be as per IS 278 & as specified in above specifications in part B and angle iron shall be as per PART C- STRUCTURAL STEEL WORK. The angle shall be of size 40 × 40 × 6 mm.

Spacing of Posts and Struts

The spacing of posts shall be 3.00 m centre to centre, unless otherwise specified or as directed by the Engineer-in-Charge to suit the dimensions of the area to be fenced. Every 15th, last but one end posts and corner post shall be strutted on both sides and end post on one side only.

Fixing of Posts and Struts

This shall be as per specifications above in part B. In addition, angle iron post at bottom shall be split and banded at right angle in opposite direction for 10 cm length to get proper grip.

Fixing G.I. Barbed Wire

The barbed wire shall be stretched and fixed in specified number of rows and two diagonals. The bottom row should be 14 cm above ground and the rest at spacing of 2.5 cm centre to centre. The diagonal shall be stretched between adjacent posts from the top wire of one post to the bottom wire of 2nd post. The diagonal wire will be inter woven with horizontal wires by fixing the odd rows of wires first, then the diagonal cross wires and lastly even rows of wires. The barbed wire shall be held by tearing the holes of 10 mm dia in the post and tied with G.I. wire, turn buckles and straining bolts shall be used at the end post, if so specified.

G.I. CHAIN LINK FABRIC FENCING

Material

G.I. Chain link fabric fencing of required width in mesh size 50 x 50 or 25 x 25 mm or specified otherwise of approved brand and made of specified dia GI wire PVC coated of specified thickness / or not as specified in item of required colour or shade to be used.

Fixing

GI chain link shall be stretched and fixed in specified width, strengthening with 2 mm dia wire or nuts bolts & washers as required to be done complete as per the direction of Engineer-in-Charge.

PART C: STRUCTURAL STEEL WORKS

APPLICABLE CODES AND SPECIFICATIONS

The supply, fabrication, erection and painting of structural steel works shall comply with the following specifications, standards and codes unless otherwise specified herein. All standards, specifications and codes of practices referred to herein shall be the latest editions including all applicable official amendments and revisions.

IS :808	Dimensions for Hot Rolled Steel sections
IS : 814	Covered Electrodes for Manual Metal Arc Welding of Carbon and Carbon Manganese Steel
IS : 817	Code of practice for training and testing of metal arc welders
IS : 800	Code of Practice for General Construction in Steel
IS : 801	Code of Practice for Use of Cold Formed Light Gauge Steel Structural Members in General Building Construction
IS: 2062	Hot rolled medium and high tensile structural steel- specifications
IS : 806	Code of Practice for Use of Steel Tubes in General Building Construction
IS : 7205	Safety Code for Erection of Structural Steel Work
IS : 7215	Tolerances for Fabrication of Steel Structures
IS : 4000	High Strength Bolts in Steel Structure – Code of Practice
AISC	Specifications for Design, Fabrication and Erection of Buildings
IS : 1161	Steel Tubes for structural purposes
IS:102	Ready Mixed paint, Brushing, Red Lead, Non-setting, Priming.
IS:110	Ready Mixed paint, brushing, grey filler for enamels for use over primers.
IS:117	Ready Mixed paint, Brushing, Finishing, Exterior Semigloss for general purposes, to Indian Standard colours.
IS:158	Ready Mixed paint, Brushing, Bituminous, Black, Lead free, Acid, Alkali and heat resisting.
IS:159	Ready Mixed paint, Brushing, Acid resisting for protection against acid fumes, colour as required.
IS:341	Black Japan, Types A, B and C

IS:2339	Aluminium paint for general purposes, in Dual container
IS:2932	Specification for enamel, synthetic, exterior, type 1, (a) undercoating, (b) finishing
IS:2933	Specification for enamel, exterior, type 2, (a) undercoating, (b) finishing
IS:3613	Acceptable tests for wire flux combination for submerged arc welding
IS:5905	Sprayed aluminium and zinc coatings on Iron and Steel.
IS:6005	Code of practice for phosphating of Iron and Steel.
IS:9862	Specification for ready mixed paint, brushing, bituminous, black, lead free, acid, alkali, water & chlorine resisting.
IS:13183	Aluminium paint, Heat resistant.
SIS-05-5900	(Swedish Standard)
IS : 1239	Mild steel tubes, tubulars and other Wrought steel fittings
	Part 1 – Mild steel tubes
	Part 2 – Mild steel tubulars and other wrought steel pipe fittings
IS : 1363 (Parts 1 to 3)	Hexagon Head Bolts, Screws and Nuts of product Grade C (Size range M5 to M64)
IS : 1367 (All parts)	Technical Supply Conditions for Threaded Fasteners
IS : 1852	Rolling and Cutting Tolerances for Hot Rolled Steel Products
IS : 1977	Structural Steel (Ordinary Quality)
IS : 2062	Steel for General Structural Purposes
IS : 2074	Ready Mixed Paint, Air drying, Red Oxide Zinc Chrome and Priming
IS : 3502	Steel Chequered Plate
IS : 3757	High Strength Structural Bolts
IS : 5369	General Requirements for Plain Washers and Lock Washers
IS : 5372	Taper Washers for Channels
IS : 5374	Taper Washer for 1 Beams
IS : 6610	Heavy Washers for Steel Structures
IS : 7318	Approval tests for welders when welding procedure approval is not required (Part 1 and 2)
IS : 8500	Structural Steel-microalloyed (medium and high strength qualities)

IS : 803	Code of practice for design, fabrication and erection of vertical mild steel cylindrical welded storage tanks
IS : 816	Code of Practice for use of Metal Arc Welding for General construction in Mild Steel
IS : 822	Code of Procedure for Inspection of Welds
IS : 1182	Recommended Practice for Radiographic examination of Fusion – Welded Butt Joints in Steel Plates
IS : 1200	Method of Measurement in Building Civil Works
IS : 1477	Code of Practice for Painting of (Parts 1&2) Ferrous Metals in Buildings
IS : 2595	Code of Practice for Radiographic Testing
IS : 3658	Code of Practice for Liquid Penetrant Flaw Detection
IS : 5334	Code of Practice for Magnetic Particle Flaw Detection of Welds
IS : 9595	Recommendations for Metal Arc Welding of Carbon and Carbon Manganese Steel

STEEL MATERIALS

Steel materials shall comply with the Codes and Standards referred to above of PART C.

All materials used shall be new, unused and free from defects.

Steel conforming to IS:2062 shall be used :

FABRICATION

General

All workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined/ground smooth true and square where so specified. All holes and edges shall be free of burrs. Shearing and chipping shall be neatly and accurately done and all portions of work exposed to view shall be neatly finished. Unless otherwise approved by the Employer's Representative, reference may be made to relevant IS codes for providing standard fabrication tolerance. Material at the shops shall be kept clean and protected from weather.

Connections

Shop/field connections shall be as per approved fabrication drawings.

In case of bolted connections, taper washers or flat washers or spring washers shall be used with bolts as necessary. The length of the bolt shall be such that at least one thread of the bolt projects beyond the nut.

In all cases where bearing is critical, the unthreaded portion of bolt shall bear on the members assembled. A washer of adequate thickness may be provided to exclude the threads from the bearing thickness, if a longer grip bolt has to be used for this purpose.

All connections and splices shall be designed for full strength of members or loads. Column splices shall be designed for the full tensile strength of the minimum cross section at the splice.

All bolts, nuts, washers, electrodes, screws etc., shall be supplied/brought to site 10% in excess of the requirement in each category and size. Rates shall cover the cost of this extra quantity.

All members likely to collect rain water shall have drain holes provided.

Straightening

All materials shall be straight and, if necessary, before being worked shall be straightened and/or flattened by pressure and shall be free from twists. Heating or forging shall not be resorted to without the prior approval of the Employer's Representative in writing.

Welding

Welding procedure shall be submitted to the Employer's Representative for approval. Welding shall be entrusted to qualified and experienced welders who shall be tested periodically and graded as per IS 817, IS : 7310 (Part 1) and IS : 7318 (Part 1).

Approval of the welding procedure by the Employer's Representative shall not relieve the Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.

No welding shall be done when the surface of the members is wet nor during periods of high wind.

Each layer of a multiple layer weld except root and surfaces runs may be moderately peened with light blows from a blunt tool. Care shall be exercised to prevent scaling or flaking of weld and base metal from overpeening.

No welding shall be done on base metal at a temperature below -5°C . Base metal shall be preheated to the temperature as per relevant IS codes.

Electrodes other than low-hydrogen electrodes shall not be permitted for thicknesses of 32 mm and above.

All welds shall be inspected for flaws by any of the methods as specified in **Error! Reference source not found.** of PART C. The method adopted shall be agreed with the Employer's Representative.

The correction of defective welds shall be carried out without damaging the parent metal in a manner approved by the Employer's Representative. When a crack in the weld is removed, magnetic particle inspection or any other equally positive means approved by the Employer's Representative shall be used to ensure that the whole of the crack and material upto 25 mm beyond each end of the crack has been removed. The cost of all such tests and operations incidental to correction shall be borne by the Contractor.

TOLERANCES

The dimensional and weight tolerances for rolled shapes shall be in accordance with IS : 1852 for indigenous steel and equivalent applicable codes for imported steel. The tolerances for fabrication of structural steel shall be as per IS : 7215.

Cutting, punching, drilling, welding and fabrication tolerances shall be generally as per relevant IS codes.

END MILLING

Where compression joints are specified to be designed for bearing, the bearing surfaces shall be milled true and square to ensure proper bearing and alignment.

INSPECTION

General

The Contractor shall give due notice to the Employer's Representative in advance of the works being made ready for inspection. All rejected material shall be promptly removed from the shop and replaced with new material for the Employer's Representative's inspection. The fact that certain material has been accepted at the Contractor's shop shall not invalidate final rejection at site by the Employer's Representative if it fails to conform to the requirements of these specifications, fails to be in proper condition or has fabrication inaccuracies which prevent proper assembly nor shall it invalidate any claim which the Employer may make because of defective or unsatisfactory materials and/or workmanship.

No materials shall be painted or despatched to site without inspection and approval by the Employer's Representative unless such inspection is waived in writing by the Employer's Representative.

The Contractor shall provide all the testing and inspection services and facilities for shop work except where otherwise specified.

For fabrication work carried out in the field the same standard of supervision and quality control shall be maintained as in shop fabricated work. Inspection and testing shall be conducted in a manner satisfactory to the Employer's Representative.

Inspection and tests on structural steel members shall be as set forth below.

Material Testing

If mill test reports are not available for any steel materials the same shall be tested by the Contractor to the Employer's Representative's satisfaction to demonstrate conformity with the relevant specification.

Tests on Welds

Magnetic Particle Test

Where welds are examined by magnetic particle testing, such testing shall be carried out in accordance with relevant IS codes. If heat treatment is performed, the completed weld shall be examined after the heat treatment. All defects shall be repaired and retested. Magnetic particle tests shall be carried out using alternating current. Direct current may be used with the permission of the Employer's Representative.

Liquid Penetrant Inspection

In the case of welds examined by Liquid Penetrant Inspection, such tests shall be carried out in accordance with relevant IS Code. All defects shown shall be repaired and rechecked.

Radiographic Inspection

All full-strength butt welds shall be radiographed in accordance with the recommended practice for radiographic testing as per relevant IS code.

Dimensions, Workmanship & Cleanliness

Members shall be inspected at all stages of fabrication and assembly to verify that dimensions, tolerances, alignment, surface finish and painting are in accordance with the requirements shown in the Contractor's approved fabrication drawings.

Test Failure

In the event of failure of any member to satisfy inspection or test requirement, the Contractor shall notify the Employer's Representative. The Contractor must obtain permission from the Employer's Representative before any repair is undertaken. The quality control procedures to be followed to ensure satisfactory repair shall be subject to approval by the Employer's Representative.

The Employer's Representative has the right to specify additional testing as he deems necessary, and the additional cost of such testing shall be borne by the Employer, only in case of successful testing.

The Contractor shall maintain records of all inspection and testing which shall be made available to the Employer's Representative.

DRILLING HOLES FOR OTHER WORKS

As a part of this Contract, holes in members required for installing equipment or steel furnished by other manufacturers or other contractors shall be drilled by the Contractor at no extra cost of the Employer. The information for such extra holes will be supplied by the Employer/Employer's Representative.

MARKING OF MEMBERS

After checking and inspection, all members shall be marked for identification during erection. This mark shall correspond to distinguishing marks on approved erection drawings and shall be legibly painted and stamped on it.

ERRORS

Any error in shop fabrication which prevents proper assembling and fitting up of parts in the field by moderate use of drift pins or moderate amount of reaming will be classified by the Employer's Representative as defective workmanship. Where the Employer's Representative rejects such material for defective workmanship, the same shall be replaced by materials and workmanship conforming to these Employer's Requirements **by the Contractor, at no cost to the Employer.**

SITE OPERATIONS

The Contractor shall complete all preliminary works at site well before the arrival of structural steel, such as establishment of a well equipped and adequately staffed site office, stores, unloading gantry, unloading and pre-assembly yard, labour quarters if any, electrical and water connections, electrical winches, derricks, cranes, compressors, all tools and tackles,

rivet guns, welding sets, torque wrenches, spud wrenches, staging, etc., as well as experienced erection and supervisory personnel as part of this contract and any other work that may be necessary so as to start erection immediately after the arrival of the first batch of steel on site.

The Contractor shall furnish at his own expense, the necessary non-inflammable staging and hoisting materials or equipment required for the erection work and shall remove and take them away after completion of the job. The Contractor shall also provide necessary passageways, fences, safety belts, helmets, lights and other fittings to the satisfaction of the Employer's Representative and to meet the rules of local authorities and for protection to his men and materials. A licensed electrician shall be kept on the job for the entire duration of the work to maintain the Contractor's electrical equipment and connections.

The Contractor shall protect all existing plant, structures, piping, conduits, equipment and facilities against damage during erection. Any damage caused by Contractor shall be rectified entirely at his cost, to the satisfaction of the Employer's Representative. If work has to be carried out adjacent to existing switch yards or electrical installations which are live, the Contractor must ensure suitable safety precautions in consultation with Employer's Representative.

If a portion of the work of the project area cannot be made available to the Contractor for his activities due to operations being carried out by other agencies, he shall suitably modify his sequence of operations so as to continue work without interruption. The Contractor shall work in co-ordination with other agencies working on the project site and plan his work suitably so as not to hinder the progress of construction at site.

ACCEPTANCE OF STEEL, ITS HANDLING & STORAGE

The Contractor shall carefully check the steel to be erected at the time of acceptance. Any fabrication defects observed should be brought to the notice of the Employer's Representative.

No dragging of steel shall be permitted. All steel shall be stored 300mm above ground on suitable packing to avoid damage. It shall be stored in the order required for erection, with erection marks visible. All storage areas shall be prepared and maintained by the Contractor. Steel shall not be stored in the vicinity of areas where excavation or grading will be done and, if so stored temporarily, this shall be removed by the Contractor well before such excavation and/or grading commences to a safe distance to avoid burial under debris.

Scratched or abraded steel shall be given a coat of primer in accordance with these Employer's Requirements for protection after unloading and handling prior to erection. All

milled and machined surfaces shall be properly protected from rust/corrosion by suitable coating and also from damage.

ANCHOR BOLTS & FOUNDATIONS

The Contractor shall carefully check the location and layout of anchor bolts embedded in foundations constructed, to ensure that the structures can be properly erected as shown on the drawings. Any discrepancy in the anchor bolts/foundation shall be reported to the Employer's Representative.

Levelling of column bases to the required elevation may be done either by providing shims or three nuts on the upper threaded portion of the anchor bolt. All shim stock required for keeping the specified thickness of grout and in connection with erection of structures on foundations, crane brackets or at any other locations shall be of good M.S. plates and shall be supplied by the Contractor at his cost.

A certain amount of cleaning of foundations and preparing the area is considered normal and shall be carried out by the Contractor at no extra cost.

Where beams bear in pockets or on walls, bearing plates shall be set and levelled as part of the work. All grouting under column base plates or beam bearing plates will be carried out by the Contractor.

ASSEMBLY & CONNECTIONS

Field connections may be effected either by riveting, bolting, welding or by use of high strength friction grip bolts as shown on the design and erection drawings.

All field connection work shall be carried as per the drawings prepared by the Contractor. All bolts, nuts, washers, rivets, electrodes required for field connections shall be supplied by the Contractor.

All assembling shall be carried on a level platform.

Drifts shall be used only for drawing the work to proper position and must not be used to such an extent as to damage the holes. Size of drifts larger than the normal diameter of hole shall not be used. Any damaged holes or burrs must be rectified to the satisfaction of the Employer's Representative.

Corrections of minor misfits and reasonable amount of reaming and cutting of excess stock from rivets shall be considered as a part of erection. Any error in the shop, which prevents proper fit on a moderate amount of reaming and slight chipping or cutting, shall be immediately reported to the Employer's Representative.

ERECTION

All structural steel shall be erected as shown on the drawings prepared by the Contractor. Proper size steel cable slings, etc., shall be used for hoisting. Guys shall not be anchored to existing structures, foundations, etc., unless so permitted by the Employer's Representative in writing. Care shall be taken to see that ropes in use are always in good condition.

Steel columns in the basement, if any, are to be lowered and erected carefully with the help of a crane and/or derrick without damaging the basement walls or floor.

Structural steel frames shall be erected plumb and true. Frames shall be lifted at points such that they are not liable to buckle and deform. Trusses shall be lifted only at node points. In the case of trusses, roof girders, all of the purlins and wind bracing shall be placed simultaneously, and the columns shall be erected truly plumb on screed bars over the pedestals. All steel columns and beams shall be checked for plumb and level individually before and after connections are made. Temporary bracings shall be introduced wherever necessary to take care of all loads to which the structure may be subjected, including erection equipment and the operation thereof. Such bracings shall be left in place as long as may be required for safety and stability.

Chequered plates shall be fixed to supporting members by tack welding or by countersunk bolts as shown/specified in relevant drawings and/or as approved by the Employer's Representative. The edges shall be made smooth, and no burrs or jagged ends shall be left. While splicing, care should be taken so that there is continuity in pattern between the two portions. Care should also be taken to avoid distortion of the plate while welding. The erection of chequered plates shall include:

- Welding of stiffening angles/vertical stiffening ribs

- Cutting to size and making holes to required shape wherever necessary to allow service piping and/or cables to pass through.

- Splicing as shown in relevant drawings

- Smoothing of edges

- Fixing of chequered plates by tack welding or by countersunk bolts

- Providing lifting hooks for ease of lifting.

As erection progresses, the work shall be securely bolted to take care of all dead load, wind, seismic and erection stresses.

No riveting or welding or final bolting shall be done until the structure has been properly aligned and approved by the Employer's Representative. No cutting, heating or enlarging of the holes shall be carried out without the prior written approval of the Employer's Representative.

Test certificates shall be furnished by the Contractor.

INSPECTION

The Employer's Representative shall have free access to all parts of the job during erection and all erection shall be subjected to his approval. In case of faulty erection, all dismantling and re-erection required will be at the Contractor's cost. No paint shall be applied to rivet heads or field welds or bolts until these have been approved by the Employer's Representative.

TOLERANCES

Tolerances mentioned in the relevant codes of practice shall be achieved after the entire structure or part thereof is in line, level and plumb.

PAINTING

Surface Treatment

All the surfaces of steel work to be painted shall be thoroughly cleaned of all loose mill scale, rust, grease, dirt and other foreign matter. The workmanship shall generally conform to the requirements of IS 1477- Part I.

Oil and grease removal shall be carried out either by solvent cleaning or by using alkali type degreasing agents. The procedure for cleaning shall be as per manufacturer's instructions.

Loose mill scale, loose rust and loose paint shall be removed by wire brushing, scrapping, chipping, rubbing with abrasive paper or steel wool. This method shall not be employed when the surface has firmly adhering mill scale. After hand tool cleaning, the surface shall be rubbed with sand paper so as to ensure that no loose material exists and the surfaces shall be dusted off.

Materials

Primer paint

Anti-corrosive primers shall be either lead based or lead free types. Red lead primer shall conform to IS 102 and red oxide zinc chrome primer shall conform to IS 2074.

All the materials shall be of the best quality from an approved manufacturer. The Contractor shall obtain prior approval of the Employer's Representative for the brand of manufacture and the colour/shade prior to procurement for usage in the works.

Primer and finish paints shall be compatible with each other to avoid cracking and wrinkling. and shall be from the same manufacturer for each painting system.

Workmanship

The type and the number of coats of the primer paint and finish paint shall be as specified.

Painting shall be carried out only on thoroughly dry surfaces.

No painting shall be done in frosty/foggy weather or when the humidity is high enough to cause condensation on the surface to be painted. Paint shall not be applied when the temperature of the surface to be painted is at 5deg.C or lower.

Primers shall adhere to the surface firmly and offer a key to the subsequent coats.

Workmanship shall generally conform to requirements specified in IS:1477-Part II.

It is essential to ensure that immediately after preparation of the surfaces, the first coat of primer paint shall be applied by brushing and working it well to ensure a continuous film. After the first coat becomes hard dry a second coat of primer shall be applied by brushing.

The dry film thickness of each coat of primer shall be not less than 25 microns.

Application of finishing paints shall be carried out within the shortest possible time interval after primer since the primer coats are too thin to give adequate corrosion protection of the steel surface over a long duration.

Painting shall be carried out either by brushing or by spraying. The Contractor shall procure the appropriate quality of paint for this purpose as recommended by the manufacturer.

After the second coat of primer is hard dry, the entire surface shall be wet rubbed cutting down to a smooth uniform surface. When the surface becomes dry, the undercoat of paint of optimum thickness shall be applied by brushing/spraying with minimum of brush marks. The coat shall be allowed to hard-dry. The under coat shall then be wet rubbed cutting down to a smooth finish, taking adequate care to ensure that at no place the undercoat is completely removed. The surface shall then be allowed to dry.

The first finishing coat of paint shall be applied by brushing or by spraying and allowed to hard-dry. The gloss from the entire surface shall then be gently removed and the surface dusted off. The second finishing coat shall then be applied by brushing or by spraying.

At least 24 hours shall elapse between the application of successive coats. Each coat shall vary slightly in shade and shall be approved by the Employer's Representative, prior to applying the next coat.

Minimum dry film thickness of each coat of finish paint of synthetic enamel shall be 25 microns. Minimum dry film thickness of other finish paints shall be as specified in the respective item of work.

GALVANISING OF STRUCTURAL STEEL

Galvanising Plant

Prior approval shall be obtained from Employer / Employer's Representative if galvanising is proposed to be carried out outside Contractor's plant.

Workmanship

After all shop work is complete, all structural materials shall be punched with the erection mark and be hot-dip galvanised. Before galvanising, the steel shall be thoroughly cleaned of any paint, grease, rust, acid or alkali or such other foreign matters as are likely to interfere with the galvanising process or with the quality and durability of the zinc coating. Pickling shall be very carefully done and shall be proper.

The weight of the zinc coating shall be at least 0.610 kg/sq.m. unless specified otherwise. Stub members and members for grillage type footing shall have heavier zinc coating not less than 0.80 kg/sq.m.

The galvanised surface shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth, and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel, globules, spikes, etc. The finish shall be as per IS:2633 unless specified otherwise.

All galvanised members shall be treated with Sodium dichromate solution or an approved equivalent after galvanising, so as to prevent white storage stains.

Galvanising of each member shall be carried out in one complete immersion. Double dipping shall not be permitted. However, in case of members over 7.5 m long, the Contractor shall take prior approval of Employer's Representative for double dipping. When the steel section is removed from the galvanising kettle, excess spelter shall be removed by 'bumping'.

Wherever galvanised bolts, nuts locknuts, washers, accessories etc. are specified, they shall be hot-dip galvanised. Spring washers shall be electro-galvanised. Excess spelter from bolts, nuts, etc. shall be removed by centrifugal spinning. Rechasing of bolt threads after galvanising shall not be permitted. Nuts, however, may be tapped, but not to cause appreciable rocking of the nuts on the bolts. Readily available GI nuts, bolts and washers conforming to galvanising requirements may also be used.

Defects in certain members indicating presence of impurities in the galvanising bath in quantities larger than that permitted by the specifications, or lack of quality control in any manner in the galvanising plant, shall render the entire production in the relevant shift liable to rejection.

Contractor shall ensure that galvanising is not damaged in transit. In the event of occurrence of any damages Contractor shall at his own cost adopt scraping and regalvanising the member to satisfy the specific requirements.

D 8. COMMON EFFLUENT TREATMENT PLANT

GENERAL PROCESS DESIGN REQUIREMENTS FOR CETP

DESIGN FLOW FOR CETP

The required ultimate capacity of the CETP is 15 MLD.

CETP will be developed in three phases having the capacity of Phase 1- 2.5 MLD, Phase 2- 5 MLD, Phase 3- 7.5MLD.

Peak hourly flow factor of 2.5

Note: CETP of 2.5 MLD is considered in this tender.

INDUSTRIAL RAW INFLUENT QUALITY

The Treatment Plant shall be designed to treat the wastewater with the characteristics summarized in table below:

Table 1 Influent Characteristics to Design New CETP

D-5Parameters	Values*	Unit
pH	6.0-9.0	
Biochemical Oxygen Demand (BOD5)	1500	mg/l
Chemical Oxygen Demand (COD)	2500	mg/l
Total Dissolved Solids	≤ 2100	mg/l
Total Suspended Solids (TSS)	600	mg/l
Total Kjeldahl Nitrogen (TKN)	100	mg/l
Total Phosphorus	20	mg/l
Oil & Grease	20	mg/l
Wastewater Temperature (Min)	20	°C
Wastewater Temperature (Max)	35	°C

Note:

- * - Influent Parameters concentration after Equalization in CETP
- Contractor to make own assessment of parameters of plant returns and account for them in the design of the CETP.
- Alkalinity (as CaCO₃) can be considered as 300 mg/l for arriving the Alkali dosage required for the process.

- Auto composite sampler shall be installed for sampling and analyses purpose of raw influent quality and treated effluent quality.
- Online Monitoring System shall be installed for raw influent and effluent quality monitoring purpose.

CETP TREATED EFFLUENT LIMITS

The characteristics of treated effluent from CETP shall be suitable for appropriate reuse. The treated effluent shall be used gardening and horticulture of common areas. Also, surplus treated effluent shall be supplied to industries for their non potable application e.g., Gardening inside their plant premises.

The Final treated effluent quality shall be as per below in table below:

Table 2: CETP Treated Effluent Characteristics

Parameters	Discharge Limit	Unit
pH	6.0 – 9.0	
Biochemical Oxygen Demand (BOD5)	≤ 10	mg/l
Chemical Oxygen Demand (COD)	≤ 50	mg/l
Total Suspended Solids (TSS)	≤ 1	mg/l
Total nitrogen	≤ 10	mg/l
Total Phosphorous	≤ 1	mg/l
Oil and Grease	Nil	mg/l
Total Dissolved Solids	≤ 2100	mg/l
Phenolic compounds	< 1	mg/l
Iron	< 0.5	mg/l
Arsenic	< 0.2	mg/l
Cadmium	< 0.05	mg/l
Lead	< 0.1	mg/l
Copper	< 3	mg/l
Zinc	< 5	mg/l
Nickel	< 3	mg/l
Mercury	< 0.01	mg/l
Selenium	< 0.05	mg/l
Trivalent Chromium	< 2	mg/l
Hexavalent Chromium	< 0.1	mg/l
Cyanide	< 0.2	mg/l
Fluoride	< 2	mg/l

Note:

The above parameters shall be guaranteed as follows:

- The Guaranteed Outlet Parameters of CETP Should be strictly as per Haryana State Pollution Control Board discharge norms OR as per Central Pollution Control Board, whichever is stringent. The Bidder has to assess the outlet parameters which are stringent, accordingly bidder has to design the Treatment units and if any additional treatment units are required, these should be considered without any additional cost.
- Successful bidder shall assist and give all technical support for Consent to Establish (CTE), Consent to Operate (CTO) and other applicable permits required for the construction / commissioning of CETP / WTP / Solid Waste Management facility. Applicable fees for the same to Govt. authority will be paid by authority.
- 24-hour auto-composite samples with 95 % plus compliance
- Conformity is based on a 30-day Rolling month with a maximum of two failures allowed per month for composite samples and at no time a grab sample exceeds the limits as specified above.
- Auto composite sampler shall be installed for sampling and analyses purpose of raw influent quality.
- The Online Monitoring System shall be installed for raw and treated water monitoring purposes.
- The guaranteed Parameters are to be achieved by the Bidder for all the influent flows and pollutant loads within the limits specified below:
 - a. Nominal design flow within a flow variation from 25 % of the nominal flow to 115 % of the nominal flow and
 - b. Pollutants variation considering all the incoming pollutants as pollutant freight (i.e. Kg/day in terms of flow receipt) in the range of minus (-) 50 % to plus (+) 10 % of the pollutants freight at nominal flow considering average pollutant values given in Table B-1 above.

TREATMENT PLANT RESIDUALS, SLUDGE GENERATION AND DEWATERED SLUDGE REQUIREMENTS

The plant residuals shall achieve the following:

- a. Screenings: The screenings shall comprise of all particles of an effective size in excess of 5 mm and “free of dripping water” i.e. the screenings on collection does not contain any dripping water when disposed from the plant.
- b. Grit: The grit removed shall contain less than 3 % organic matter on dry basis of an average particle size of more than 150 microns but less than 1000 microns.
- c. Centrate and Plant Drains: Centrate from Sludge Decanting Device along with plant drain shall be collected and recycled back to Raw Sewage Sump.
- d. A sludge treatment system shall be provided for the sludge generated in CETP. Excess Sludge shall be of open body truck able consistency and with a solid content in of at least 20 % or more. Treated sludge shall be disposed to **Common Hazardous Waste Transportation, storage and disposal facilities (CHWTSDF)** by contractor.
- e. Hazardous waste to be generated by the CETP to be disposed at approved facility is the responsibility of successful bidder. The Bidders has to identified the distance from CETP location to Hazardous waste Management site and charges required to transport sludge and disposal charges shall be considered in his O & M cost for the period mentioned.

TREATED ODOUR QUALITY

- There should not be any odour nuisance generated from the CETP. Odour treatment shall be therefore capable of achieving the following standard.
- “5 Odour Units (OU)/m³ on a 99.8 %ile on an hourly averaging basis measured at the nearest receptor”.

NOISE LIMITS

There should not be any noise nuisance generated by the CETP. Therefore, noise limits at 1m away from the blower or any other equipment should not exceed 80 dB (A).

WORK LIFE EXPECTANCY

The Contractor shall design the Works for a life expectancy as follows:

• Concrete structures	:	50 years;
• Mechanical plant	:	15 years;
• Electrical plant	:	15 years;
• Control panels	:	15 years;
• External instrumentation systems	:	15 years;

- Computer systems : 10 years.
- Piping : 30 years
- Chemical Tanks : 30 years for GRP/FRP

GENERAL ARRANGEMENT OF PLANT

- Bidder must consider space provision of CETPs proposed to be constructed on modular basis. Initial capacity under this EPC tender and ultimate capacity are as follows.

S.N.	Treatment Plant	Phase-I (Present Proposed Capacity in this EPC Tender) in MLD	Phase-II (Only Space Provision for this Capacity) in MLD	Phase-III (Only Space Provision for this Capacity) in MLD	Total Ultimate Capacity in MLD
1	CETP	2.50	7.00	7.50	15.00

- The Contractor shall ensure that the whole of the Works as installed is safe for use by the operating and maintenance staff, and by any other persons having access thereto. Guards, electrical safety devices, thermal insulation, noise-supervision devices, written notices, safety colors and the like shall be provided where necessary during erection permanently. The equipment layouts should provide easy and safe access to all operating devices, free from hazardous obstructions. Nothing in this Specification shall remove the Contractor's obligation from drawing the attention of the Employer's Representative to any feature of the Works which is not consistent with safety, or prevent him making proposals for incorporating equipment or designs which would increase the safety of plant equipment.
- A set of special tools and tackles which are necessary or convenient for erection, commissioning, maintenance and over hauling of the equipment shall be supplied.
- The tools shall be shipped in separate containers clearly marked with the name of equipment for which they are intended.
- The following general rules but not limited to below shall be followed in arranging and Designing the Plant units:
 - Sufficient room (of not less than 2.0 m wide) shall be allowed between items of Plant and adjacent Plant or fixed structures to permit safe and convenient access for operation and maintenance; for provision of appropriate structure foundations. In the case of the areas that

require movement of heavy equipment for installation and replacement, sufficient access shall be provided to move heavy vehicles.

- An area adjacent to all mechanical plants shall be provided as a maintenance lay down area.
- Fixed runways, lifting eyes or other means shall be provided to permit the removal of Plant Equipment that may logically be required to be removed during the course of its normal operational life for maintenance or any other purpose.
- The Pumps should be designed for positive suction. Pumps shall generally comply with the requirements of standard codes as cited in the tender documents. Pumps should be so selected as to have a maximum capacity of not less than 125% of the rated capacity. Pump sets shall be suitable for the required duty conditions and shall be designed and constructed for 24-hour continuous duty at full load. The pumps shall be designed for continuous operation at any point of the head capacity curve between 25% and 125% of pump rated flow without undue vibration or overheating areas where leakage is likely to occur whether in normal use or during maintenance shall be provided with underground drain line or covered RCC drainage channels which shall direct spillage either to a suitable drain or to a sump from where it can be pumped to drain.
- Plant where necessary shall be provided with removable acoustic coverings to limit the noise produced during normal operation to the limits detailed in the General Requirements.
- Plant shall be arranged, and the building shall be designed to permit the removal/relocation of Plant items. The Plant layout shall be such that no flooding of units is allowed even during heavy monsoon and should always be accessible.
- All distribution chambers should have a minimum of 5 min. retention time.
- All pumps/blowers should have RCC pump house except submersible pumps.
- All the units shall have drain valves. The drain valves of diameter less than 250mm shall be manually operated and higher than 250mm valve shall be electrically operated. For the valves located below ground level extended spindle shall be provided for ease of operation.
- Equipment Bases: Steel base plate with proper corrosion restraint paint/protection shall be provided for all rotating equipment which is to be installed on a concrete base, unless otherwise specifically agreed to by the Employer's Representative. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections. Bases shall be appropriately painted for protection against corrosion.

- All motors have running indication.
- Aeration blowers shall be located inside the blower room with necessary acoustic hoods complying with statutory and safety norms.
- Main control room housing PLC/SCADA shall be located in such a manner so that entire STP is preferably visible to the operator through glazed windows.
- Knife Gate valves shall be provided for Raw Sewage and sludge application.
- Doors, Windows and Ventilators shall be of aluminum glazed type.
- EOT shall be provided for the Centrifuge Building, Blower room, etc. as required of adequate capacity (minimum 2 times the weight of the heaviest equipment).
- Adequate measures shall be taken to prevent dry running of the pump. Every sump and tank shall be provided with ultrasonic level transmitter. The level of tanks and sumps shall be displayed on the control room panel.
- Contractor should design the plant in such a manner that the Vehicular approach shall be provided from entry and exist point of CETP up to the centrifuge building, Blower Room for execution and Operation and maintenance point of View.
- Flushing connections shall be provided for all sludge handling units and sludge lines.
- Access to platforms shall be by stairs/ ladders. Access shall be by stairway if unit required frequent attention of operating personnel.
- Common delivery header and suction header of pumps (and blowers) shall be provided with a blind flange on one end.
- A sludge handling system with bricket making to be provided and storage area also be properly designed with flooring & roof.
- A proper Odour Control system for the whole unit shall be designed and provided.
- The whole area should have a well-designed Landscapes, tree plantations, Tiled pathways, Proper Safety hand railings at all Units, area lighting for the whole plant area and well-designed storm water drainage system.
- Chemical House including storage area, Testing Laboratory with all required equipment's, testing chemicals/agents required for regular testing and testing kits etc;
- Chemical pipework shall be secured to racks or trays to be fixed to duct walls or walls of tanks and buildings as necessary. The method of securing the pipes to the racks shall be by

clips or something similar, facilitating ease of removal in such a way that individual runs can be changed without dismantling adjacent pipes.

- All chemical pipes shall be colour banded and suitably labelled to enable individual lines to be identified throughout their run. Particular attention should be paid to the layout of the chemical pipework, which shall be functional and neat in appearance. Generally, where pipework is installed in ducts, it should be supported not less than 150 mm clear of the floor.
- When selecting materials for pipework, the Contractor shall give consideration to the deteriorating effect of some of the synthetic materials due to the action of ultra-violet light. Where such materials are employed, they shall be shielded from direct sunlight. All the exposed MS piping should be Zinc Epoxy coated as base then painted 2 coats with approved colour to suit to the type of carriage liquids.

COMMON EFFLUENT TREATMENT PLANT STAFFING REQUIREMENTS

- The bidder shall provide all the necessary minimum operating staff and maintenance personnel as noted below to operate the Works for a total period of 60 months.
- The Contractor shall provide a detailed proposed staffing schedule before the anticipated start of the 30-day operation period for each of the sections of the Works. The schedule shall cover all categories of staff from the works superintendent to cleaners, including adequate numbers of maintenance staff.
- The staffing schedule shall be prepared for operating the Plant 24 hour per day basis with three equal shifts of 8 hours during the complete O&M contract period.
- The O&M staff shall have the min. following personnel in table below

Table 3 Requirement of O&M Staff for CETP

Position	Min. Number	Desired Qualification
Plant cum HSE Manager	1	Bachelor's degree in environmental / Chemical Engineering with minimum experience of 10 years in similar nature of work.
Chemist	1	Bachelor's degree in chemistry with minimum experience of 7 years in similar nature of work.
Lab Technician	1	Bachelor's degree in chemistry with minimum experience of 5 years in similar nature of work.

Process Engineer	1	Diploma in Environmental/Chemical Engineering with minimum experience of 7 years in similar nature of work.
Mechanical Engineer	1	Diploma in Mechanical Engineering with minimum experience of 7 years in similar nature of work.
E&I Engineer	1	Diploma in Electrical Engineering with minimum experience of 7 years in similar nature of work.
Mechanical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Electrical Operators	4	ITI with minimum experience of 5 years in similar nature of work.
Required Security Staff		
Required Gardner, housekeeping staff		

TREATMENT SCHEME

- Industrial wastewater shall be collected in the pumping station through receiving chamber that shall be followed by screening for removal of the floatable materials and O&G removal chamber with Mechanized oil skimmer.
- The Industrial influent after removal of screening shall be collected in an Equalization tank through oil & Grease removal Chamber, which shall have followed by primary treatment. The mixing shall be provided in the equalization tank via submersible mixers to keep solids in suspension and to homogenize the industrial influent. Primary treatment consists of coagulation, flocculation followed by primary sedimentation. Sufficient chemicals should be dosed in the primary treatment area and primary sludge formed should be transferred to sludge handling section. Primary treated effluent should flow to secondary treatment by gravity. Secondary treatment is activated sludge process which shall be Integrated with Anaerobic, Anoxic and Two stage Extended Aeration. It consists of anaerobic and anoxic followed by aerobic bioreactors and clarifiers for solid-liquid separation. Necessary mixing arrangement by means of submersible mixer shall be provided in the respective BNR removal units. The air in the aerobic tank shall be provided through fine bubble air diffuser system to oxidize COD/BOD and NH₄-N. suitable recycle ratio to be selected for pumps based on the overall stoichiometry requirements for BNR and BOD removal. Also, based upon degree of denitrification required, mixed liquor from aeration tank should be pumped to anoxic tank.
- Depending on the MLSS to be retained in the Extended Aeration Tanks the sludge wasting flowrate to be calculated. The secondary sludge is settled by clarifiers and shall be dewatered by centrifuge where dewatered sludge shall be collected in the form of cake for safe land disposal. Centrate shall be transferred suitably to equalization tank.

- Odour Control Unit shall be provided. Malodorous gases from all the sources shall be treated in two stage OCU to make the plant free of obnoxious odour.

DEWATERED SLUDGE DISPOSAL (OFF-SITE)

The Contractor shall be responsible for identifying suitable Chemical Hazardous Waste Disposal and Treatment Facility (CHWSTF) disposal location/land/site and route(s) for all sludge arising from the Works and dispose of the sludge and for paying all tipping & transportation charges and other associated costs including that for land/site. The Contractor shall dispose of waste dewatered sludge off-site in accordance with existing laws and regulations. All permissions and consents from respective authorities shall be obtained by the contractor. The CETP waste shall be disposed off to the Nearest Hazardous Waste Landfill site.

SLUDGE STORAGE FACILITIES

The Contractor shall, from the start of Commissioning, provide sludge storage facilities for dewatered sludge at the Works. The volume of storage shall be 3 to 5 days. Sufficient capacity should be provided due to inclement weather or other factors that do not allow transport or disposal. The dewatered sludge may be stored in steel or concrete containers or stockpiled on concrete slabs or other impervious pad areas or other means to store dewatered sludge. It should be located and stored to preclude re-wetting by rainfall and groundwater contamination.

LABORATORY, CONTROL ROOM AND MCC ROOM

- A laboratory with suitable area with necessary laboratory equipment, chemicals and glass wares shall be provided. The control room with MCC room of suitable size shall be provided.
- The Laboratory / operator room/ SCADA and MCC Panel rooms shall be located at a suitable place.
- The building shall be RCC framed structure with brick wall panels. The brick walls, plastering, painting, plinth protection etc. shall be as per civil specification.
- All the rooms shall be provided with doors of the standard sizes and Aluminium windows/ventilators glazed with aluminium grill. The outer doors, windows, shall be provided with aluminium fittings. All the outer doors, window, ventilators shall be provided with wire gauge shutters in additions to glazed panelled shutters.

- The laboratory hall at First floor shall be provided with RCC. Tiled platform projecting 750 mm from the wall at about 750 mm height from floor level along the walls of room which shall be used for keeping the bottles of chemicals and shall be provided with glazed tiles. The white glazed tiles shall be provided on the walls all along the RCC tiled platform up to 60 cm height above the platform. The space underneath the platform is provided with shutters with door fittings. There shall be three laboratory sinks in stainless steel of reputed make of good quality installed in the RCC platform suitably and one wash basin installed along the opposite wall in each hall. The floor of laboratory shall be provided with glaze tiles or marbles. The Contractor should also provide for supply of laboratory equipment, instruments, glass ware, chemicals and miscellaneous items.
- It shall have the equipment, storage space and chemicals for the all chemical and bacteriological analyses.

SAMPLING AND ANALYSIS

- Sampling and analysis shall be performed to measure the physical, chemical and biological parameters as per design requirement, at the appropriate locations and frequencies. In case of multiple units (Such as clarifiers, aeration tanks, filters), the indicated sampling and analyses shall be performed for each individual module.
- All the sampling and analyses shall be performed as per procedures in APHA (American Public Health Association), Standard Methods for examination of water and wastewater, latest edition. An original copy of APHA standard methods shall be procured and permanently stored at the laboratory.

CETP PIPE MATERIAL AND TYPE OF VALVES

The design requirements for Pipe material and Valve type for CETPs are provided in Table below

Table 5: Pipe Material and Valve Type Specifications

S No	Application	Pipe Material	Valve Type
1.	Industrial wastewater	GRP/HDPE	Gate valve
2.	Treated effluent	HDPE /GRP	Butterfly valve
3.	Sludge	GRP / SS 304	Gate valve

S No	Application	Pipe Material	Valve Type
4.	Thickened and Dewatered Sludge	SS 304	Knife edged gate valve
5.	Grit Line	SS 304	Gate valve
6.	Air pipe	SS 316	Butterfly valve
7.	Chemical	Polymer: SS 316 /GRP Alum: uPVC/CPVC/HDPE/GRP NaOCl: uPVC/CPVC/HDPE/GRP (MOC shall be selected as per chemical compatibility and options to be selected as per suitability based on type of installation, whether exposed to sunlight, or inside shed, or overhead or underground)	Ball valve / Diaphragm valve
8.	Odour	GRP	Butterfly valve

CHEMICAL DOSING SYSTEMS

For all the chemical dosing systems in the plant, material of construction used shall be compatible with the dosing chemical. All chemical lines shall be colour banded and suitably labelled to enable individual lines to be identified through their run. Appropriate dike wall shall be constructed for each dosing systems. All the dosing systems shall have calibration column, strainer, pressure damper, safe overflow arrangement, drain arrangement, vent. Chemical dosing systems shall be installed inside the building with appropriate ventilation.

CETP PARTICULAR DESIGN REQUIREMENTS

CETP RECEIVING CHAMBER

CETP receiving chamber should be designed for the peak flow. A penstock should be provided in the incoming sewage effluent line at the CETP receiving chamber. The design requirements for CETP receiving chamber are provided in table below:

Table D-6: Design Parameters of Receiving Chamber for 2.5 MLD CETP

Description	Values	Unit
Average daily flow	2500 m ³ /day for CETP	m ³ /d
Peak factor	2.5	
Retention time at ultimate peak flow	60	sec

Description	Values	Unit
Material of construction	RCC M35	
Liquid depth	As per Bidder's design	
Freeboard	As per Bidder's design	

Odour extraction provision should be provided in the Receiving Chamber, and the interconnecting duct should be provided between Receiving Chamber and Centralized CETP Odour control unit.

COARSE SCREEN CHAMBER

- Coarse Screen chamber should be designed for the peak flow.
- A auto operated penstock should be provided upstream and downstream of each coarse screen chamber for isolation.
- One mechanical and one manual screen should be provided.
- Level Indicating Transmitter should be provided upstream and downstream of each mechanical coarse screen.
- Odour extraction provision should be provided in Coarse screen chamber. Interconnecting duct should be provided between Fine screen chamber and Centralized CETP Odour control unit.

The design requirements for coarse screen chamber are provided in table below:

Table 6: Design Parameters of Coarse Screen Chamber for 2.5 MLD CETP

Description	Values	Unit
Quantity of Coarse screen chamber	2	Nos
Design Flow to each screen chamber	2500	m ³ /d
Quantity of mechanical screen	01	Nos
Type of mechanical screen	Step screen	
Screen opening size	20	mm
Angle of Inclination	45 or as per manufacturer Std.	Degree
Quantity of manual screen	01	no.
Type of manual screen	Bar screen	
Screen opening size	20	mm

Description	Values	Unit
Angle of Inclination	As per CPHEEO	Degree
Quantity of manual screen	01	no.
Maximum velocity at peak flow	1.2	m/s
Head loss in screen during peak flow at 50 % clogging not to exceed	300	mm
MOC of screen and related accessories	SS 316 L	
Wash water arrangement	To be provided	
Odour extraction provision	To be provided	
Belt Conveyor	To be provided	

FINE SCREEN CHAMBER

- Fine screen chamber should be designed for the peak flow.
- A manual penstock should be provided upstream and downstream of each fine screen chamber for isolation.
- Two mechanical screens should be provided
- Level Indicating Transmitter should be provided upstream and downstream of each mechanical fine screen.
- Odour extraction provision should be provided in Fine screen chamber. Interconnecting duct should be provided between Fine screen chamber and Centralized CETP Odour control unit.

Table D-7: Design Parameters of Fine Screen Chamber for 2.5 MLD CETP

Description	Values	Unit
Quantity of Fine screen chamber	2	Nos
Design Flow to each screen chamber	2500	m ³ /d
Quantity of mechanical screen	2	Nos
Type of mechanical screen	Step screen	
Screen opening size	6	mm
Angle of Inclination	45 - 55	Degree
Maximum velocity at peak flow	1.2	m/s
Head loss in screen during peak flow at 50 % clogging not to exceed	300	mm
MOC of screen and related accessories	SS 316 L	
Wash water arrangement	To be provided	

Description	Values	Unit
Odour extraction provision	To be provided	
Belt Conveyor	To be provided	

EQUALIZATION TANK AND RAW INFLUENT TRANSFER PUMPS

- Equalization tank should be constructed for balancing the flow and concentration coming in the influent from various industries. The equalization tank shall be designed for 15000 m³/day flow. Equalization tank with two equal compartments should be provided with RCC M35 construction. Necessary arrangement should be done to have ease in emptying out and cleaning the tank. One automatic operated penstock should be provided at the upstream of each equalization tank compartment for isolation.
- 3 Nos. (2W+1S) of Submersible / horizontally mounted centrifugal pumps for each phase should be installed for pumping the flow to downstream. Gantry crane and electrical chain hoist with suitable capacity should be provided for the Equalization tank pumping station.
- Submersible mixers shall be provided in the equalization tank along gantry crane and electrical chain hoist with suitable capacity to equalize the flow.
- An Auto composite sampler should be provided for equalized influent.
- A level indicating transmitter and pH analyser shall be provided in the each equalization tank compartment. Electromagnetic flow meter shall be provided at the common header of Equalization tank pump discharge. The Equalization tank shall be provided with submersible mixers for keeping the solids in suspension. Fixed Lifting Davit crane with suitable capacity shall be provided for each submersible mixers for lifting in case of maintenance.
- Odour extraction provision should be provided in the Equalization tank and its pump sump. Interconnecting duct should be provided between Equalization tank and CETP Centralized Odour control unit.

The design requirements for Equalization tank is provided in table below:

Table 7 Design Parameters of Equalization Tank for 2.5 MLD CETP

Description	Values	Unit
Design Average daily flow	2500	m ³ /d
Design Peak factor	2.5	

Description	Values	Unit
Equalization Tank HRT at average daily flow (Minimum)	8	Hrs
Material of Construction	RCC M35	
Liquid depth	As per Bidder's design	m
Submersible Mixers		
Mixing requirement (Minimum)	8	w/m ³
Type of Mixers	Submersible mixers	
MOC of submersible mixers with guide rails & chains	SS 316	
Type of lifting equipment for mixers	Fixed lifting davit	
Equalization Tank Transfer Pumps		
Number of Equalization tank transfer pumps for each phase	3 (2W+1S)	Nos
Type of pumps	Horizontal mounted centrifugal /Submersible	
MOC of pump	Casing: SS 316, Impeller: SS316, Shaft: SS410	

FLASH MIXING TANK

- Necessary chemical dosing - Acid/Alkali/Lime dosing should be dosed in flash mixing tank for pH adjustment. Poly Aluminium Chloride/Ferric Chloride dosing should be provided as coagulant in Flash mixing tank.

The design requirements for Flash Mixing Tank are provided in below table:

Table Design Parameters of Flash Mixing Tank for CETP

Description	Values	Unit
Design flow	2500	m ³ /d
No of tank (Minimum)	1	Nos
Retention time (Minimum)	5	minutes
MOC of Flash Mixing Tank	RCC M35	
Qty of agitator in the tank	1	No
Type of flash mixer	Rapid speed agitator	
MOC of agitator	SS 316L	

FLOCCULATION TANK

- Coagulated mass shall be agglomerated to form heavy flocs by polymer dosing in the flocculation tank. Sufficient mixing and time shall be provided in the tank.

The design requirements for Flocculation Tank are provided in **Table below**

Table 7: Design Parameters of Flocculation Tank for each phase CETP

Description	Values	Unit
Design flow	2500	m ³ /d
No of tank (Minimum)	1	Nos
Retention time (Minimum)	20	minutes
MOC of Flash Mixing Tank	RCC M35	
Qty of agitator in the tank	1	No
Type of flash mixer	Slow speed Paddle type flocculator	
MOC of agitator	SS 316L	

PRIMARY CLARIFIER

Coagulated and flocculated mass shall be agglomerated to form heavy flocs by polymer dosing in the flocculation zone followed by gravity settling the primary clarifier tank.

- Heavy metals present in the wastewater should be removed in primary treatment to maximum possible extent. Chemicals should be dosed in sufficient quantity for Phosphorus removal as well. Significant amount of Phosphorus concentration shall be removed through chemical precipitation in primary clarifier and some phosphorus shall be removed biologically in the bioreactor.
- Primary Clarifier shall perform to provide average outlet TSS of not more than 50 mg/lit.

The design requirements for Primary Clarifier are provided in **Table below**

Table D-8: Design Parameters of Primary Clarifier for each phase CETP

Description	Values	Unit
Primary Clarifier		
Design flow	2500	m ³ /d
minimum no of Primary Clarifier	1	Nos
MOC of Clarifier Tank	RCC M35	
Surface Loading rate (maximum)	< 35	m ³ / m ² /d
Weir Loading rate (maximum)	< 125	m ³ / m ² /d
Side water depth (Minimum)	3.5	m
Freeboard (Minimum)	0.5	m
Bottom slope	1:12	
Design maximum primary sludge consistency	1.5	%
Type of bridge	Half bridge	

Description	Values	Unit
Drive mounting	Central Driven	
Width of walkway (Minimum)	1.2	m
Influent feed and type of inlet	Bottom feed and pipe	
Type of weir with V notch	Single weir	
Type of launder	Internal	
MOC of Launder	RCC	
MOC of Scraper mechanism	SS 316	
MOC of bridge	SA21/2 sand blasted & CSEP	
MOC of handrails	SS316	
MOC of weir and fasteners	SS 316	
Epoxy coating Minimum DFT	250	μm
MOC of telescopic valve	SS 316	

The design requirements for Coagulant - Poly Aluminium Chloride/Ferric chloride and lime dosing system are provided in **Table below**

Table D-9: Coagulant Dosing System Description for 15 MLD CETP

Description	Values	Unit
Type of coagulant	Alum/ PAC	
Coagulant Dosing Tank		
No of coagulant dosing tank (Minimum)	1	No
Minimum capacity of Tank	2-day HRT	
MOC of dosing tank	FRP/HDPE/RCC with lining	
Level Measurement	Level Indicating Transmitter	
Coagulant Dosing Tank agitator		
No of Agitator	1	No
Type of Agitator	Vertical shaft agitator	
MOC of Agitator	SS 316	
Coagulant Dosing Pumps		
No of Dosing pumps (Minimum)	4 (3W+1S)	Nos
Type of pumps	Single Diaphragm	
Capacity and Head of pumps	As per Bidder's Design	
Lime Dosing tank		
No. of lime dosing tank	1	no.
Minimum capacity of the tank	1 day HRT	
MOC of the dosing tank	FRP/HDPE/RCC with lining	
Level Measurement	Level Indicating Transmitter	
Lime Dosing Tank agitator		
No of Agitator	1	No
Type of Agitator	Vertical shaft agitator	

Description	Values	Unit
MOC of Agitator	SS 316	
Lime Dosing Pumps		
No of Dosing pumps (Minimum)	3 (2W+1S)	Nos
Type of pump	Peristaltic	
Capacity and Head of pumps	As per Bidder's Design	

The design requirements for Polymer dosing system for flocculation are provided in **Table below**

Table 9: Polymer Dosing System for Flocculation Description for CETP

Description	Values	Unit
Polymer Dosing Tank		
No of Polymer dosing tank (Minimum)	1	No
Polymer dosing concentration	0.1	%
Capacity of Tank	1 day HRT	
MOC of dosing tank	FRP/HDPE	
Level Measurement	Level Indicating Transmitter	
Polymer Dosing Tank Agitator		
No of Agitator per tank	1	No
Type of Agitator	Vertical shaft agitator	
MOC of Agitator	SS 316	
Polymer Dosing Pumps		
No of Polymer Dosing pumps (Minimum)	3 (2W+1S)	Nos
Type of pumps	Single Diaphragm	
Capacity and Head of pumps	As per Bidder's Design	

DISTRIBUTION CHAMBER FOR BNR TANK

- Distribution chamber for BNR tank should be designed for average flow of 5000 m³/d. Auto operated weir penstocks should be provided in distribution chamber of BNR tank.
- The distribution chamber should be constructed in RCC M35.

ANAEROBIC TANK

- The Influent i.e. overflow from primary unit/s shall first enter into Anaerobic Tank wherein phosphorus-accumulating bacteria release stored phosphorus to the wastewater. The underflow from secondary clarifier/s is recirculated to anaerobic tank to get mixed with fresh influent by enhancing anaerobic conditions leading to removal of phosphorus biologically in

absence of Oxygen. The phosphorous released through this process is being fed to Anoxic Tank along with the overflow.

- The anaerobic tank shall be provided with submersible mixers for keeping the mixed liquor in suspension.
- Fixed Lifting Davit crane with suitable capacity shall be provided for each submersible mixer for lifting in case of maintenance.
- Minimum two submersible mixers (1W+1S) shall be provided in each tank

The design requirements for Anaerobic Tank are provided in **Table below**

Table D-10: Design Parameters of Anaerobic Tank for each phase CETP

Description	Values	Unit
Quantity of Anaerobic Tank	1	Nos
Material of Construction	RCC M35	
Design Flow to Anaerobic Tank	Average Flow + Recirculation Flow (RAS)	m ³ /hr
Anaerobic Tank HRT (Minimum)	As per Design guidelines - Metcalf Eddy Book	Hr
Liquid depth	As per Bidder's design	m
Submersible Mixers		
Quantity of Anaerobic Mixers	As per design and tank volume	Nos
Mixing requirement (Minimum)	8	w/m ³
Type of Mixers	Submersible mixers	
MOC of submersible mixers with guide rails & chains	SS 316	
Type of lifting equipment for mixers	Fixed lifting davit	

ANOXIC TANK

- The overflow from Anaerobic tank enters to Anoxic tank for denitrification process. The wastewater from the aeration stage is internally recycled to each Anoxic tank at suitable flowrate typically 200-400% of Average inflow. This stage is specified as anoxic due to no free oxygen presence apart from oxygen supplied in the form of nitrates/nitrites present in the internal recirculation stream from the aeration stage. Denitrifying bacteria metabolize the nitrate and covert it to nitrogen gas as they consume the organic matter in the wastewater.
- The anoxic tank shall be provided with submersible mixers for keeping the mixed liquor in suspension.

- Fixed Lifting Davit crane with suitable capacity shall be provided for each submersible mixer for lifting in case of maintenance.
- Minimum two submersible mixers (1W+1S) shall be provided in each tank

The design requirements for Anoxic Tank are provided in **Table below**

Table D-11: Design Parameters of Anoxic Tank for each phase CETP

Description	Values	Unit
Quantity of Anoxic Tank	1	Nos
Material of Construction	RCC M35	
Design Flow to Anoxic Tank	Average Flow + Internal Nitrified stream Recycle + Recirculation Flow (RAS)	m ³ /hr.
Anoxic Tank HRT (Minimum)	As per Design guidelines - Metcalf Eddy Book	Hr.
Liquid depth	As per Bidder's design	m
Submersible Mixers		
Quantity of Anoxic Mixers	As per design and tank volume	Nos
Mixing requirement (Minimum)	8	w/m ³
Type of Mixers	Submersible mixers	
MOC of submersible mixers with guide rails & chains	SS 316	
Type of lifting equipment for mixers	Fixed lifting davit	

TWO STAGE EXTENDED AERATION TANK

The wastewater from Anoxic Zone enter into first stage Extended Aeration tank (Aerobic condition) wherein carbonaceous material is oxidized along with Ammonia into Nitrates, Nitrites etc. Overall carbonaceous Material and Biological nutrient removal processes are controlled by maintaining process control parameters, such as mean cell residence time (MCRT), return activated sludge (RAS) recycle rate, mixed-liquor suspended solids (MLSS) concentration, Nitrified Effluent Internal Recycle rate, and the food-to-microorganism (F/M) ratio, DO, alkalinity, pH etc. The nitrified mixed liquor is to be recycled back to each anoxic tank.

The effluent from the first stage extended aeration tank flows into a Secondary Clarifier-I and the clarifier sludge is recycled back to inlet of Anaerobic tank as per the design requirement. Further the excess sludge which is to be wasted is transferred to the Dewatering unit.

The overflow of clarifier-I shall be fed to the Second stage Extended Aeration Tank. The second stage extended aeration tank with additional aeration and longer SRT, enables

thorough decomposition of organic matter. The longer retention time ensures that even less biodegradable compounds gets adequate time for its metabolism to enable maximum BOD reduction. The second stage extended Aeration Process stabilizes the sludge, reducing its volume and making it easier to handle and dispose of. The effluent from the second stage extended aeration tank undergoes final clarification through Clarifier -II for solid liquid separation. Further the RAS is recycled suitably as per design requirement to second stage Extended Aeration tank inlet and excess sludge to be wasted is transferred to Dewatering unit.



- The required oxygen shall be provided by fine bubble membrane air diffusers only. The diffusers MOC should be silicone elastomer with UV protection or PU Membrane.
- Sufficient quantity of dissolved oxygen analysers should be provided in the aeration tank.
- An electromagnetic flow meter should be provided in the common header of Sludge Recirculation pumps. One Level Indicating transmitter should be provided in Conventional Aeration Tank.
- Aeration blowers shall be installed in a blower house.
- Aeration Tank Air Blowers should be provided with individual Variable frequency drive (VFD) and it should be operated based on the DO maintained in the aeration tank.
- Each blower should be provided with acoustic enclosure and the noise level should not exceed 80 dB (A) at 1 m away from the blower.
- Blower house should be provided with EOT crane of suitable capacity. The capacity of crane should be 2 times of the heaviest equipment to be lifted.
- Material of construction of pipe between blower house and aeration tank, drop pipe and air distribution pipe & laterals should be in SS 316. Diffuser supports should be in SS 316 material.

- SOTE per unit diffuser submergence: as per guaranteed by the manufacturer (bidder to include in the bid a letter from the manufacturer of the diffuser, giving reference of this project, guaranteeing the SOTE of the proposed diffuser system, the minimum guaranteed service life of the diffuser and the head loss during the last year of diffuser's service life. and also conduct SOTE at field as per international standards and process.)

The design requirements for Two Stage Extended Aeration Tank are provided in Table below

Table 10: Design Parameters of Two stage Extended Aeration Tank for each phase CETP

Description	Values	Unit
No. of First Stage Extended Aeration Tank (Minimum)	1	No
No. of Second Stage Extended Aeration Tank (Minimum)	1	No
Design Flow	2500	m ³ /d
MOC of Aeration tank	RCC M35	
Maximum design MLSS	As per Design guidelines - Metcalf Eddy Book	mg/l
MLSS/MLVSS ratio	As per Design guidelines - Metcalf Eddy Book	-
F/M	As per Design guidelines - Metcalf Eddy Book	Day ⁻¹
HRT (minimum)	As per Design guidelines - Metcalf Eddy Book	hrs
θ_c	As per Design guidelines - Metcalf Eddy Book	days
Q _R /Q Recirculation ratio	As per Design guidelines - Metcalf Eddy Book	ratio
Maximum Liquid depth	6.0	m
Freeboard	0.6	m
Oxygen for BOD removal	0.8 to 1.2	Kg/kg BOD removed
Nitrification oxygen requirement	4.6	Kg/kg NH ₄ -N nitrified
Allowable maximum oxygen credit from denitrification	50%	kg O ₂ /kg NO ₃ -N to be denitrified
Minimum DO to be maintained in the aeration tank	2.0	mg/l
Total Actual oxygen demand additional safety factor	20%	
Diffused Aeration in Aeration Tank		
Oxygen transfer correction factor for wastewater, α	0.60	

Description	Values	Unit
Fouling factor for diffusers	0.80	
Salinity-Surface tension correction factor, β	0.95	
Type of Aeration	Fine bubble diffusers	
Type of Diffusers	Tubular Silicon Type	
Type of Diffuser Installation	Retrievable	
Maximum air flow through Tubular membrane diffuser	10	Nm ³ /h
Mounting distance of diffuser from floor level up to its enter line (Minimum)	0.20	m
Air Blowers		
Quantity of Air Blowers provided per tank	2 (1W+1S), 100% standby	nos.
Capacity and head of blowers	As per Bidder's Design	Nm ³ /h
Type of Blowers	Rotary Type (Tri lobe)/ Turbo blower	
Type of Blower operation	VFD based	
Aeration system sizing basis liquid temperature	Max liquid temp or 30 , whichever is maximum	Deg C
Aeration system sizing basis air temperature	Max.Air temperature	Deg C

SECONDARY CLARIFIER – I & II

After Extended Aeration Tank, the mixed liquor flows into a Secondary Clarifier-I & II respectively, where the biomass (sludge) settles out. A portion of this sludge is returned to the aeration tank as Return Activated Sludge (RAS), while the excess is removed as Waste Activated Sludge (WAS)

- Secondary Clarifier shall perform to provide average outlet TSS of not more than 50 mg/lit.

The design requirements for Secondary Clarifier-I & II are provided in Table below

Table 12: Design Parameters of Secondary Clarifier -I & II for each phase CETP

Description	Values	Unit
Secondary Clarifier-CAT		
Design flow	2500	m ³ /d
minimum no of Secondary Clarifier-I	1	No
minimum no of Secondary Clarifier- II	1	No
MOC of Clarifier Tank	RCC M35	
Surface Loading rate	8 to 15	m ³ / m ² /d
Solid Loading Rate	25 to 120	Kg/day/sqm
Weir Loading rate (maximum)	< 185	m ³ / m ² /d
Side water depth	≥ 3.0 to 4.0	m

Description	Values	Unit
Freeboard (Minimum)	0.5	m
Bottom slope	1:12	
Design maximum secondary sludge consistency	0.8	%
Type of bridge	Half bridge	
Drive mounting	Central Driven	
Width of walkway (Minimum)	1.2	m
Influent feed and type of inlet	Bottom feed and pipe	
Type of weir with V notch	Single weir	
Type of launder	Internal	
MOC of Launder	RCC	
MOC of Scraper mechanism	SS 316	
MOC of bridge	SA21/2 sand blasted & CSEP	
MOC of handrails	SS316	
MOC of weir and fasteners	SS 316	
Epoxy coating Minimum DFT	250	µm
MOC of telescopic valve	SS 316	

FILTER FEED TANK CUM PRE-CHLORINATION TANK

Secondary treated water as Supernatant from Secondary Clarifier-2, flow by gravity to the Disinfection Process to Filter Feed Tank cum Pre-Chlorination tank. To disinfect the harmful bacteria in the treated water as well as to remove the refractory organics from treated water, in this tank hypo chlorite solution is dosed with the help of dosing system. Tank shall be provided with Level indicating transmitter. The design requirements for Filter Feed Tank cum pre-chlorination tank are provided in **Table below**

Table 13: Design Parameters of Filter Feed Tank cum Pre-chlorination Tank for each phase CETP

Description	Values	Unit
Design flow	2500	M ³ /d
MOC	RCC M35	
Number of Compartments in Tank	2	Nos
HRT based upon average daily flow (Minimum)	1	hr
Liquid depth	As per Bidder's design	m
Freeboard (Minimum)	0.5	m
Chlorine Mixing Tank		
Qty of Chlorine Mixing Tank	1	Nos

Description	Values	Unit
MOC of Chlorine mixing tank	RCC	
Number of Agitator (Minimum)	1	Nos
MOC of agitator	SS316	
NaOCl dosage (Minimum) – Pre-chlorination	3	Mg/l
NaOCl concentration	10 to 12%	
NaOCl Dosing Tank		
Number of dosing tank (Minimum)	1	Nos
Capacity of tank	1 day Retention	
MOC of day Tank	FRP/MSRL	
NaOCl Dosing pumps		
Number of NaOCl dosing pumps	2 (1W+1S), 100% Standby	Nos
Capacity and Head of dosing pumps	As per Bidder's design	
Type of dosing pumps	Metering pump	
Filter Feed Pumps		
Number of Filter Feed Pumps	2 (1W+1S)	Nos
Operation hours	22	hrs
Type of pumps	Non-Clog, Horizontal mounted centrifugal	
MOC of pump	Casing: C.I. Impeller: SS, Shaft: SS410	

PRESSURE SAND FILTER

A pressure sand filter uses a bed of sand to trap suspended solids, turbidity, and other impurities from water, effectively removing contaminants and producing clean water. The process involves water entering the filter under pressure, passing through multiple layers of sand media, and then being collected as filtered water. After a period of use, the filter is backwashed to remove trapped particles and restore the sand bed to its original state. The design requirements for Pressure Sand Filters are provided in **below**:

Table 14: Design Parameters of Pressure Sand Filter for each phase CETP

Description	Values	Unit
Quantity of PSF	2 Working	Nos
Maximum Working Hours of Filter	22	hrs
Rate of Filtration Rate	10-12	m ³ /m ² /Hr.
Type of media	Sand	
Material of Construction	MSEP	

ACTIVATED CARBON FILTER

Activated carbon filters work by adsorption, where contaminants in water or air are drawn to the surface of the carbon particles and retained due to physical and chemical interactions. The porous structure of activated carbon provides a large surface area for this adsorption process, allowing it to effectively remove a wide range of impurities. The design requirements for Activated Carbon Filters are provided in **Table below**

Table 15: Design Parameters of Activated Carbon Filter for each phase CETP

Description	Values	Unit
Quantity of ACF	2 Working	Nos
Maximum Working Hours of Filter	22	hrs
Rate of Filtration Rate	10-12	m3/m2/Hr.
Type of media	Activated Carbon IV 1200 minimum	
Material of Construction	MSEP	
Backwash Operation for PSF and ACF		
Water Backwash	Independent Water Backwash Pump shall be provided	
Water Backwash Rate	42 -54	m3/hr
Minimum Water Backwash Time	10	Minutes
Water Backwash Pump Capacity (m ³ /hr) & Head (m)	As per bidder's design and design should be as per latest CPHEEO manual /As per Metcalf book	
Type of water backwash Pump	Horizontal Centrifugal	
Air Backwash System	Independent Air Blowers shall be provided	
Air Scouring rate	45 – 50	nm3/ m2/hr
Duration of air scouring (minimum)	5 minutes	
Capacity of Air Scour Blower (Nm ³ /hr) and Head (Kg/cm ²)	As per bidder's design and design should be as per latest CPHEEO manual /As per Metcalf book	

ULTRA-FILTRATION SYSTEM FEED TANK

The treated sewage from ACF and PSF will be transferred to UF Feed Tank.

A UF (Ultrafiltration) feed tank is a crucial component in the ultrafiltration process, ensuring a consistent and stable supply of feed water to the UF system. The UF feed tank serves as a buffer to maintain a steady flow of water to the ultrafiltration membranes. This helps in

managing fluctuations in the feed water quality and flow rate, ensuring optimal performance of the UF system.

The design requirements for UF Feed Tank are provided in **Table below**

Table15: Design Parameters of UF Feed Tank for CETP

Description	Values	Unit
Quantity of UF Feed Tank	1	Nos
Material of Construction	RCC M35	
Design Flow to UF Feed Tank	56	m ³ /hr
UF Tank HRT (Minimum)	1	hrs
Liquid depth	As per Bidder's design	M
Recirculation Transfer Pumps		
Number of UF Feed Pumps	2 (1W+1S)	Nos
Capacity of UF Feed Pump	56	m ³ /hr
Type of pumps	Horizontal mounted centrifugal / Submersible	
MOC of pump	Casing: SS 316. Impeller: SS 316, Shaft: SS410	

ULTRA-FILTRATION SYSTEM

The treated effluent from ACF and PSF will be transferred to UF system. The operation of the Ultra filtration unit will be completely automated, and the service & backwash sequence will be controlled by a UF controller. The permeate water is stored in the treated water tank and will be used for Flushing and Gardening. The reject is recycled back to the equalization tank of CETP.

Pre-Treatment to UF

Contractor to provide the necessary pre-treatment before UF to meet the UF feed quality requirements if needed to meet the required UF feed water characteristics.

Ultra-Filtration System

The primary purpose of the Ultrafiltration system is to remove sub-micron particles including bacteria, colloidal and other suspended solids from the secondary effluent. It also serves as a barrier to the microorganisms.

The Ultrafiltration system includes:

- Auto Self-Cleaning strainers

- UF Permeate Pump
- Ultra-filtration modules
- UF Backwash System
- UF CIP system
- UF Air Scouring Blowers

Self-Cleaning Strainers: (If required)

The Contractor shall provide Self Cleaning strainers to remove particles and debris, such as drill shavings, present in the secondary effluent that could be expected to damage the membranes used in the UF process.

The screening properties of the strainer shall be based on the requirements of the UF membrane process.

The self-cleaning filters are automatic with a self-cleaning backwash mechanism.

UF Compartments:

UF Trains should be designed for N-1 operation philosophy. The Contractor is free to optimize total no. of trains to ensure minimum downtime and availability is achieved.

UF Backwash System:

Part of the UF permeate shall be stored in backwash tank and shall be used to backwash the Ultra Filtration trains to maintain the operating flow/flux of the membranes. Air scouring blowers shall be used to scour the attached suspended particles from the surface of the membranes.

UF CIP System:

A CIP system shall be provided for the ultra-filtration plant. This can be used to undertake maintenance or recovery cleans of the UF membranes to maintain plant performance.

UF System Operation:

The UF system shall consist of the following modes of operation

- i) Service Cycle

ii) UF Backwash (BW) Cycle

iii) Maintenance Cleaning (MC) Cycle

iv) Recovery cleaning (RC) Cycle

The design shall provide for easy isolation of each UF and shall include all required facilities for complete and automatic backwash and clean-in-place (CIP) functionality.

The Contractor shall be fully responsible for the detailed design and layout, and provide all associated equipment, tanks, and controls to provide a fully functional, operating system which.

meets the specified performance requirements. Each UF train shall be capable of operating independently from the other UF Trains. These independent operations shall include filtering, backwashing and membrane chemical cleaning. Each Train shall have inlet and outlet connections, stop valves, control valves, actuators, instrumentation, membrane integrity checking systems, process and filtrate quality monitoring systems, to provide an independent operating unit which is fully functional. Each train shall have its own membrane integrity monitoring system.

A Separate UF Building shall be provided for the UF system.

This UF Building shall house all UF system-related equipment such as UF Feed Pumps, Self-Cleaning Strainers, UF modules, Air Scouring Blowers, Back pulse Pumps as applicable. In addition, the UF Equipment building shall house all equipment necessary for membrane cleaning. i.e., UF CIP system and the dosing systems.

The design requirements for UF System are provided in **Table below**

Table 17: Design Parameters of UF System for CETP

Description	Values	Unit
Type	Pressurized Ultrafiltration System	Nos
No. of Skids	2 Working + 0 Standby	No.
No. of Racks per Skid	As per Design	No.
No. of Module per Rack	As per Design	No.
Flow to each UF Skid	As per membrane vender	m ³ /hr.
Operation hours	22	Hrs.
Minimum Average Recovery	90	%

Description	Values	Unit
Design Flux Maximum	50	LMH
Total UF Permeate	As per Design	
Type of UF Membrane	Hollow Fiber outside-in	
MOC	PVDF	
No. of modules per skid	As per Design	
UF membrane area per module	As per Manufacturer	
Backwash / Recovery clean Pump	2 (1 Working + 1 Standby)	Nos.
Capacity of Backwash / Recovery clean Pump	As per Design	
Head	As per Design	
MOC	Casing: SS 316. Impeller: SS 316, Shaft: SS410	
UF Air Scouring Blower		
Type of Blower	Twin Lobe / tri Lobe	
Qty of Air Blower	2 (1 Working + 1 Standby)	
Capacity of Air Blower	As per Design	
Head of Air Blower	As per Design	
CIP System	As per Design	
UF System should be Complete in all respect for safe operation and guaranteed performance, shall be included in the scope of work of the Bidder/Contractor.		

TREATED WATER TANK CUM POST-CHLORINATION TANK

In ultrafiltration (UF), a permeate tank serves as a collection point for the filtered liquid (permeate) that passes through the ultrafiltration membrane.

Treated effluent storage tank should be designed for receiving the treated effluent flow from CETP (15000 m³/d). As CETP treated water shall be reused for toilet flushing and gardening it is recommended to do post chlorination for disinfection process, Post disinfection stage to maintain the residual chlorine to prevent algal growth and reactivation of the pathogens. Minimum residual chlorine of 1 mg/l is to be maintained in the treated water for reuse applications. The design requirements for Treated Water tank cum Post-Chlorination Tank are provided in **table below**

Table 18: Design Parameters of Treated Water Tank cum Post-chlorination Tank for 2.5 MLD CETP

Description	Values	Unit
Design flow	2500	M ³ /d
MOC	RCC M35	
Number of Compartments in Tank	2	Nos
HRT based upon average daily flow (Minimum)	8	hr
Liquid depth	As per Bidder's design	m
Freeboard (Minimum)	0.5	m
Chlorine Mixing Tank		
Qty of Chlorine Mixing Tank	1	Nos
MOC of Chlorine mixing tank	RCC	
Number of Agitator (Minimum)	1	Nos
MOC of agitator	SS316	
NaOCl dosage (Minimum) – Pre-chlorination	5	Mg/l
NaOCl concentration	10 to 12%	
NaOCl Dosing Tank		
Number of dosing tank (Minimum)	1	Nos
Capacity of tank	1 day Retention	
MOC of day Tank	FRP/MSRL	
NaOCl Dosing pumps		
Number of NaOCl dosing pumps	2 (1W+1S), 100% Standby	Nos
Capacity and Head of dosing pumps	As per Bidder's design	
Type of dosing pumps	Metering pump	
Treated Water Transfer Pumps		
Number of Filter Feed Pumps	2 (1W+1S)	Nos
Operation hours	16	hrs
Type of pumps	Non-Clog, Horizontal mounted centrifugal	
MOC of pump	Casing: C.I. Impeller: SS, Shaft: SS410	

SLUDGE TREATMENT (SLUDGE SUMP AND DEWATERING SYSTEM)

The sludge generated from the Primary Clarifier and Secondary Clarifier will be collected in Separately in 2 nos. sludge holding tanks and shall be dewatered using the mechanical dewatering units like Centrifuge.

To enhance the dewatering process / treatment of excess sludge, Poly electrolyte will be dosed to the bio-sludge. The dewatered sludge will have the solid concentration of 18 to 20% depending upon the type of dewatering equipment used. The Dewatered sludge cake shall be

collected and suitably treated for pathogen reduction, so that it can be disposed without any environmental hazard as per regulatory guidelines. Dewatered sludge should be disposed to Solid Waste Disposal and Landfill disposal location/land/site. The design requirements for sludge dewatering system are provided in **table below**

Table19: Design Parameters of Sludge Treatment Units for 15 MLD CETP

Description	Values	Unit
Sludge Sump -1 For Primary Clarifier	Chemical Sludge	
Design flow	As per Sludge Generation design	M ³ /d
MOC	RCC M35	
HRT based upon Sludge Generation	12	hr
Liquid depth	As per Bidder's design	m
Freeboard (Minimum)	0.5	m
Sludge Sump -2 For Secondary Clarifier	Biological Sludge	
Design flow	As per Sludge Generation design	M ³ /d
MOC	RCC M35	
HRT based upon Sludge Generation	12	hr
Liquid depth	As per Bidder's design	m
Freeboard (Minimum)	0.5	m
Type of Mixing in Sludge Sump 1 & 2		
Type	Coarse bubble/Mechanical mixers	
MOC	SS316 – for Mechanical Mixer EPDM / PU / Silicon Rubber – for Coarse Bubbled diffused aeration tubular type.	
Centrifuge Feed Pump for Sludge Sump-1		
Qty of pumps	2 (1W+1S)	No
Type of pumps	Progressive cavity type with pressure safety valve loop /Peristaltic	
Operation	with VFD to each pump	
Centrifuge Feed Pump for Sludge Sump-2		
Qty of pumps	2 (1W+1S)	No
Type of pumps	Progressive cavity type with pressure safety valve loop /Peristaltic	
Operation	with VFD to each pump	
Centrifuge (Common for Chemical & Biological Sludge)		
Qty of centrifuge	2 (1W+1S)	no.
Operating duration	14 hours/day, 7 days/week	
Minimum solids recovery	95%	

Description	Values	Unit
MOC of centrifuge bowl, scroll and other wetted parts	SS316 / SS 316L	
MOC of discharge chute	SS316 / SS 316L	
Mode of operation	Automatic with VFD	
Polymer dosing system		
Dry polymer design basis	2	kg/ton of dry solid
Maximum design polymer solution concentration	0.1%	w/w
Qty of polymer dosing tank	1	no
Polymer preparation tank MOC	FRP/MSRL/RCC	
Type of agitator	vertical shaft mounted	
MOC of agitator	SS316	
Polymer dosing pump qty	2 (1W+1S)	
Type of dosing pump	Diaphragm type	

PLANT DRAIN RETURN SUMP

Centrate from Dewatering centrifuge, Backwash from PSF, ACF, UF and all process and chemical drains shall be received in Plant Drain return sump. Submersible pumps shall be provided with Guide rails and lifting chains to transfer the return flow to inlet chamber/ equalization tank. MOC of Guide rails and lifting chains should be in SS 316. The plant returns should be pumped back to inlet works. A level transmitter should be provided in the Plant Drain Return Sump. An electro-magnetic flowmeter should be provided in the common discharge header of plant return pumps. The design requirements for Plant Drain Return Sump are provided in **Table below**

Table 20 : Design Parameters of Plant Drain Return Sump for CETP

Description	Values	Unit
No of Plant Drain Return Sump	1	No
MOC of tank	RCC M35	
Retention time (Minimum) considering the flow of Centrate from Dewatering centrifuge, Backwash from PSF & ACF, UF	1	Hr
Maximum Liquid depth	3	m
Number of Plant Drain Return Pumps	2 (1W+1S)	Nos
Capacity and Head of pumps	As per Bidder's design	
Type of pumps	Submersible	
MOC of Pumps	SS316	

ODOUR CONTROL UNIT (OCU)

Centralized odour control unit should be provided for odour generated CETP Inlet works area. Odours gases should be extracted from all the points wherein raw sewage, sludge contaminates the air. STP Odour control unit shall extract the odours gases from the following areas but not limited to:

- CETP Receiving chamber
- Coarse Screen Chamber
- Fine Screen chamber
- Equalization Tank
- Equalization Tank pump sump
- Sludge sumps

12 Air changes per hour should be considered for designing the air volume extracted at each odour points mentioned above. Two stage Odour control system should be provided. Biological Odour Control Unit should be followed by Activated carbon type Odour control Unit to be provided. Dampers and Non return valves shall be provided for each odour extraction points. The Contractor shall design and supply all necessary supports for the odour control covers, with adequate sealing. A negative pressure must be maintained below the covers to avoid escape of odorous air to atmosphere.

OCU needs to achieve < 500 OU/m³ at the OCU outlet & 5 OU/m³ on a 99.8% i.e, one hourly average basis measured at the site boundary. Fixed H₂S Analyser should be provided at the inlet of 1st stage OCU, at the inlet of 2nd stage and at the stack of 2nd stage OCU. OCU Extraction fans shall be provided in SS 316 L material and acoustic enclosure should be provided for each fan to achieve <80 dB (A) at 1 m. OCU should be provided with chemical dosing system (NaOH and Nutrient) if required for the process. Air velocity in the odour duct should not exceed 5 m/s. MOC of Odour Cover at open channels/ chambers and duct should be in GRP. The operating level for Equalization tank should not be considered more than 70% of liquid depth for calculating the gas volume for OCU.

Table 21: Guidance for Air Contaminants Concentration for CETP

Odour extraction points	Undiluted H ₂ S Concentration (PPM)		Undiluted NH ₃ Concentration (PPM)	
	Average	Peak	Average	Peak
Receiving Chamber	200	300	10	20

Odour extraction points	Undiluted H ₂ S Concentration (PPM)		Undiluted NH ₃ Concentration (PPM)	
	Average	Peak	Average	Peak
Coarse Screen Chamber	200	300	10	20
Sludge Sump and Pump house	200	300	10	20
Fine Screen Chamber	200	300	10	20
Equalization Tank	200	300	10	20
Equalization Tank pump sump	200	300	10	20
Any other extraction points not mentioned above	200	300	10	20

Table 22: Required OCU Discharge Quality

Contaminant	Percentage removal of contaminants	Maximum Discharge Concentration at Peak load (ppm)	Maximum Discharge Limit
Hydrogen Sulphide (H ₂ S)	99.9%	1.0	Total contaminants not to exceed < 500 OU/m ³ at the discharge of stack and < 5 OU/m ³ at the plant boundary

UTILITY AND ANCILLARY BUILDINGS

Contractor shall construct all utility and ancillary buildings as below but not limited to, Admin Building, Air Blower House, Workshop & Tool room and MCC and Control room, Laboratory, Office & Conference room, Chlorination House, Chlorine Tonner House, Sludge Pump House, Centrifuge House, U.F. Building, HT Substation, DG House, Security Cabin and other allied structures.

D 9. WATER TREATMENT PLANT

TENDERING INFORMATION

1. TECHNICAL / DESIGN CRITERIA:

I. Plant Capacity

- a) Plant Capacity as per tender
- b) Overloading of units of Treatment Plant: All interconnecting pipelines/channels/launders (water conveying system) within WTP shall be designed for 20% hydraulic overload. However, individual filter Inlet & outlet system shall be designed for 100% hydraulic overload condition. The design flow rates shall be calculated considering 22 hours of pumping per day.
- c) Source of Raw Water:

Construction Period - It has been envisaged that ground water/ treated water may be used as the source of water during construction period. However, EPC contractor needs to take necessary permissions/ permit from the concerned authorities for using the same.

GENERAL ARRANGEMENT OF PLANT

- Bidder must consider space provision of WTPs proposed to be constructed on modular basis. Initial capacity under this EPC tender and ultimate capacity are as follows.

S.N.	Treatment Plant	Phase-I (Present Proposed Capacity in this EPC Tender) in MLD	Phase-II (Only Space Provision for this Capacity) in MLD	Phase-II (Only Space Provision for this Capacity) in MLD	Total Ultimate Capacity in MLD
1	WTP	5.00	5.00	5.00	15.00

Operation Period - The water demand of IMC Hisar will be meet through Hybrid water source i.e. the combination of the surface water source and Ground water source.

- d) Quality of Raw Water: The quality of water as per mentioned in tender. However it is expected that such quality may not prevail at other times particularly during the monsoon.
- e) Raw water quality given in tender is indicative only. Successful bidder needs to carry out necessary sampling & analysis. Based on analysis, design Raw water quality parameters shall be decided. However in no case, it shall be lower than as defined in tender documents.
- f) Raw water characteristics vary considerably. Turbidity of raw water may go as high as up to 1000 NTU in rainy season. (The below mentioned raw water characteristics are assumed since the source of water is yet to be finalized).
- g) The quality of raw water considered for the design shall be as given below:

Table1: RAW WATER QUALITY PARAMETERS

Sr. No.	Parameters	Values	Unit
1	P ^H	7 to 8.5	-
2	Total Suspended Solids (TSS)	< 100	Mg/lit
3	Turbidity (Non Monsoon)	5 to 500	NTU
4	Turbidity (Monsoon)	< 1000	NTU

- h) Though the turbidity of water is expected to remain within 25 NTU throughout the year; in rainy season turbidity is expected to shoot up to 200 NTU & above for two to three weeks. Turbidity may remain above 500 NTU for shorter period. Hence the plant should be able to take shock load of 500 NTU for one month and 1000 NTU for few days in a year.
- i) The above parameters are for guidance only and client assumes no responsibility for the correctness of the same and it is the responsibility of bidder to carry out the sampling tests of raw water by themselves to ascertain the raw water quality for treatment process at no extra cost to design the plant for worst conditions. The Employer will not be responsible for the above and no relaxation will be given to the guarantee conditions of desired treated water quality. For design purposes the lower parameters than the above mentioned parameter shall not be allowed.

2. TREATMENT PLANT PERFORMANCE GUARANTEES

The individual components of the plant will be designed for the design rated capacity. However all the units must have a capacity to hydraulically pass through additional 20% of plant capacities. The treated water quality on the design flow rate shall be as defined below in the table for individual clarifiers, filters and the combined stream in the filter Clearwater channel and CWR.

3. PROCESS GUARANTEES

Table 2 PROCESS GUARANTEES

Sr. No.	Parameters	Values
1	Turbidity of the settled water at outlet of the clarifiers	Not exceeding 5 NTU during Normal season & 10 NTU during Monsoon.
2	Suspended solids in settled water at outlet of the clarifiers	Not exceeding 5 NTU during Normal season & 10 NTU during Monsoon.
3	Total aluminium in settled water at outlet of the clarifiers	Not more than 0.5 mg/l

4	Turbidity of the Filtered water	< 1 NTU
5	Suspended Solids of the Filtered water	< 1 mg/l
6	Colour	Not exceeding 5 Hazen units
7	Test and odour	unobjectionable
8	Iron as Fe	< 0.1 mg/l
9	Manganese as Mn	< 0.1 mg/l
10	Total Aluminium as Al	< 0.2 mg/l
11	Coliform organism	Absent (MPN/100ml)
12	Minimum filter run period at any time of the year between successive backwashing	20 hours
13	Minimum filter run during 90% of the year	36 hours
14	Maximum backwash water during any period of 7 consecutive days at any season of the year	3 % of Filtered water output

In extreme conditions during monsoon, when the raw water turbidity changes, the operator should make changes in alum dosage by Jar Test; so the filters should receive above quality of settled water.

If at any time during testing, commissioning and defects liability period, any of the quality and process parameters cannot be reached, the Contractor shall at his expenses carry out all necessary modifications to the civil structures, the mechanical, hydraulic, electrical and other components of the plant, or modify the operation procedures and the chemical dosing parameters in order to achieve the required performance of the plant.

4. TREATMENT PLANT PROCESS

It should be ensured by intending tenderers that the scheme of treatment is designed to give adequate operational flexibility & reliability. During the works performance test and trials, the contractor will be required to demonstrate and optimize performance abilities of the works.

5. TREATED WATER QUALITY

In general, the treated water leaving the plant shall be consistently as per the following standards:-

Table 3: TREATED WATER QUALITY AS PER IS 10500;2012

S.N.	Characteristics	As per IS 10500, 2012	
		Requirement (Acceptable Limit), IS 10500; 2012.	Permissible limit in absence of alternate source

1	Turbidity, NTU, Max	1.0	5
2	Colour, Hazen Units, Max	5	15
3	Taste & odour	Agreeable	Agreeable
4	pH	6.5 – 8.5	No relaxation
5	Total Dissolved Solids, mg/l, Max	500	2000
6	Total hardness (as CaCO ₃), Max, mg/l	200	600
7	Chloride (as Cl), max, mg/l	250	1000
8	Sulphate (as SO ₄), Max, mg/l	200	400
9	Fluoride (as F), Max, mg/l	1.0	1.5
10	Iron (as Fe), mg/l, Max	0.3	No Relaxation
11	Aluminium as Al, mg/l, Max	0.03	0.2
12	Free Residual chlorine content of the treated water, 30 minutes after the contact in the chlorination chamber, mg/l, Min	0.2	1.0
13	E. coli or thermos tolerant coliform bacteria	Shall not be detectable in any 100 ml sample	
14	Total coliform bacteria	Shall not be detectable in any 100 ml sample	

In addition to above, treated water quality parameters shall be as per table no. 2.2 and 2.3 of latest edition of CPHEEO manual & is extracted here under Table#1.

The tenderer shall give guarantee for the degree of purification as specified. In addition, treated water quality at WTP outlet should also be well within prescribed limits as per Indian & international drinking water standards as mentioned in Table # 1 given below. To establish the quality of filtrate and performance of other units as specified above, the tenderer shall have to arrange for taking samples and send them to recognized laboratory and get the raw, clarified, and filtered water samples analysed for physical, chemical and bacteriological qualities of all the three raw, clarified, and filtered water. The tests are to be taken by the tenderer at his cost during the period of trial run of the plant.

During trial runs, however, the turbidity to be achieved, should be less than 1.0 NTU since the plant designed for this requirement will be able to produce water of acceptable standard even if adequate operating conditions cannot be guaranteed continuously. The contractor shall at

his own cost undertake the necessary sampling and testing to prove that the treated water conforms to the foregoing standards. If the tests show that the water quality has not been reached to specified levels, the contractor shall submit his proposals for meeting guaranteed requirements to the Engineer. The contractor shall have to carry out at his cost whatever measures; such as improvements, additions, alternative or additions to the plant and equipment (Civil, electrical, mechanical, instrumentation works) that are required to be taken to achieve

specified water quality. No charge will be levied to the contractor for water used during testing. However, energy charges will be charged as per actual.

Table 4 GUARANTEE OF FINAL TREATED WATER QUALITY REQUIREMENTS:

Following Table gives Indian standard and international standard of drinking water.

S. N.	Parameter	Indian Standards (CPHEEO Manual Water Supply & Treatment, May 1999)		International Standard	
		Acceptable	Cause for Rejection	Acceptable	Cause for Rejection
1	Turbidity (NTU)	1.0	10	5.0	25.0
2	Colour (Unitson platinum Cobalt scale)	5.0	25.0	5.0	5.0
3	Taste	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
4	Odour	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
5	PH	7 – 8.5	< 6.50 or > 9.0	7.0 to 8.50	6.50 to 9.20
6	Total dissolved solids	500	2000	500	1500
7	Total hardness (mg/l as CaCO ₃)	200	600	100	500
8	Chlorides as Cl (mg/l)	200	1000	200	600
9	Sulphate (mg/l as SO ₄)	200	400	100	400
10	Fluorides (mg/l as F)	1.0	1.5	0.60	1.70

S. N.	Parameter	Indian Standards (CPHEEO Manual Water Supply & Treatment, May 1999)		International Standard	
		Acceptable	Cause for Rejection	Acceptable	Cause for Rejection
11	Nitrates (mg/l as No ₃)	45	45	45	45
12	Calcium (mg/l as Ca)	75	200	75	200
13	Magnesium (mg/l as Mg)	<30 or = 30	150	75	200
		If there are 250 mg/l of sulphates, Mg content can be increased to a maximum of 125mg/l with the reduction of Sulphates at the rate of 1 unit per every 2.5 units of Sulphates.		If there are 250 mg/l of sulphates Mg++ content can be increased to 125mg/l	
14	Iron (mg/l as Fe)	0.1	1.0	0.1	1.0
15	Manganese mg/l as Mn.	0.05	0.5	0.05	0.5
16	Copper (mg/l as Cu.)	0.05	1.5	0.50	1.50
17	Aluminium as Al, mg/l	0.03	0.2	-	-
18	Alkalinity, mg/l	200	600	-	-
19	Residual Chlorine, mg/l	0.2	>1.0	-	-
20	Zinc(mg/l as Zn)	5	15	5	15
21	Phenolic Compounds (as Phenol) (mg/l as phenol)	0.001	0.002	0.001	0.002
22	Anionic detergents (mg/l as MBAS)	0.2	1.0	0.200	1.0

S. N.	Parameter	Indian Standards (CPHEEO Manual Water Supply & Treatment, May 1999)		International Standard	
		Acceptable	Cause for Rejection	Acceptable	Cause for Rejection
23	Mineral oil (mg/l)	0.01	0.03	0.1	0.30
24	Arsenic (mg/l as As)	0.01	0.05	-	0.05
25	Cadmium (mg/l as Cd)	0.01	0.01	-	0.01
26	Chromium (mg/l as Hexavalent Cr)	0.05	0.05	-	-
27	Cyanides as CN mg/l	0.05	0.05	-	0.05
28	Lead (mg/l as Pb)	0.05	0.05	-	0.10
29	Selenium (mg/l as Se)	0.01	0.01	-	0.10
30	Mercury (Total Hg) (mg/l)	0.001	0.001	-	0.001
31	Polynuclear aromatic hydrocarbons (PAH as µg/l)	0.20	0.20	-	0.20
32	Pesticides (Total, mg/l)	Absent	(Refer to WHO guidelines for drinking water quality. Vol. I, 1993)	-	-
33	Gross alpha Activity (Bq/l)	0.1	0.1	3.0	3.0
34	Gross Beta Activity (Bq/l)	1	1	30	30

S. N.	Parameter	Indian Standards (CPHEEO Manual Water Supply & Treatment, May 1999)		International Standard	
		Acceptable	Cause for Rejection	Acceptable	Cause for Rejection
35	E.-coli or thermotolerant coliform bacteria count	Must not be detectable in any 100 ml sample			
36	Total coliform bacteria	Must not be detectable in any 100 ml sample			

Source:

- "Manual on water supply and treatment" Central Public Health and Environmental Engineering Organization, Ministry of Urban Development, New Delhi, May 1999.
- CPHEEO Manual 1991 Addition, the criteria should be provided.
- International standard for drinking water world health organization Geneva, 1971 (3rd Edition).

6. PLANT LAYOUT CONSIDERATIONS

The water levels at the inlet and outlet shall be as mentioned in tender documents & shall be governed by the loss of head across the treatment plant.

The principal considerations for a good layout of the plant shall be –

- Smooth flow of water from inlet to outlet
- Foundations and floors firmly resting on naturally consolidated soil
- Working space between structures
- Isolation of hazardous areas
- Easy vehicular approach to all equipment/material handling areas / units
- Well connected drainage system up to disposal point
- Stair access to high level outdoor operation areas with hard standing at the foot
- Security of the main operation areas
- Economic area lighting
- Architecture and aesthetics
- Adequate earth cover to buried pipes and ducts
- Birds / reptiles / insects menace

Contractor to adopt/adhere to the general engineering specifications and practice given below while designing the treatment plant which shall form as part of specific requirements and shall supersede general requirements specified elsewhere in tender when observed to be in conflict to below requirements:

Monorail and chain pulley block (manually operated) shall be provided at all pump houses (both underground and above ground) for handling of dirty water / sludge pumps, backwash pumps, etc.; at blower room for handling backwash air blowers; at chemical house for handling alum, etc.; whereas Monorail with Electrically operated Hoist & Trolley/EOT as specified shall be provided at Chlorine Tonner Room for handling chlorine tonners, etc. as required and each shall be of adequate capacity (min. 1.5 times the weight of the equipment / single heaviest component). Monorail / Rail shall be extended outside the pump house / building to facilitate loading / unloading of equipment directly on vehicle, for which ramp approach shall be given. Adequate measure shall be taken to prevent dry running of the pump in all modes of operation i.e. manual as well as auto mode. Low level to trip the pump shall be above the top of pump casing. The sump floor shall slope towards suction pit / channel. Care must be taken especially for underground sludge sumps to provide suction pit of adequate size for emptying the sump for ease of maintenance.

All pumps shall be provided with flooded suction. Effective liquid depth of units shall be considered between levels corresponding to lowest liquid level and highest liquid level as per design. Accordingly all sumps/tanks shall be provided with required suction pit flooded suction requires that lowest liquid level shall not be lower than the top of suction pipe. Displacer / Float type Level switches (in addition to level transmitter where specified for auto operation / alarms) shall be provided for dry run protection of pumps to trip the pumps irrespective of auto or manual mode of operation of the pumps.

Operating platforms shall be provided for operation of any equipment and to take care of valves causing inconvenience to operate from ground/floor level. For this 1.5m width or adequate height of operating platform with sufficient head room must be provided. Platform shall have minimum width of 900mm with galvanized grating / chequered plate.

All pump areas / pedestals shall be provided with kerb walls and suitable arrangement for collection of leakage and connection to the nearest piping/unit, keeping in mind the process requirement. In dry wells, necessary drain collection pit and dewatering pump of sufficient capacity and head requirement for auto operation with low & high level switches and alarm with high-high level switch shall be provided in all pump houses, especially underground pump house for this purpose.

Vehicular approaches shall be provided to the units for operation and wherever required maintenance .

Flushing connections shall be provided for all sludge handling units and sludge lines.

Access to all units / walkways / platforms shall be by RCC stairways except for valve and such operating platforms requiring occasional use where access with ladders shall be accepted.

Hand rails shall be of 40mm dia. (or 38mm OD) medium duty MS pipes.

The clear distance between adjacent pump / blower pedestal shall be minimum 1000mm. The clear distance from pedestal to internal face of end walls shall not be less than 1500mm. The clear distance from pedestal to internal face of walls on suction and motor side of the pumps shall not be less than 2000mm.

Minimum clearance of 1000mm shall be provided around pumps, blowers, equipment pedestal for paving etc.

Motors of all outdoor equipment shall be covered with canopy.

Mixers in chemical solution tanks without baffle shall be located off-centre to avoid vortex.

All chemical dosing pumps shall be provided with pulsation dampeners.

Metering pumps shall have bypass with valves and external pressure safety valves.

- a) Safety shower and eye wash facility, and service water connection shall be provided near chemical handling areas, especially at chlorination area.
- b) All instrument indication facility shall be readable from grade.
- c) All below grade valves shall be operable from grade by providing extended spindle and hand wheel arrangement.
- d) Epoxy lining in alum tanks and any other units as required, shall be provided. Complete wetted surface including free board and top of walls shall be lined.
- e) All overhead units, underground tanks where specified, & other units as required shall be able to be segregated for manual desludging / draining, whenever required, along with drain piping and valve. The purpose is to have possibility to drain all the tanks and other applicable units to make empty for cleaning / maintenance purpose. The drain pipe / drain valve (sluice valve) shall be of minimum 150mm size.
- f) Common delivery header and suction header of pumps (and blowers) shall be provided with a blind flange on one end. All Sludge Pump shall be provided with individual suction line.
- g) Backwash air blowers shall be located inside the blower room with necessary acoustic hoods (to maintain noise level below 85 db at 1.86 m distance from blower) complying with statutory and safety norms.
- h) Clear Distance between two Civil units shall not be less than 5 m.
- i) Knife Gate valves shall be provided for sludge application.
- j) Doors, Windows and Ventilators shall be of aluminium glazed type with EZ section.
- k) All sludge lines shall be of minimum 200mm dia. Size.

- l) The plinth level of all the building shall be min. 600 mm above formation level (FGL). The roof of the building (bottom of slab) shall be min. 3.6 m above plinth level or higher as required.
- m) All the building shall be provided with 1000 mm wide plinth protection of 75 mm thick CC 1:2:4 laid over 150 mm consolidated rubble soling.
- n) All cables within building shall be laid on cable trays or in cable trenches or both and for cables on walls / platforms of various buildings or civil units shall be laid on cable trays and rest all cables to be laid outside the building / outdoors shall be laid buried in ground. All cables trays shall be of medium duty GI and cable trenches shall be constructed in RCC.
- o) Except for pipes / channels for which minimum sizes are specified in tender specifications and in this specific requirement, fluid velocity to be considered in the design of balance pipes / channels and all valves / gates shall be sized as under:
For gravity flow: 0.9 m/sec max.
For pump discharge: 2.5 m/sec max
For Pump Suction: 1.2-1.5 m/sec max

7. MECHANICAL WORKS

The scope includes design, engineering, supply, installation, testing and commissioning of Suitable Pumping machinery as specified in the price bid with required electrical & mechanical accessories, including comprehensive operation & maintenance at various pumping stations of clear water included in the scope of the tender.

- a) SITC of Suitable Pumping Machinery as specified in price bid for three head works for clear water transmission.
- b) The contractor must complete & furnish pump/ model study, Sump/Intake well model study and CFD Analysis before submission of drawings & documents.
- c) Design & supply associated piping, Valves, instrumentation & accessories as specified in price bid.
- d) Installation, testing & commissioning of the above equipments & accessories.
- e) Submission of data sheets, QAP, GA drawing, cross section drawing, layout drawings of all equipment and to get approval of same.

Operating Units

For effective running of pumping machinery, operating staff is required to stay at HW site, hence provision is made for operating units at different head works site as per requirement along with site engineer's office cum residence.

8. GENERAL PROCESS DESIGN REQUIREMENTS FOR WTP

Table D-12: GENERAL PROCESS DESIGN REQUIREMENTS

S.N.	Particulars	Parameter / Requirement
1	General	
1.1	Item	Water Treatment Plant
1.2	Type	Conventional
1.3	Capacity	5 MLD Net treated water at WTP outlet (Considering 22 hrs running time) for WTP
1.4	Raw water source	Source Rajli Head
2	DESIGN DATA The design Data given above is for estimation. Contractor shall conduct survey & soil investigations and submit designs for approval based on actual site data. No extra payment shall be given for variation in design data provided at bidding stage.	
2.1	Control Levels	
a	Average ground level (GL)	Bidder to conduct investigation
b	FSL at Aerator	Up to 5.0 to 6 mm above GL OR As per bidders design
C	FSL at Clear water sump	Equal to Average GL
2.2	S.B.C. at site	Bidder to Conduct Investigation
2.3	Water Table	Bidder to Conduct Investigation
2.4	Water Quality	
a	Raw Water	As per Tender
B	Required Treated Water	As per Tender
3.0	DESIGN REQUIREMENT	
3.1	Design Capacity	
3.1.1	Design Flow	WTP components are to be designed for delivering Net Treated Water Quantity of 15 MLD at WTP outlet considering 22 hr/day operation. This plant capacity is exclusive of all Water requirements like filter Backwash, water loss with clarriflocculator sludge, Chemical solutions preparations, laboratory & Plant usage The Individual Design flow for any intermediate unit/s to be calculated considering Water losses & additional flow due to recycling (as applicable) to produce the net treated Water Quantity as specified. The Filter backwash Wastewater is to be recycled to the WTP at raw water channel after cascade Aerator, the Filter backwash Wastewater is to be disposed off suitably with clarifier sludge. For preparing Flow balance Diagram, Water losses shall be considered as 2% of Clarifier output for clarifier sludge & 1% of filter Output for Dirty backwash water loss along with sludge as per CPHEEO manual guidelines & considering 2% dirty backwash water will be recycled within WTP.
3.1.2	WTP Overloading Capacity	

S.N.	Particulars	Parameter / Requirement
a	All pipes/channels/launders within WTP	20% Overloading over design flow
b	Inlet and Outlet arrangement of Filter works	100% Overloading over design flow
c	All balance components except a) & b) mentioned above	20% Overloading
3.2	Cascade Aerator	
3.2.1	Number of units	1 No
3.2.2	Inlet Level	Up to 5.0 to 6 mm above GL OR As per bidders design, whichever higher
3.2.3	Design Flow	Net Treated Water Quantity of 5 MLD at WTP outlet considering 22 hr/day operation
3.2.4	Number of steps	4 to 5 Nos
3.2.5	Surface loading rate	0.03 m ² / m ³ /hr
3.2.6	Ht. of each riser	0.3 m
3.2.7	Ht. of inlet pipe above First tier	50 mm
3.2.8	Velocity in peripheral launder	0.6 m/s maximum
3.2.9	Free Board in peripheral launder	0.5 m
	Note- The Cascade Aerator should be pooled cascade aerator having pooling effect with 1" extra rise above each tread.	
3.3	Raw water channel- From Cascade Aerator to Flash Mixer (with Parshall Flume as Flow measuring Device designed as per CPHEEO Manual and 1 m x 1 m Float Chamber with fixed calibrated flow measuring device)	
3.3.1	Design Flow	Net Treated Water Quantity of 15 MLD at WTP outlet considering 22 hr/day operation + above 20% Overloading
3.3.2	Dimensions	
	a) Total Length of channel	10.0 m (minimum)
	b) Width	As per design requirement
	c) Freeboard	Minimum 0.5 m
	d) Approach channel upstream of Parshall Flume	15 times throat width
	e) Channel downstream of Parshall flume	7 times throat width
	f) Design of Parshall flume	As per CPHEEO manual for water treatment
3.3.3	Velocity in raw water channel	0.6 m/ sec (maximum)
3.3.4	Range of flow rate Indicator	0 to Design flow including 20% overloading + 10% Additional capacity.
3.4	Alum Dosing Tanks (With Dissolving trays, Constant head alum dosing tank with taper needle valve)	
3.4.1	Number of tanks	3 Nos (one for preparation, Second for dosing, third as standby)
3.4.2	Capacity (each)	8 hours for imparting average 30 mg/l Alum dose (Non Ferric Alum with min 16% Al ₂ O ₃ content) to raw water flow.
3.4.3	Tank Material	RCC epoxy lined
3.4.4	Accessories	Level Indicator, Constant head device, dissolving trays, perforated water spray line, drain & overflow arrangement etc.
3.4.5	Free Board	0.50 m

S.N.	Particulars	Parameter / Requirement
3.4.6	Agitator MOC	SS 316
3.4.7	Solution strength	5%
3.4.8	Agitator RPM	60-100 rpm
3.4.9	Optional Dosing aluminium Chloride	
3.4.10	Chemical specs	Liquid PAC with 10+/- 0.5% Al ₂ O ₃ content
3.4.11	Stock tank	Minimum 1 no. 15 m ³ wet capacity+0.5 m FB, HDPE/FRP/suitably Rubber lined tank to store Liquid PAC with 10+/- 0.5% Al ₂ O ₃ content. Tank with suitable mixer to keep tank contents in suspension PP/FRP pumps with piping & valves to transfer liquid PAC from stock tank to solution tanks & to transfer PAC from tanker to stock tank
3.4.12	Solution tanks	2 Nos (one for preparation, Second for dosing, third as standby), with Liquid depth./Diameter OR liquid depth: L/W ratio as 1:1 to 3:1
3.4.13	Capacity (each)	8 hours for imparting average 20 mg/l PAC with 10+/- 0.5% Al ₂ O ₃ content to raw water flow
3.4.13	Tank Material	RCC with 5 mm thk. FRP lining/ suitably Rubber lined
3.4.14	Accessories	Level Indicator, Constant head device, water line, drain & overflow arrangement etc.
3.4.15	Free Board	0.5 m
3.4.16	Agitator MOC	MS with 5 mm thk. FRP lining/ suitably Rubber lined/Hastelloy C/SS 316
3.4.17	Solution strength	5%
3.4.18	Agitator RPM	80-100 rpm
3.6	Distribution Chamber to divide equal flow between numbers of Flash mixers (If applicable)	
3.6.1	Number of units	As per design
3.6.2	Design Flow	As per Sr. No 3.1.1 above
3.6.3	Detention time	60 sec
3.6.4	Free Board	0.5 m
3.6.5	Gates/valves at inlet outlet	Suitable gates/valves shall be provided at Distribution chamber inlet & outlet to for unit isolation & flow control
3.6.6	Velocity in outlet from distribution chamber	Max 0.9 m/s (if channel provide with 0.5 m Free Board)
3.6.7	MOC of outlet	As per specifications
3.7	Flash Mixer	
3.7.1	Number of units	1 No.per Each Clariflocculator
3.7.2	Design Flow	As per Sr. No 3.1.1 above
3.7.3	Detention time	60 seconds (minimum)
3.7.4	Mixing Mechanism	Mechanical as per IS 7090-1985
3.7.5	Velocity Gradient	Minimum 300 S ⁻¹
3.7.6	Ratio of Tank Height to Diameter	1:1 to 3:1
3.7.7	Ratio of Impeller Diameter to tank diameter	0.2 to 0.4

S.N.	Particulars	Parameter / Requirement
3.7.8	Shaft Speed of propeller	100 rpm
3.7.9	Power Requirements	1 to 3 watts/m ³ /hr of flow
3.7.10	Tangential velocity	>= 3 m/s at the tip of the blade
3.7.11	Baffles to reduce vortex formation	Projecting 1/10 to 1/12 tank diameter, at minimum of 4 places
3.7.12	Tank (Shape & Construction)	Circular/Square RCC Tank open at top (As per Bidder's design)
3.7.13	Free Board	0.5 m
3.7.14	Agitator MOC	SS 316
3.7.15	Minimum Shaft Diameter	As per Bidder's design
3.8	Inlet Pipe from Flash Mixer to Clariflocculator	
3.8.1	Design Flow	As per Sr. No 3.1.1 above + 20% Overloading over design flow
3.8.2	Pipe Diameter	As per Bidder's design
3.8.3	Length	As per actual layout
3.8.4	Velocity	0.9 m/s max.
3.8.5	Material	As per specifications.
3.9	Clariflocculator	
a)	Type	Circular tank with central flocculator and Clarifier with horizontal flow pattern
b)	Design Flow	As per Sr. No 3.1.1 above
c)	Overloading	No overloading in unit design. Only 20% overloading in peripheral launder & settled water channel.
d)	Number of units	As per design
e)	Maximum permissible Diameter of single unit	35.0 m
3.9.1	Flocculation Zone	
a)	Detention time	30 minutes (minimum)
b)	Velocity gradient	20 S ⁻¹ to 75 S ⁻¹ (maximum)
c)	Velocity of flow at inlet ports	0.2 to 0.3 m/s.
d)	Recommended Range of Peripheral Velocity of blades	0.3 to 0.4 m/sec
e)	Total area of paddles	10 to 25% of CS area of tank parallel to plane of shaft
f)	Range of G.T.	For Alum- 2 to 6 x 10 ⁴ ; For Ferric - 1 to 1.5 x 10 ⁵
g)	Power Consumption	10 to 36 KW/MLD
h)	RPM of paddle	2 to 5
i)	Tangential velocity of water adjacent to paddle edge	25% of velocity of paddle edge
j)	Tank Depth	3.0 m to 4.5 m
k)	Tank Dimensions	Circular As per design
l)	Flocculator Mechanism	MSEP min 6 mm thk. , underwater fasteners- SS 316
m)	Service Factor for Gear box	2.0
n)	Applicable standard	IS: 7208- 1974 (Type C)
o)	Depth below partition wall for flow entry to Clarifier Zone- Maintain velocity of	0.3 m/min
p)	Additional depth below partition wall for sludge storage	25% of Flocculator SWD
3.9.2	Clarifier Zone with Mechanical sludge scraping mechanism	

S.N.	Particulars	Parameter / Requirement
a)	Number of units	As required so as to have maximum unit diameter as 35 m
b)	Detention time	2.50 hours (minimum)
c)	Surface Loading	1.25 m ³ /m ² /hr (maximum)
d)	Weir loading	12.50 m ³ /m/hr (maximum)
e)	Tank diameter	As per design. Maximum unit diameter as 35 m
f)	Side depth of clarifier	3 to 5 m
g)	Free board	0.5 m
h)	Floor Bottom slope	1 : 10 to 1 : 12 (V:H)
i)	Sludge well slope	1:1 to 2:1 (V:H)
j)	Sludge discharge arrangement	Telescopic sludge bleeding valve
k)	Water Flushing	Required in sludge line
l)	Minimum sludge Pipe diameter required	200 mm
a)	Outlet arrangement	90 deg V notches or circular orifice at 300 mm C/C submerged 3 cm to 90 cm below water surface.
b)	Velocity in outlet conduit in case of orifice (Launder-at interface of clarifier with submerged orifice)	0.15 o 0.25 m/sec.
c)	Velocity in peripheral launder	0.6 m/s
d)	Walkway & Stair to periphery	1.20 M wide RCC walkway with MS pipe railing epoxy painted.
e)	Scraper blades	MSEP min 6 mm thk. MOC of Bridge & Scrapper- MS IS 2062, underwater fasteners- SS 316 rest all GI, bridge – GI Grating/MS Chequered plate Painting- 2 Coats of primer & 2 coats of Epoxy
f)	Applicable Standard	IS: 10313- 1982
g)	Scraper Velocity	1(one) revolution in 30 to 40 minutes
h)	Tip velocity of scrapper	0.3 m/min
i)	Power requirements	0.75 w/m ² tank area
j)	Clarifier Mechanism	Centrally driven fixed type/peripheral driven type with 1.2 m wide Bridge
k)	Unit Free Board	0.3 m
3.9.3	Sludge Withdrawal (A constant bleeding type telescopic desludging arrangement for de-sludge pipe shall be provided for observation of sludge quantity)	
a)	Type (continuous/ periodic)	Periodically withdrawn through a telescopic sludge withdrawal valve
b)	Design Velocity in sludge pipe	0.75 m/sec
c)	Size	As per design. However Minimum 200 mm dia.
d)	Material	CI/DI flanged pipe with inside epoxy painting and outside encasing
3.9.4	Sludge Disposal	
a)	Up to Plant Boundary	By Gravity / pumping upto chamber at plant boundary (As per hydraulics)
b)	Beyond Plant Boundary	RCC NP2 pipe approx. 500 m Long
c)	Design Flow in RCC pipe	As per the Design or minimum 2 MLD
d)	Design Velocity in sludge pipe	0.75 m/sec
e)	Pipe Dia	As per design or minimum 200 mm

S.N.	Particulars	Parameter / Requirement
3.9.5	RCC Channel from Clariflocculator to Filter	
a)	Design Flow	As per Sr. No 3.1.1 above with 20% overloading
b)	Dimensions	As per design
c)	Freeboard	Minimum 0.5 m
d)	Velocity	0.9 m/ sec (maximum)
3.10	Filter Plant	
3.10.1	Filters	
a)	Type	Variable head declining rate filters
b)	Design Flow	As per Sr. No 3.1.1 above
c)	Overloading	No overloading on Filter design. However 100% overloading for Filter inlet & outlet arrangements.
d)	Number of Beds	Minimum 2 filter beds, each with 2 units/compartments i.e. twin bed type
e)	Area of Single Unit	20-30 m ²
f)	Filter Sand	As per Technical Specification : Filtration works
3.10.2	Rate of Filtration	6 m ³ /m ² /hr on average
a)	Length to Width ratio	1.2 to 1.33 Preferred
b)	Filter bed Depth incl. Free board	Approx. 3.90 m + depth of underdrain system
c)	Free board	0.50 m
d)	Sand Depth	0.90 m Minimum
e)	Gravel bed	0.50 m Minimum
f)	Minimum Water Depth on Sand	2.0 m
3.10.3	Inlet & Outlet control	
a)	Inlet & Outlet control arrangement	Designed to permit 100% overload for emergency occasions
b)	Velocity at control points Filter Inlet Filter outlet Wash water inlet Wash water outlet Air inlet	1.0 m/s 1.3 m/s 2.5 m/s 2.0 m/s 15-20 m/s
3.10.4	Filter Backwash	
a)	Backwash rate	36 m ³ / hr/ m ² (600 lpm/m ²) for a duration of 10 minutes
b)	Wash water tank	Separate O/H wash water cum service water tank to be constructed by contractor
c)	Wash water tank capacity	Suitable to supply water to wash 2 filter units i.e. 1 Twin bed at a time + water supply required for office and laboratory use (12 m ³) +, water required for chemical solution preparation incl. Chlorination Equipment requirement (i.e.10% extra on above)

S.N.	Particulars	Parameter / Requirement
d)	Elevation of Wash water tank	Suitable to generate minimum 9.00 meter head at under drain from bottom of farthest filter bed. Note- The bottom of the backwash water tank should be minimum 1 m above the Filter House Roof with separate slab
e)	Wash Water supply line	Diameter to restrict velocity up to 2.50 m/sec.
f)	Wash water supply pump	2 x 100% capacity pumps suitable to fill wash water tank in 1 hour.
g)	Dirty backwash recirculation sump with pumps (required for WTP of more than 1000 m ³ /hr capacity)	Wet volume to hold dirty backwash from 1 Twin bed+0.5 m free board. Sludge settling time-30 minutes minimum, Sloped bottom tank, Pumps- 2 nos (1w+1s) common for wasting sludge or recirculating water to WTP with 2 nos. Discharge pipes, one for wasting sludge & other for recirculating back to WTP. Separate pumps can be provided as per contractor's design.
3.10.5	Air Scouring System	
a)	Air Scour rate	45 m ³ / hr/ m ² for a period of 5 minutes at pressure of 0.35 Kg/ cm ² at underdrain
b)	Number of Air Blowers	2 x 100 % (1 W +1 S) of suitable capacity & 0.4 kg/cm ² delivery pressure
3.10.6	Under Drain System	
a)	Type	Manifold & Lateral system
b)	Material of Manifold & Lateral pipes	Central Manifold- RCC/CI Lateral Pipes-HDPE/PVC pipes 6 kg/cm ² rating
c)	Ratio of Total area of orifice/perforations to Filter area	0.3%
d)	Ratio of Total area of perforations to total CS area of lateral	<=0.50 for 12 mm orifice <= 0.25 for 5 mm orifice
e)	Ratio of Total area of manifold to Total area of Laterals	1.5
f)	length of lateral/diameter of Lateral	< 60
g)	Other details	Perforation size: 5 mm to 12 mm, staggered at slight angle from vertical axis of pipe Perforation spacing: vary from 80 mm for perforations of 5 mm to 200 mm for perforations of size 12 mm
h)	Spacing of laterals	Appx. 300 mm
3.10.7	Pipeline from Filter Plant to Clear Water Sump	
a)	Design Flow	As per Sr. No 3.1.1 above with 20% overloading

S.N.	Particulars	Parameter / Requirement
b)	Material	If Dia is >600 mm then MS pipe or else CI/DI K-7, MS pipe with min. 5 mm (thickness) with I/S solvent free epoxy lining and O/S Epoxy painting.
c)	Velocity	0.90 m/sec max.
3.10.8	Bypass Arrangement with Gates/Valves	
a)	From WTP Inlet Pipe to Clear water Sump (Bypass WTP)	Required
b)	From raw water Channel to Filter Inlet (Bypass Flash mixer, Clariflocculator)	Required
c)	From clear water channel to Clear Water Sump (Bypass RSF)	Required
d)	Design Flow	As per Sr. No 3.1.1 above with 20% overloading
e)	Velocity	0.9 m/sec max.
3.10.9	Chemical House Area (Minimum)	
a)	Ground Floor	
i)	Alum Store	40.00
ii)	Toilet Block	25.00
iii)	Electrical Room	20.00
iv)	Air Blower Room	20.00
v)	Stair case	15.00
vi)	Chlorinator Room	25.00
vii)	Chlorine Tonner Store (5.00 m height)	30.00
	Total Area of Ground Floor	175.00
b)	First Floor	
i)	Alum tanks	60.00
ii)	Store	15.00
iii)	Laboratory	55.00
iv)	Office	30.00
v)	Staircase	15.00
	Total Area of First Floor	175.00
	Total Area of Ground Floor & First Floor	350.00
3.10.10	Chlorination Arrangement	
a)	Residual Chlorine	0.40 ppm
b)	Chlorinator	Vacuum Type
c)	For Pre Chlorination	Vacuum type, with 100 % standby, to achieve pre-chlorination dose of 5 mg/l
d)	For Post Chlorination	Vacuum Type, with 100 % standby, shall be provided to achieve post-chlorination dose of 3 mg/l
e)	Capacity	Suitable as per Maximum Dosage Required & design flows
f)	Quantity	1 W + 1 S for 100% Capacity, each for pre & post Chlorination
g)	Chlorine storage required	30 days usage
h)	Number of Chlorine tonners	As required, with -100% Standby each for

S.N.	Particulars	Parameter / Requirement
		Pre-chlorination & -100% Standby each for Post chlorination Total no of tonners should meet 30 days storage requirement In any case, minimum 2 nos. Tonners to be provided for Pre-chlorination & 2 nos. For Post Chlorination.
i)	EOT	3 MT
j)	Weighing scale	As per specifications
3.10.11	LABORATORY INSTRUMENTS	As per list attached on following pages
3.10.12	Security cabin	3 m x 3m
3.10.13	(Chlorine Contact Tank)	
a)	Number of units	1
b)	Detention time	30 min
c)	No. of baffles	As per design
3.10.14	Neutralization Tank	2.5 L x 2.5 W x 2.5 D m or as per design whichever is higher
3.10.14	Security Cabin	3 m x 3 m
3.10.15	Vendor List	As per GWSSB website in line with the inviting bid
3.10.16	Mechanical Works	All Mechanical Works as per Detailed specifications
3.10.17	Electrical Works	All electrical works as per Detailed specifications

9. SLUDGE SUMP

Sludge from Clariflocculator, Backwash from RGSF and all process and chemical drains shall be received in Sludge sump. Suitable retention time shall be provided with overflow/baffle wall to transfer the supernatant water back to inlet chamber of flash mixer. Settled Sludge should be suitable disposed.

10. Standby Requirements

The Contractor shall design the Works such that each stage of the process includes appropriate standby capacity and bypass arrangements. The works must be designed such that at full Flow any individual unit can be taken out of service for planned maintenance work without breaching the specified performance requirements. This requirement includes all process units including biological treatment, settlement tanks and all sludge treatment facilities.

All mechanical and Electrical rotating equipments shall be arranged in duty/standby configurations with automated rotation of duty to ensure even wear, and automated changeover to standby units in the event of plant failure. Standby plant shall be of the

same type and capacity as the duty plant. The following table gives the minimum standby capacity requirement versus the number of duty plant units.

Table 7 Minimum Standby Requirements

No of duty units	Minimum Standby (%)
1	100
2	50
3	33
>3	25 (Except for clear water pumping where it is 4W + 2S)

Note: This clause supersedes and prevails over any other clauses elsewhere in the tender document. Contractor shall design and provide equipment according to this clause.

11. Ventilation and Air Conditioning

The Contractor shall provide control rooms with PLC installation with appropriate air conditioning systems which maintain the rooms at positive pressure with respect to process areas.

The electrical/switch rooms shall be provided with proper ventilation.

Any access ways from the process areas to electrical rooms shall be by means of a double door system which will act as an airlock with positive pressure. The design shall also prevent surface condensation which may otherwise cause corrosion.

Each blower stage in the ventilation systems shall be supported by a standby, with automatic starting of the standby unit at failure of a duty machine.

To limit power consumption and minimise the risk of noise nuisance, the velocity of the air through the ventilation ducting shall not exceed 8m/s.

The ducting shall be manufactured from suitably corrosion resistant material. Galvanised steel will not be acceptable.

Mechanical and natural ventilation rates shall take into account any requirements arising from the conclusions of the Hazardous Areas Classification.

Note-

- Settling tank/clarifier should be capable of giving settled water having turbidity not exceeding 10 NTU in normal season & max. 20 NTU (During monsoon season).
- Restrict Circular Clariflocculator diameter to maximum 35.0m dia is to reduce wind effect.
- Sludge disposal line should be provided from the Clariflocculator to sludge chamber, the minimum size of chamber should be (1m x 1m)

- If launder is provided inside the Clariflocculator, the area of launder should be added in calculating final area of Clariflocculator.
- Construction of Wash water tank is in Scope of the Agency.
- One chain pulley block of 1 M.T. capacity hand operated shall be provided for lifting/handling of alum.
- The capacity of E.O.T for lifting of chlorine cylinders shall be 3.00 M.T.
- Wash water channel should be RCC upto filter gallery and thereafter is should be RCC NP2 class pipes.
- Post chlorination tank with RCC baffles with 10 Minutes detention time at Net treated water output flow shall be provided before leading the water to Clear water sump.
- Datasheet takes prevalence over civil specifications in case of any mismatching information.
- The offered areas are indicative and minimum; the contractor should provide calculations for arriving at these areas & provide this as minimum area or else provide higher area if required as per the calculations & as per the approved Mechanical/ GA drawings for respective equipments.
- Staircase should be provided at a location from where all areas/rooms are easily accessible.
- Normal storage required for chemicals is: 90 days for alum storage +10% extra for other sundry storage, 30 days for Chlorine tonners.
- All water retaining structure should be in M.30 and 20 mm thick waterproof plaster in C.M. 1:2 inside of all water retaining structure to be provided. SBC at site 15 T/m² and Water table not found up to 5.0 m. (monsoon season). Soil Bearing Capacity (S.B.C.) & Water table given is for estimation purpose only. Contractor shall carry out the S.B.C. test before designing the plant. No extra payment shall be given for variation in SBC.

Table 8 List & Details of Instruments / Analyzer required for WTP

Sr No.	Details
1	Parshall Flume- Measurement Ultrasonic type flow instrument to be provided to measure level at parshall flume & corresponding/proportionate Flow values to be calculated & displayed on field.
2	Clariflocculator- Overload Torque switch with High alarm & High Trip of Clariflocculator mechanism
3	Filters- LOH (Loss of head) measuring system (Ultrasonic based) & ROF (rate of flow) measuring system to be provided
4	Sump/ Tank/ ESR - Float & board type Level Indicator & Displacer/Float type level switch- Low & High alarm with trip to respective pumps
5	Chemical dosing tanks - Float & Horizontal Scale type level gauge
6	Pressure Gauges- at all pump/ blower discharge and common header

Sr No.	Details
7	Constant Head Flow Measurement at Alum dosing tanks- Float operated flow meter
8	All alarm/indications shall be provided in instrument chamber of MCC
9	pH indicator cum Transmitter at Raw Water Channel, At Inlet to Filter & Outlet of Chlorine Chamber- Online Analyzer
10	Turbidity Indicator cum Transmitter at Raw Water Channel, At Inlet to Filter & Outlet to Filter- Online Analyzer
11	Chlorine Indicator cum Transmitter at Outlet of Chlorine Chamber- Online Analyzer
12	Sampling Pump for Sampling to Laboratory at Raw Water Channel, At Inlet to Filter & Outlet to Filter
13	PLC with HMI system at Electrical room for plant monitoring, data logging and report generation

Note - For detailed scope of work for Instrumentation refer Instrumentation section of technical specification.

12. Laboratory Instruments for WTP

Minimum Equipment needed for Physical & Chemical tests

Sr. No.	Details	Specs & requirement	Output Capacity of the plant up to 7.5 MLD	Output Capacity of the plant more than 7.5 MLD.
1	Digital pH meter completed with 1 calomel Electrode & Glass Electrode	Microprocessor based pocket type, Range: 014, 2 nos.	√	√
2	pH Kit with different discs for PH measurement	2 sets	√	√
3	Digital TDS meter	Microprocessor based pocket type, range: 01000 ppm, 1 nos.	√	√
4	Digital Turbidity meter	Portable type, Range 01000 NTU, 2 Nos. for raw water Range 0-20 NTU, 2 Nos. for Filtered/settled water	√	√
5	Conductivity meter	1 No.	√	√
6	Hot Plates	1 No.	√	√

Sr. No.	Details	Specs & requirement	Output Capacity of the plant up to 7.5 MLD	Output Capacity of the plant more than 7.5 MLD.
7	Distilled water Plant	1 No.	√	√
8	Demineraliser	1 No.	×	√
9	Refrigerator	1 No.	√	√
10	Magnetic Stirrer	1 No.	√	√
11	Analytical balance with weight box	1 No.	√	√
12	Jar test apparatus	1 No.	√	√
13	Digital Fluoride Test Kit	1 No.	√	√
14	Gas Cylinder if piped gas supply not available	1 No.	√	√
15	Necessary glassware & accessories (like beaker, conical flask, burette, pipette, Volumetric flask etc.) & chemicals required to do routine Physical, chemical & Biological analysis	As required	√	√
16	Flouride Test Kit (Digital)	1 No.	√	√

Minimum Equipment needed for Bacteriological Examination

Sr. No.	Details	Specs & requirement	Output Capacity of the plant up to 7.5 MLD	Output Capacity of the plant more than 7.5 MLD.
1	Hot Air Oven	Up to 200 Deg C	√	√
2	Autoclave or Pressure Cooker		√	√

Sr. No.	Details	Specs & requirement	Output Capacity of the plant up to 7.5 MLD	Output Capacity of the plant more than 7.5 MLD.
3	Incubator 37°C or 44°C	(Water/AirJacketed)	√	√
4	Binocular microscope		√	√
5	pH Meter		√	√
6	Pipette Box (Stainless Steel)		√	√
7	Wooden Racks/Aluminium Racks		√	√
8	Wire Baskets		√	√
9	Cotton/ Aluminium Foils		√	√
10	Burners (Bunsen) With Pilot Lamp		√	√
11	Suction Flask (1 Litre Cap)		√	√
12	Suction Pump		√	√
13	Sampling Bottles 250 ml capacity		√	√
14	Bacteriological Media			
a)	M. Endo Broth (dehydrated)		√	√
b)	Lactose or Lauryl Tryptose broth		√	√
c)	Mac Conkey broth		√	√
d)	Brilliant Green Bile Lactose Broth		√	√
e)	Total Plate Count Agar		√	√

Sr. No.	Details	Specs & requirement	Output Capacity of the plant up to 7.5 MLD	Output Capacity of the plant more than 7.5 MLD.
f)	Peptone/ Tryptone Water		√	√

Note: The equipment shall be supplied with all the accessories that are necessary to make the equipment functional for analyzing parameters. Contractor can offer additional equipment if necessary.

Colorimeter/ Photometer: The instrument shall be capable of colorimeter tests for more than 90 parameters, from aluminum to zinc for testing natural waters. The instrument should be designed specifically for field testing. The instrument should be water proof, dust proof and should have a chemical resistant housing. The instrument should have simple, push-button program selection and step-by-step prompts that guide users through each testing procedure.

Technical Specifications:

Wavelength Selection	Auto select
Photometric Range	0 to 2 A
Operational Modes	Concentration, ABS, %T
Concentration Unit	ug/L, mg/L, g/L, ABS, %T
External Outputs	RS 232 via Data Transfer Adapter (optional)
Data logging	50 sample readings (each reading includes date/time, parameter, program number oncentration, absorbance, % transmittance, sample number, instrument serial number)
User programs	Five user-entered programs, 12 data points each
Display	Large liquid-crystal display (LCD) displays results, parameter name, and units
Power	4 AA alkaline battery operated
Storage Temperature Range	-40 to 60 deg.C
Operating Temperature Range	0 to 50 deg. C
Environmental	Meets IP67 standard, dustproof and waterproof to one meter for at least 30 minutes

Laboratory pH Meter:

Instrument should be able to give quick and easy pH measurements. Instrument should have large LCD display. Instrument should have RS232 interface with data logging facility.

Technical Specifications

Range: pH: -6.00 to 20.00, mV: -2000 to 2000 mV, Temp: -10.0 to 120.0°C

Resolution: pH: 0.01 pH, mV: 1.0 mV, Temp: 0.1°C

Accuracy: pH: ± 0.01 pH, mV: ± 0.05 % full scale ± 1 LSD, Temp: $\pm 0.5^\circ\text{C}$

Laboratory Turbidity Meter:

Turbidity meter shall have pre-programmed features for measurement of turbidity with ratio color correction covering the range from 0 to 10,000 NTU with auto signal averaging. Turbidity meter should come along with the following accessories: A complete set of calibration standards (0.02, 10, 100, 1750 NTU), Two measuring cuvettes with light shield caps, Operators' manual, and plug in power adaptor

Technical specifications

Principal of operation: Nephelometric

Light Source: Infra red

Extended auto ranging up to 10,000 NTU, 0 - 2,450 EBC, 0 - 10,000 FNU, 0 - 10,000 FAU

Resolution: 0.0001 NTU on lowest range

Accuracy: $\pm 2\%$ to $\pm 10\%$ of reading (in 3 ranges)

Response time: less than 6 seconds

Sample size: 30 ml

Air purge: connection for external dry air supply Auto alert calibration prompt.

Outputs: RS-232 Serial Port

Reusable Calibration Standards

Certification: UL, CSA, CE, ISO7027

Instrument should have option for connecting flow thru cell.

Portable Turbidity Meter

The instrument should have microprocessor-control operation and Ratio optics to bring greater accuracy, sensitivity and reliability to field testing. The instrument shall compensate for color in the sample, light fluctuation and stray light, allowing analyst to achieve laboratory-grade performance on a wide range of samples, under a wide range of conditions.

Technical Specifications

Ranges: 0 - 1000 NTU in automatic range mode; 0-9.99, 0-99.9 and 0-1000 NTU in manual range selection.

Accuracy: $\pm 2\%$ of reading or ± 1 Least significant digit up to 500 NTU $\pm 3\%$ of reading above 500 NTU to 1000 NTU

Repeatability: $\pm 1\%$ of reading or ± 0.01 NTU, whichever is greater.

Resolution: 0.01 NTU on lowest Range

Stray Light: < 0.02 NTU

Sample required: 15 ml

Residual Chlorine Meter

The instrument should be a handy model which should be capable of analyzing three water quality tests. Instrument should be simple to use and should display error messages as and when they occur. The instrument should be pre-programmed to conduct the following tests:

pH 6.8 – 8.6

Chlorine 0 – 5.0 ppm

Alkalinity 0 – 500 ppm In addition, Instrument should include the following: Intransclam packing with reagents for 100 free chlorine tests, Crushing rod and 2 test cells. The instrument should be provided with a operations & instructions manual.

Associated Lab Equipment:

Sterilizer, Autoclave

Purpose: For sterilization of glassware and culture media for bacteriological analysis.

Double wall construction with inner & outer chamber made of Aluminum. Electrically heated by means of superior quality emersion heaters with working pressure 15 PSI. Inner Chamber Size: 550X750mm. rating: 6.0 KW, Volume: 175litre.

Balance, Analytical (Electronic)

Purpose: For preparation of standard solutions used in chemical analysis.

Specifications: Should be based on E.M.F.C. Technology

Type: Electronic single Pan, Capacity: 200 mg, Resolution: 0.1 mg, Stainless steel weighing pan; Pan size: 100 mm Diameter, Display: Sharp, Clear LED Display and Standard bidirectional RS232C interfaces. Multiple weighing Units: Grams & Carat. It should have auto calibration facility, Overload protection and auto zero facility. Balance should come along with Set of certified calibration weights, Voltage stabilizer, Dust proof cover, Operational manual and necessary tools.

Incubator Bacteriological

Purpose: For incubation in bacteriological analysis

Double walled cabinet. Outer wall should be made of mild steel, inner wall of stainless steel, lagged with a special insulating material. The inside door should be made of glass panel set in a metal frame fitted with a felt gasket and be fastened by a ball catch.

Temperature range: 5°C above ambient to maximum 60°C.

Accuracy: $\pm 2^{\circ}\text{C}$ Size: 600X600X600cm Rating: 1000Watts.

Refrigerator

Purpose: For cooling and storage of (standard) solution in a laboratory

Type: Vertical double door

Capacity: approx: 280 litre.

Ware Purifier, Distillation Unit (Automatic)

Purpose: For generation of reagent water type III which is used for washing and quantitative analysis.

Made of stain less steel, vapor baffle, condensing tube and lid are stainless steel This is fitted with immersion type element.

The stopcock fitted to the unit.

The still is provided with wall mounting iron bracket to be fixed on the wall which the still can rest.

Supplied with 3 core wire and plug to work on 220 Volts AC

Capacity: 2 Litre

Load: 2 K.W

Low water cut-off device for 2 liter and 4-litre cap.

13. Major submittals of WTP drawings & documents for approval

Sr No.	Description
A	BASIC ENGINEERING PACKAGE
1	Water Balance Diagram
2	Process & Unit Size Calculations
3	Plant Layout
4	Piping & Instrumentation Diagram (P & ID)
5	Hydraulic Calculations
6	Hydraulic Flow Diagram (HFD)
7	Electrical Load List
8	Equipment List for Civil, Mechanical, Electrical & Instrumentation works

Sr No.	Description
9	Single Line Diagram (SLD)
B	DETAILED ENGINEERING PACKAGE
	GA drawings, Data Sheets, QAP (from Equipment supplier) for Electromechanical works covering all details for equipment provided confirming to tender requirements. Mechanical
1	Agitator for Flash Mixer
2	Clariflocculator
3	Sluice Gates
4	Valves
5	Chlorination system with Booster Pumps
6	Backwash Pumps for filling Backwash OHT
7	Air Blowers for Filter media air scouring
8	Clear water pumps
9	Lifting Equipments (EOT/HOT/Hoist/Chain Pulley block)
10	Piping
11	Constant Head Tank
12	Sludge Sump
13	Recirculation Pumps
14	Lab Instrument list with specifications
C	Electrical & Instrumentation
1	Fault Level & Sizing calculations for Incomer Breakers, Capacitors & Power Cables etc.
2	Switchyard
3	Transformer
4	HV/LV metal enclosed Switchgears
5	LT APFC Panel(s)
6	Local Control Stations/Consoles
7	Instrument Indicator Panel (where applicable)
8	PLC Based Control System/ SCADA (where applicable)

Sr No.	Description
9	Layout drawings for Electrical Rooms, Cabling, Lighting, Earthing & Lightning Systems.
10	Instrument Location Plan/ Hookup Diagram
11	Flow, Level, Pressure & Temperature Measuring/ Indicating Instruments (as applicable)
12	Online Process Analyzers (where applicable)
13	Battery & Battery Charger/UPS (where applicable)
D	CIVIL GA drawings
	Process Units
1	Cascade Aerator with Peripheral Launder and Inlet Pipe
2	Flow Measuring Unit
3	Flash mixer
4	Clariflocculator
5	Filter House incl. Annex building, air blower room, filtered water channel, Post Chlorination chamber etc.
6	Under Drain System for Filter
7	Chlorinator Room and Chlorinator Tonner Room
8	Backwash Water Tank
9	Backwash water Pump House
10	Clear Water Storage Tank & its pumphouse
11	Dirty backwash recirculation sump & Pump house
D 1	Other Units
1	Chemical House with required Administration/Laboratory/Chemical Dosing Tanks/Control Panel, HT/LT room, transformer yard etc.
2	Staff Quarter, security cabin ,as Applicable
3	Any other as applicable
E	STRUCTURAL DRAWINGS
	Process Units
1	Cascade Aerator with Peripheral Launder and Inlet Pipe
2	Flow Measuring Unit
3	Flash mixer

Sr No.	Description
4	Clariflocculator
5	Filter House incl. Annex building, air blower room, filtered water channel, Post Chlorination chamber etc.
6	Under Drain System for Filter
7	Chlorinator Room and Chlorinator Tonner Room
8	Backwash Water Tank
9	Backwash water Pump House
10	Clear Water Storage Tank & its pumphouse
11	Dirty backwash recirculation sump & Pump house
E1	Other Units
1	Chemical House with required Administration/Laboratory/Chemical Dosing Tanks/Control Panel, HT/LT room, transformer yard etc.
2	Staff Quarter, security cabin, as Applicable
3	Any other as applicable

14. NOISE LIMITS

There should not be any noise nuisance generated by the CETP. Therefore, noise limits at 1m away from the blower or any other equipment should not exceed 80 dB (A).

15. WORK LIFE EXPECTANCY

The Contractor shall design the Works for a life expectancy as follows:

- Concrete structures : 50 years;
- Mechanical plant : 20 years;
- Electrical plant : 20 years;
- Control panels : 15 years;
- External instrumentation systems : 15 years;
- Computer systems : 10 years.
- Piping : 30 years
- Chemical Tanks : 30 years for GRP/FRP

16. UTILITY AND ANCILLARY BUILDINGS

Contractor shall construct all utility and ancillary buildings as below but not limited to, Admin Building, Air Blower House, Workshop & Tool room and MCC and Control room, Laboratory, Office & Conference room, Chlorination House, Chlorine Tonner House, HT Substation, DG House, Security Cabin and other allied structures.

D 10. SEWAGE TREATMENT PLANT

1. DESIGN FLOW FOR STP

The required ultimate capacity of the STP is 2.76 MLD. STP will be developed in two phases. Bidder must consider space provision of STPs proposed to be constructed on modular basis. Initial capacity under this EPC tender and ultimate capacity are as follows.

S.N.	Treatment Plant	Phase-I (Present Proposed Capacity in this EPC Tender) in MLD	Phase-II (Only Space Provision for this Capacity) in MLD	Total Ultimate Capacity in MLD
1	STP	1.50	1.26	2.76

Bidder shall design the plant based on following influent raw sewage characteristics. However, the plant shall be robust to take care of 20% variation in the raw sewage characteristics.

SOURCES OF SEWAGE

Soil and waste from the bathrooms, toilets, plant rooms, shall be collected separately by a pipe gravity flow system from buildings and treated in the Sewage Treatment Plant.

Table 13: Influent Raw Sewage Characteristics for Design

Sl.No.	Influent Raw Sewage Characteristics for Design		
1.	pH		5.5-9.0
2.	Min. Sewage Temperature (Tmin)	°C	20
3.	Max. Sewage Temperature (Tmax)	°C	25
4.	Total BOD ₅ 5 Days @ 20°C	mg/L	200-250
5.	COD	mg/L	300-400
6.	TSS	mg/L	350-450
7.	Oil and grease	mg/L	10-25
8.	TKN	mg/L	40-50
9.	Total Phosphorus	mg/L	5-7
10.	Total Coliforms	MPN/100 ml	10 ⁷ - 10 ⁸

The discharge of treated sewage from the STP will be to a watercourse near to the STP site. The contractor shall take the necessary clearance for consent to operate the plant.

STP shall be met with the following effluent discharge norms as per Pollution Control Board.

Table 14: Effluent Quality (After CCT)

Sl. No.	Parameters	Effluent Discharge Standards (CPCB/NGT)
1	pH	5.5 – 9.0
2	Biochemical Oxygen Demand (BOD)	10 mg/l
3	Total Suspended Solids (TSS)	20 mg/l
4	Chemical Oxygen Demand (COD)	50 mg/l
5	Total Nitrogen	10 mg/l
6	Total Phosphorus - Total (For Discharge into Ponds, Lakes)	1.0 mg/l
7	Fecal Coliform (FC) (Most Probable Number per 100 ml, MPN/100 ml)	Desirable-100 Permissible-230

2. TREATMENT PROCESS DESCRIPTION

The raw sewage shall be made available to the Contractor at the inlet of STP by the Employer. The treatment process for proposed STP is Moving Bed Bioreactor (MBBR). The raw sewage shall be passed through mechanically cleaned bar screen followed by standby screen in parallel by gravity to screen the floating materials, plastics, papers, etc. The screening shall be collected and safely disposed off. The screened sewage shall flow by gravity to oil and grease trap chamber where oil and grease shall be trapped. The preliminary treated sewage shall be collected in the equalization tank which shall be served as balancing tank to store the excess flows during peak hours and to supply the sewage to the plant during the lean period so as to maintain constant average flow rate at downstream units of the plant. Air shall be supplied at the bottom of equalization tank to keep sewage in mixed condition in the tank and to maintain aerobic condition in the tank.

The sewage from equalization tank shall be pumped to MBBR basin. The oxygen shall be supplied to MBBR basin through fine air bubble diffused aeration and shall effectively bio-degrade the organic matter to the required BOD level of purity as stipulated in Process Requirement. The effluent from MBBR basin shall be passed through lamella clarifier where sludge shall be settled and supernatant shall overflow to Clear Water Tank (CWT), where chlorine in form of sodium hypochlorite shall be added to kill fecal coliform.

The settled sludge shall be collected in sludge holding tank. The air shall be supplied in the sludge holding tank to maintain the aerobic condition of the sludge. The sludge shall then be feed to the filter press which shall be of plate and frame type. The sludge shall be

dewatered to required sludge concentration by filter press. Supernatant from filter press shall be recycled back to the inlet of STP. The sludge cake shall be collected from outlet of filter press and safely dispose off by the Contractor.

From CWT, the treated sewage shall be pumped to Pressure Sand Filter (PSF) for further removal of suspended solids to required limit and then it shall be passed through Activated Carbon Filter (ACF) for filtering residual BOD/COD. The PSF and ACF shall be regularly backwashed and backwash water shall be brought to the inlet of STP. The treated sewage shall be disinfected with UV radiation system and stored in Treated Water Tank for reuse applications such as flushing and gardening.

3. SCOPE OF WORKS

Design, Construction, Supply, Installation, Testing, Commissioning and Operation and Maintenance for (5) years of 2.76 MLD Sewage Treatment Plant based on MBBR technology.

Details of Scope of Work are given below.

- (i) Design of the system and the specified process for the Sewage Treatment Plant meeting the requirements as specified below.
- (ii) Selection, Supply, Installation, Testing and Commissioning of mechanical, electrical and instrumentation equipment for the satisfactory operation of the plant undergoing the following stages and unit processes of treatment:
 - (a) Mechanically cleaned and Manual Bar Screens
 - (b) Oil and Grease Trap Chamber
 - (c) Equalization Tank
 - o Aerators for pre-aeration purpose, diffused aerators, controllers, etc.
 - o Submersible pumps and accessories for transferring influent to MBBR tank
 - (d) Treatment Plant (MBBR Tank and Lamella Clarifier)
 - o The treatment plant assemblies, diffused aerators, mechanical drive equipment
 - (e) Clear Water Tank
 - o Submersible pumps & accessories
 - (f) Chlorination
 - o Sodium hypochlorite tank & feed pump
 - o Automatic chlorine dosing equipment with accessories
 - (g) Treated Water Tank
 - (h) Sludge Holding Tank
 - o Diffused Aerators for sludge-stabilization purpose.
 - o Submersible sludge feed pumps and accessories
 - (i) Sludge Dewatering System

- o Filter press
- o Polymer tank & feed pump
- (j) Pressure Sand Filters, Activated Carbon Filters
- (iii) Submission of Plant layout, Hydraulic flow diagram, Single Line Diagram, P&ID diagram along with preliminary calculation at the time of Tender submission to justify the allocation of plant space / Employer's work requirement. Supporting evidence such as equipment catalogues, etc. shall be submitted to substantiate the design.
- (iv) Detailed design, detail calculation, detailed plant layout, Hydraulic flow diagram, Single Line Diagram, P&ID diagram, GA drawings, Civil and structural drawings, selection of equipment, preparation of construction drawings for the complete sewage treatment plant operation to the requirement as stipulated in this specification.
- (v) Shall the space allocated require modification to suit the Contractor's design / equipment; such change must be submitted at the time of tender submission. Late information will not be entertained.
- (vi) All civil works such R.C.C. tanks, foundations, opening on structures etc complete.
- (vii) For Electrical System, the Contractor's scope starts from the outgoing cable termination of Main LV Switchboard provided by client. The Contractor shall provide 1.1kV, XLPE insulated, multi core, armoured type cable up to STP through suitable cable trays/ walls.
- (viii) The electrical scope of works for 2.76 MLD STP includes design, manufacture, testing at works, supply and delivery at site, unloading & storing the equipment at site of installation, testing and commissioning of the following equipment at site:- 415V Metal enclosed switchboards/ motor control centres, Variable Frequency drives, Power & control cables, Cable carrier system, Earthing protection system.
- (ix) Transportation and disposal of sludge
- (x) Provision of priming and finishing coats painting to all metal pipework and auxiliary equipment as stated in the specification.
- (xi) Static testing of plant.
- (xii) Testing and commissioning of the plant under normal operational conditions.
- (xiii) Provision of test reports at the frequency of twice a month for the 6 consecutive months after commissioning. Quality of the incoming raw sewage and outgoing treated sewage shall be included. Parameters shall be analysed.
- (xiv) Sealing gaps between pipe sleeves and pipework / conduit, etc. if any.
- (xv) A complete package submission to local government authority for approval and obtaining license/consent for establishment/consent for operation, if required.
- (xvi) Preparation of As-built drawings and Operation and Maintenance Manual as detailed elsewhere in the specification.

- (xvii) One year defects liability period from the date of handover of the works.
- (xviii) Operation and maintenance of the constructed plant for period of five years from date of handover of the works.
- (xix) Ventilation and general lighting for sewage treatment plant room will be done by Employer.

4. PROPOSED TREATMENT PROCESS

The process proposed for the Sewage Treatment Plant is Moving Bed Bio Reactors (MBBR). The unit process and operation is as below:

- Screening,
- Flow equalization
- MBBR basin
- Lamella clarifier
- Chlorination
- Sludge dewatering system
- Tertiary treatment – Pressure sand filter and Activated carbon filter
- UV disinfection
- Treated water tank

The treatment plant shall be designed to exclusively treat the sewage of the specified characteristics with an ability to absorb $\pm 10\%$ fluctuations in the parameters indicated. The plant design shall not account for any toxic contamination and industrial effluents.

The Contractor shall use this description together with other specific information as given below and provided elsewhere in these tender documents, all of which are integral to this Process and Facilities Description.

PROCESS REQUIREMENTS

Item	Minimum Requirements
Screens Type	Bar screen with manual cleaning
Screens - MOC	SS 316
Aeration system in equalization tank	Coarse bubble diffused aeration (tubular type)
Bio-film carriers	PVC cylindrical shape
HRT in MBBR basin	16-18 hrs
SRT in MBBR basin	8-10 days
Aeration system in MBBR tank	Fine bubble diffused aeration (tubular type)
Lamella plates – MOC	PVC
Sand filter type	Multi-grade

Aeration system in sludge holding tank	Coarse bubble diffused aeration (tubular type)
Sludge dewatering equipment	Filter press – Plate and frame type
Chlorine dose	2 to 5 ppm
Chlorine form	Sodium hypochlorite
Polyelectrolyte dose	0.5 to 1 ppm
HRT in treated water tank	2 hrs
Sludge concentration in dewatered sludge	20%
Solids capture in filter press	90%

5. EQUIPMENTS & COMPONENTS

Contractor shall coordinate with the Main Contractors to ensure all necessary building works are incorporated.

Upon completion, all equipment and materials shall be cleaned, tested for static performance and signed off by the Project Manager.

All the equipment shall be issued in catalogue form, together with working drawings for builders work, layout arrangement, electrical control arrangements.

Prior to equipment being ordered and work starting, approval in writing shall be issued by the Project Manager.

Motor control center shall be completely dry tested to prove proper functioning of the control circuiting.

Tenderer shall furnish proof to the Owner that the plant equipment supplier shall have a local qualified and experienced field servicing engineer who can furnish adequate servicing facilities to the owner and operator during normal operation and emergency.

5.1 Screening

Manual fine screen 1 duty, 1 standby with appropriate flow rate shall be installed.

A stainless steel dewatering tray shall be provided above the inlet channel for the collection of the screening.

Both screens shall be stainless steel 316. The screen bars shall be tapered with the widest face upstream to prevent blocking of the spaces between bars. Fine screen shall have bar spacing of not greater 6 mm.

5.2 Sewage Pump

Submersible pump, 1 duty, 1 standby with appropriate flow rate and head shall be installed as per Schematic Process Flow Diagram.

Pumps shall be suitable for pumping unscreened grossly polluted raw sewage containing hairs, fibrous materials, coarse solids and tough plastic materials, free from clogging and catching. Solid handling capacity upto 50 mm.

Pump casing shall be of high grade cast iron, impeller shall be zinc free bronze material and shaft shall be of stainless steel SS410 Mechanical Seals shall be provided. The entire pump assembly shall be adequately protected from corrosion. Flanges shall conform to BS EN 1092-2. Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non grease type.

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration levels shall not exceed the levels given in BS 4675.

Pump flange shall be suitable for automatic coupling to discharge pedestal with single guide rail of stainless steel. Motor shall be of submersible type, insulated against heat and humidity to Class "F" with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

Duckfoot discharge connection, stainless steel (AISI 304) lifting chain with stainless steel (AISI304) guide bar, stainless steel hooks for chains shall be provided so that pump can be automatically connected to the discharge pipework. One set of sluice valve and non-return valve shall be provided at the discharge pipe of each pump in case the pumps share the common discharge line or outlet point is submersed in water. All necessary accessories for fixing such as bolts, nuts, washers, etc. shall be included. Detailed of fixing to pump sump shall be submitted to the Consultant for approval.

The operation of pumps shall be controlled by level float regulators. Both pumps shall be able to operate as the duty pump. The standby pump shall be arranged to start automatically on failure of the duty pump and the electricity supply to the failed unit shall

be cut off. The switch gear shall be suitable for automatic operation with manual override. The pump shall be designed to have pump starts less than 10 times per hour.

5.3 End suction Pump

End suction pump, 1 duty, 1 standby with appropriate flow rate and head shall be installed as per Schematic Process Flow Diagram and Service water application for Chemical & Polymer tanks and for flushing points.

End suction pumps shall be horizontally mounted complete with drive motor on a common base plate. The pump/drive coupling shall be of the spacer type to facilitate removal of the pump rotating element and bearing housing without dismantling the pump casing, adjoining pipe work or drive motor.

Pump casing shall be of high grade cast iron, impeller shall be zinc free bronze material and shaft shall be of stainless steel SS410. Mechanical Seals shall be provided. The entire pump assembly shall be adequately protected from corrosion. Bearings shall be easily accessible for inspection and maintenance. The bearings shall have a minimum working life of 40000 hours of working. Bearings shall be grease lubricated or non grease type.

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 85 dBA at 1.86 M at sites. Vibration levels shall not exceed the levels given in BS 4675.

The dimensions of the pump shall be metric conforming to BS 5257 or its equivalent standard. Flanges shall conform to BS EN 1092-2.

The bedplate shall be of substantial fabricated steel construction with floor fixing bolt holes ready drilled. All holding down bolts etc. shall be supplied with the units.

The velocity at the entrance to the pump impeller shall not exceed 3.5 m/s.

Impellers shall be provided with means to prevent abrasive matter reaching the glands and with fully shrouded impellers, to prevent the trapping of matter between the impeller vanes and the casing.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class "F" with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

Flushing facilities shall be provided for mechanical seals where pump fluid may be contaminated with abrasive material.

Lubrication arrangements shall be so designed that there is no contamination of the pumped fluid.

The pumps and associated pipe work shall be, wherever possible, arranged so that air can be completely expelled during priming. Where this is not possible, facilities shall be provided for the removal of the trapped air. Adequate facilities shall be provided for drainage of the pumps for inspection purposes.

Tappings shall be provided at both the suction and discharge flanges for pressure gauge equipment.

5.4 Dewatering Pump

The pump motor shall be suitable for working with or without submergence in water/waste water. The motor rating shall be more than the maximum power required by the pump.

Pump shall be vertical, centrifugal, submersible, non-clog & single stage type. The pump set shall be portable with necessary hooks.

The pump shall have double mechanical seals to prevent ingress of moisture in to the motor. The pump impeller shall be mounted on the extended shaft of the motor. The pump shall be supplied with flexible hose pipe of 25 m length. Suitable cable of 20 M length shall be supplied with the pump.

5.5 Air Blowers

General

- (a) Blowers shall be of the rotary tri or twin lobe positive displacement type or Centrifugal type, each provided with inlet filter and silencer, pressure reducing valve, pressure gauges, pressure relief valve, drain, air flow indicator and acoustic bend or silencer in the delivery branch. Bearing housings and gear boxes shall be separated from the blower housings by air spaces. The units shall be complete with a self contained oil cooling system for the bearings. The noise level shall not exceed 90 dBA at 1 meter from the Blower. Vibration levels shall not exceed the levels given in BS 4675.
- (b) 2 Nos. (1W+1S) Air blowers with appropriate flow rate and pressure shall be installed as per Schematic Process Flow Diagram. The blowers should start and stop through high or

low level switches in the tanks and the duty should be continuous as per the Dissolved oxygen requirement. For every four hours blowers operation, the blowers shall be interchanging automatically for equal operation hours. There shall be dry run protection as part of the controlled scheme. A four point level switch shall be provided for Equalisation tank.

(c) The blowers shall be rated to deliver required quantity of oil free air at the design pressure while operating at not more than 1500 rpm. The blower shall be driven by a squirrel cage induction motor selected for 125% of the power absorbed at the rated discharge and pressure. The drive shall be with multiple V belts and protected through a suitable belt guard. The air blowers should have acoustic enclosure & with antivibration pads.

(d) The bearings shall be generously designed to give long operational life. Bearings at the drive end may be oil or grease lubricated. The gears and bearings at the non-drive end shall be oil lubricated. Bearings shall be provided with oil throwers to prevent leakage of oil. The bearings shall have a minimum working life of 40000 hours of working. The blower shall be arranged for horizontal inlet and vertical outlet, delivery velocity not exceeding 25 m/s and each blower shall be provided with following components but not limited to:

- (1) Common base frame for Blower & Motor.
- (2) Inlet silencer and filter.
- (3) Discharge Silencer & non-return valve in delivery branch.
- (4) Screwed end metallic Ball valves in both inlet and delivery branches with metal to metal sealing.
- (5) Pressure relief valve or excess pressure safety device.
- (6) Bellows type couplings on inlet and delivery branches.
- (7) Acoustics Enclosure.
- (8) V-Belt drive arrangement with Belt Guard.
- (9) Isolating valves, Pressure reducing valves & Pressure gauges
- (10) Air Flow meters, Temperature gauges.
- (11) Water trap.

(e) The interconnecting pipe work shall be flanged to BS EN 1092-1/BS: 4504. A drain cock shall be provided at the lowest point in the each delivery pipe work along with reflux valve. Individual stop valves and safety valves shall be provided for each unit.

(f) Each blower shall contain one inlet air pressure, one discharge air pressure, and one discharge air temperature gauge. The pressure gauges shall be calibrated in kPa absolute and be of the compound type. The gauges shall have circular dials, minimum 100 mm diameter with black figures on white background. Pressure gauges shall be

furnished with pulsation damper. Temperature gauges shall be manufactured with standard temperature bulb.

- (g) Process Air Blower Motors shall be EFF-1 Energy Efficient type. Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply. Electrical cable of sufficient length which shall be waterproofed shall be supplied by Blower manufacturer.
- (h) Appropriate cooling arrangement shall be provided at the blower discharge line so as to bring down the outlet air temperature within tolerable limits, so as to safeguard the life of both fine and coarse bubble diffusers satisfactory performance of the same.

Accessories

- (a) Inlet filter and silencer :

Each blower shall be provided with an inlet filter/silencer mounted directly on the inlet of the Blower via a flexible connection. Such mounting is for the purpose of reducing pressure drop across the inlet appurtenances and of minimizing noise from pipes. Filter/silencer housing shall consist of galvanized steel plate and acoustical sound-deadening material on the inside.

Filters shall be removable through easily accessible doors and have very high removal efficiency and shall be sized for maximum face of velocity of 2m/sec at peak air flow.

- (b) Discharge Flex Connector :

Each blower shall be provided with discharge expansion joint. The expansion joint shall alleviate stress caused by thermal expansion and contraction in the piping system. The expansion joints shall be capable of withstanding the pressure under all operating conditions and shall be rated for temperatures up to 160°C.

- (c) Discharge Cone Diffuser Silencer :

Each blower shall be supplied with a combined discharge cone diffuser-silencer to increase the discharge from the blower outlet to the discharge pipe, thus reducing the air velocity to max. 20 m/sec. The length of the discharge cone shall be aerodynamically designed in order to recover dynamic pressure head and minimize discharge turbulence. The discharge cone shall be constructed of galvanized steel plate and acoustical sound-

deadening material on the inside, with flanges, and be equipped with a stud for a possible measuring device.

(d) Blow-off (Bypass) Valve :

Each blower shall be provided with a blow-off valve to allow unloaded start-up and unloaded stop. The valve shall be a Screwed end metallic ball valve, for air service.

Blow-off silencer shall be provided for each blower and mounted on the discharge by-pass line. The blow-off valve silencer shall be constructed of galvanized steel and contain sound absorption material encased in an outer shell. The silencer shall have one sleeve inlet connection for mounting onto the end of the bypass line.

(e) Discharge check valve (Back-flow Barrier) :

Each blower shall be provided with one discharge check valve located in the discharge side pipe work, spring loaded butterfly design for mounting between flanges according BS EN 1092-1. The pressure losses of the fully open valve must not exceed 1.0 kPa. The valves shall be rated for temperatures up to 160°C.

(f) Base plate and anchor bolts:

Each blower unit shall be furnished with a frame of adequate size to support the blower, motor, magnetic bearing controller frequency converter, control cabinet and other accessories. The base plate shall be constructed of fabricated steel, provided with lifting lugs and of sufficient rigidity to permit lifting by a fork-lift, with all equipment mounted, without distortion or other damage to the base plate or to components parts of the machinery.

Material of Construction

Sl. No.	Part Description	Material of Construction
a	Blower Housing	Cast Iron
b	Lobe	Aluminium alloy
c	Shaft	Carbon steel (high tensile)
d	Base plate	Profiled steel
e	Inlet filter, silencer casing	Galvanized steel
f	Acoustic enclosure	Al-Zn coated steel, insulated with glass wool
g	Blow-off silencer and motor cooling silencer	Galvanized steel
i	Inlet cone extension	Galvanized steel

j	All connecting accessories and anchor bolts	AISI 316

Control

The control system of the blower should be well connected with the control system of the whole plant. All the real time monitor and protection function shall connect with the control software; the remote control shall be carried out with 4-20 mA or network.

Local control panel and control cabinet shall be combined, that include display screen and keypad, main switch and lock stop push button. The blower operation shall be controlled by the main running switch and keypad.

Performance Guarantee:

The Performance of the compressor shall be guaranteed according to the requested project design values subject allowed tolerances on Flow & Pressure: +/- 0%, and Power: 2%. Blower or any portion thereof is liable for rejection, if it fails to give any of the guaranteed performance parameters.

5.6 Air Diffusers

All air piping network shall use UPVC piping and valves for sectionalisation. Air diffusion should be through Silicone elastomeric tubular or disc type Fine and Coarse diffusers held in SS-304 nipples and should be of non-clog characteristic.

Air diffuser grid shall be retrievable type and suitable lifting arrangement shall be provided.

All civil works will be carried out by vendor based on approved drawings, layout and all internals and pipe inserts in the concrete.

5.7 Lamella Plate settlers

Lamella Plate settlers shall be of PVC plates with an angle of inclination of plates - 55 deg, Min. thickness of plate 1.2 mm.

5.8 Treatment Plant

Tenderer shall submit complete technical data, flow diagrams, general arrangement, Piping & Instrumentation (P&ID) diagrams of the treatment plant in the tender itself.

5.9 Filters (Pressure Sand and Activated Carbon Filter)

Pressure Sand Filter 1 working and Activated Carbon Filter 1 working, Filters shall be of vertical type. Vessels shall be designed as per IS 2825 Class II, the filter Shell and dish

End shall comprise a mild steel IS 2062 Gr.B electrically welded shell complete with nozzles and nozzles plates internal distribution and draw-off through, faced pads for inlet, outlet, wash-in, drain, adequate sized access manholes, filter supporting feet, necessary filtering media and sundry accessories. Shell shall be treated internally with an approved anti-corrosion coating(Polyurethane), and externally with primer and under coat prior to application of two coats of finishing paint of food grade quality of approved colour with Total DFT 250 microns. Corrosion allowance of 3 mm shall be considered thickness of the shell and Dish End and 1mm thinning allowance for Dish Ends. Full GA and design details shall be submitted at time of tendering for acceptance.

Filters shall be equipped with automatic and bulk air release valves, back-wash water sight glasses, inlet and outlet pressure gauges, flow meters and associated panels, drain pipe and valves, draw-off cocks for taking samples of raw and filtered water and can be manually washed.

Filter bed shall consist of at least two but preferably more layers of filter media, each having a different particle size properly supported by suitable under drain. Where nozzles are provided as a form of under-drain, they shall be completely manufactured from polypropylene screwed into a high quality heavy gauge steel plate and do not have any metal screws or holding bolts.

Filter vessels shall be welded and tested by the manufacturer before shipment. Finished filter vessels shall be subjected to a pressure test of not less than 7.0 Bar or twice the actual working pressure whichever the greater.

The filter shall comprise a high strength filament mould fiberglass construction designed to withstand chemicals, a top mounted multi-port valve with 5 positive lock positions (i.e. filter, backwash, rinse, waste and closed) and necessary filtering media and sundry accessories. The filter shall also be equipped with automatic air release valves, water control valves, wash water sight glasses, inlet and outlet pressure gauges and draw-off cocks for taking sample of raw and filtered water.

Filter media shall consist of adequate 6.4mm to 2.5mm double washed and graded pebbles and double washed and graded filter sand to 16/30 B.S. sieve size. Filter media for Pressure Sand Filter shall confirm to AWWA B100 and Activated Carbon Filter shall confirm to AWWA B604.

Filters may be selected at a maximum filtration rate of 10 cubicmetres of water per square metre of filter area per hour provided that it complies with manufacturer's recommendation and gives operation to the satisfaction of the Consultants.

The filters shall be designed for maximum design flow of 250 lpm at 2.5 kg/cm² flow through the filters based on one back-wash or out of service. Backwash shall be initiated automatically by head loss in the filter. Filter backwash shall be directed into the Equalization Tank.

5.10 Chemical Dosing Pumps (NaOCl or polymer)

2 Nos. (1W+1S) Dosing Pumps with appropriate flow rate and pressure shall be installed as per Schematic Process Flow Diagram. Chemical dosing pumps shall be piston, piston diaphragm or mechanical diaphragm type as specified. Pumps may be simplex type. The pump design shall incorporate positive stroke return. The maximum stroking speed shall not exceed 100 strokes per minute (spm). Pump, motor and driving arrangement shall be mounted on a robust combined baseplate.

Pump liquid ends shall be selected for compatibility with the pumped liquid. Suction and discharge valves shall be the single ball type allowing a free flow self cleaning action. Ball and seat materials shall be resistant to abrasion.

Pumps shall incorporate a variable stroke mechanism to allow the output to be varied while the pump is running. Stroke adjustment shall be manual or where specified by electrical or pneumatically controlled stroke positioner. A stroke length indicator and digital stroke counter shall be fitted. Pumps shall be driven by a flange mounted IP 55 motor, via an oil bath reduction gearbox and variable stroke mechanism giving stepless adjustment between zero and maximum stroke length. Where flow proportional dosing is required the variation of output shall be achieved by varying the speed of the pump motor and not the pump stroke length.

Materials shall be selected to suit the chemicals being pumped. Liquid ends shall be polypropylene, 316 stainless steel, glass, or Hastelloy C. Diaphragm materials shall be butyl rubber, PTFE, or Hypalon and glands shall be PTFE or Neoprene.

Each pump shall be provided with inlet and outlet isolating valves and where necessary, with pressure relief with a set point of 110% of system maximum working pressure and non-return valves. Dosing pumps shall be provided with back pressure loading valves and pulsation dampeners in the delivery lines depending on the downstream conditions.

The open end of the return pipe shall be located where it is visible, so that any relief valve leakage/operation can be detected. Pump transferring/dosing chemicals to systems under pressure shall incorporate a pressure gauge on the pump delivery. Air cocks shall be provided for release of air where necessary.

Flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application of the chemical. Facilities shall also be provided for flushing chemical pump suction and delivery manifolds and delivery lines to point of application.

Dosing pumps and motors shall preferably incorporate an integral reduction gearbox drive which shall be totally enclosed and oil bath lubricated. The gear box shall incorporate the cams for the diaphragm drive and shall be provided with filling and drain connections and visible oil level indication.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class "F" with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

All dosing pumps shall have facility/terminals for pulse input & output (4-20 mA) to facilitate online control via plant PLC.

5.11 Chemical Tank and Mixer

i. General

1 no. of Mixer per tank, this tank shall be used to dissolve the Sodium Hypochlorite NaOCl (10-50 ppm @ 100% concentration) or polymer (0.5-1 ppm, 0.2% solution strength) to a constant concentration and feed the solution to the outlet channel of the tank or the dewatering equipment. It shall be a vertical tank and shall be composed of tank main body, mixer, manhole, electronic level gauges, direct reading level gauge, ladder, air exhaust pipe etc.

ii. Fabrication

- The tank shall be made of corrosion resistant material.
- The tank shall be provided with a removable cover to prevent chemical scattering, and also with a vent pipe.
- The tank shall be provided with necessary mounting seats for overflow pipe, etc.
- The motor-driven mixer shall be vertical speed reducer, direct-coupled type of 2-stage propeller type, as a rule and shall be constructed to endure continuous operation free

from vibration, etc. The mixer shall be at the center or at a position off the center according as the tank being rectangular or circular.

- The mixer shall be protected by electrical prevention of dry operation.
- The tank shall be constructed to seal gas and splash from below at the area where the mixer shaft drive portion passes through.

(i) Materials

(a) Main Tank body	HPDE
(b) Mixer frame	: Stainless steel
(c) Mixer shaft	: Stainless steel
(d) Blade	: Stainless steel

(ii) Accessories (per Unit)

(a) Foundation bolt and nut	1 set
(b) Air vent pipe	1 set
(c) Mixer	1 unit
(d) Direct reading level gauge	1 unit

5.12 Sludge Dewatering System

A plate filter press with polypropylene plates shall be supplied to handle incoming sludge with a dry solids content of 0.8 – 2.0%. The dewatering system shall be designed sludge from the sludge holding tank can be processed. The dewatered sludge cake shall have a solids content of not less than 20 percent. The dewatering system shall not be operated for more than 8 hours per day.

5.13 Sludge Feed Pump

Sludge feed pumps shall be of progressing cavity type having an output characteristic which is substantially independent of change in head. Pump speed shall be less than 500 rpm.

Casings shall be of close grained cast iron to B.S. 1452 capable of withstanding all pressures that may be produced due to normal operating pressure surges. Flanges shall accord with BS EN 1092.

Casings shall be mounted on base plates manufactured from cast iron. Casings shall be accurately aligned and located by dowels or machined spigots. Holes shall be provided in the base plates or stools for foundation bolts.

Casings shall not be integral with the stool or base plate, but shall be designed to allow the ready removal of the pump complete from the stool or base plate. Easy access to suction pipe connections must be available.

Stools or base plates shall be fixed to concrete plinths.

Casings shall be sealed against leakage along the rotor shaft by a soft packing stuffing box which shall contain a bronze lantern ring to facilitate greasing and efficient sealing of the gland.

Gland housing shall be cast iron and split to facilitate packing of the gland.

A grease stuffer shall be provided for lubrication of the gland.

Flushing connections shall be provided at each pump inlet and flushing shall be manual. When flushing, water shall be discharged either locally through a drain valve or to the point of application. Facilities shall also be provided for flushing pump suction and delivery manifolds and delivery lines to point of application.

Pumps shall be designed to run unattended for long periods. They shall be capable of passing solids, stringy matter, rags, paper, plastics and shredded metals without choking or damage to the stator or rotor.

A resilient stator shall be fitted into a rigid housing and be intimately bonded to it.

Startors shall form a double internal helix of constant circular section in which a single helical rotor shall rotate to form progressive cavities.

Stator materials shall be compatible with the liquids and materials being pumped. Stator materials shall generally be natural rubber, nitrile rubber, or Hypalon depending on the application.

The rotating parts shall have a smooth finish and the materials shall be compatible with the liquid and materials being pumped. Rotors shall generally be hard chrome plated stainless steel, tool steel or nitralloy.

Coupling rods shall be hard chrome plated stainless steel. The rod shall be joined to the rotor and input shaft by flexible joints preferably of the ball and socket type.

The stator housing shall be flanged cast iron and jointed to the casing. A flanged delivery connection at the free end of the rotor shall be flange jointed to the stator housing. The suction flange may be part of the casing or be an interleaving flanged casting between stator housing and casing.

Where pumps incorporate long stator housings such housings shall be supported from the base plate.

Shaft diameters and keyways shall conform to the relevant Indian Standards. If Indian Standards is not very specific on these, the Shaft diameters shall be to B.S. 4506; shaft keyways shall be to B.S. 4235 Part 1 or ISO R223.

Pumps shall be provided with connections for a bypass pipe to be fitted between suction and delivery sides of the rotor.

Pumps shall be equipped with the following fittings as standard requirements:

A bypass pipe between suction and delivery sides of the rotor for a returned flow of liquid for rotor lubrication.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class “F” with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

Pumps shall run smoothly without undue noise & vibration. Noise level shall be limited to 62 dBA at 1.86 M at sites. Vibration levels shall not exceed the levels given in BS 4675.

A drainage pipe to allow drainage of gland seepage liquid. A compound suction and delivery pressure gauge. An engraved nameplate indicating material of rotor & stator, output at normal speed, & serial number. A 25mm plugged tapping on the suction side for manual flushing the pump. A pressure release device on the-delivery side.

Drive shaft shall be supported in heavy duty ball or ball and roller bearings. Bearings shall have a life BIO of 100000 hour. The pump shall be driven by an IP55 motor through anti-static v-belts or direct coupling.

5.14 Filter Press

The pressure sludge cake shall have a dry solid content of 20% or better.

Filter press shall consist of a rigid frame having a number of vertically orientated filter plates compressed together by a pressure head operated from one end of the frame. Each plate shall be recessed on both sides with a raised filtration surface covering the whole area. The filter cloth shall cover the filtration area on both sides of the plate with a feed hole in the centre.

Compression of the plate pack shall form a series of sludge dewatering. Introduction of the sludge into the centre of the filtration chambers shall allow the solids to be retained on the cloths, while the liquid passes through the cloth and escapes by the plate drainage surface to a collection point.

The frame shall consist of fabricated steel end supports and carbon steel sidebars. The closing mechanism shall be mounted centrally in one of the end supports. A fabricated steel pressure head shall be supported on the sidebars and connected to the closing mechanism. The plates shall be packed between one end support and the pressure head, and shall be pressure sealed by the closing system. The filter cloths shall be made of synthetic materials which shall be long lasting and easily be cleaned.

The filter press shall use an automatic hydraulic system to close and tighten the filter plate pack. It shall consist of a self contained hydraulic power pack having a low and high pressure system operation a double acting cylinder. Automatic pressure and temperature compensation shall be incorporated into the system.

The press shall have safety guard protection on both sides of its body. A pull cord switch able to stop the press shall be installed along the press body.

Discharge hopper and mobile cake trolley shall be supplied.

The hydraulic equipment shall include oil reservoir, hydraulic pump, pressure relief valve, flow regulating and non-return valves, surge absorber, oil cooler (if required), screen and micro-filters, pressure gauge and switches, oil temperature gauge and cut out switch and all other ancillary equipment for the satisfactory operation of the hydraulic system. The Contractor shall provide a hydraulic compartment adjacent to the press to house this equipment.

Sludge shall be conditioned in a separate tank by the conditioning polymer before dewatering by the filter press.

Motor shall be of Squirrel Cage Induction type, insulated against heat and humidity to Class "F" with bimetallic thermal overload protectors incorporated in motor windings. Operating voltage shall be of 415V three phase 50 Hz supply with permissible speed not exceeding 1500rpm. Motors shall be EFF-2 Energy Efficient type. Electrical cable of sufficient length which shall be waterproofed shall be supplied by pump manufacturer.

A sludge cake collection trolley made of Mild steel (heavy gauge) with epoxy protection shall be provided.

5.15 Fire Extinguishers

Portable fire extinguishers are to be provided for all units as per the requirement of Tariff Advisory Committee (TAC) or meeting the requirement of local regulations whichever is stringent. All the extinguishers shall have ISI mark / TAC approved. Two nos. of capacity of each 2 Kg shall be provided.

5.16 UV Disinfection

Efficiency of UV shall be 99.5% with UV dosage more than 30,000 microwatts sec/sq.cm.

Specification of UV System		
Sl. No.	Description	Specification
1	Quantity	1
2	Capacity	Appropriate
3	Efficiency	99.5%
4	UV dosage	> 30,000 microwatts sec/sq.cm
5	Wavelength	0.1to 0.4 Microns
6	Lamp life	7000 running hrs
7	Type of bulbs	Slim line
8	Power	Single phase, 60 watts
9	MOC of housing	SS304

5.17 Hand Operated Hoists and Trolleys

Manual hoists shall be complete with hand-chain, trolley, pulley block, hook, hand and load chains, brake and other accessories. They shall comply with the latest applicable standards, regulations and safety codes in the locality where equipment will be installed.

Each hoist shall be operated on a monorail (I-Beam). The factor of safety shall not be less than 5. The load chain may be heat-treated to give ductility, toughness and conforming to I.S. 3109/B.S. 1663/B.S. 3114. The load wheel is to be made from heavy duty malleable castings. The hand chain is to Conform with B.S. 6405:1984 and hand chain wheel may be made from pressed sheet steel with roller type guarding. Gears shall be cut from solid cast or forged steel blanks or shall be stress – relieved welded steel construction. Pinions shall be of forged carbon or heat treated alloy steel. Strength, Quality of Steel, heat treatment, face, pitch of teeth and design shall confirm to BS-436, BS-545 and BS-721. Spur and helical gears must comply with B.S. 436 and worm with B.S. 721. Bearing must be ball and roller type conforming to I.S. 2513/B.S.2525-32:1954.

Proper lubricating arrangements are to be provided for bearings and pinions. The brake for the lifting gear shall be automatic and always in action.

The proof testing of each chain pulley block is to be carried out as per latest applicable standards. The safe working load is to be marked in such way that is clearly visible from the operating level.

5.18 Jib cranes

Fixed Jib Cranes shall be provided in the for lowering/removal of equipments/parts to/from the tank. The Jib Crane capacity shall be 1.5 times the maximum weight to be handled. The lift and reach of the cranes shall be suitable for the tank depth offered. The crane shall be capable of being swivelled by 360°. All materials used in the construction shall be corrosion resistant. Mild steel used shall be galvanised. Ropes, chains and pulleys shall be of stainless steel construction. Hardware shall be of SS 316.

5.19 Propeller Exhaust Fan

The fan should comply with IS 2312.

The blades shall be of mildsteel and properly balanced so as to avoid noise and vibration. The blade and blade carriers shall be securely fixed so that they do not loosen in operation. The means provided for securing the fan mounting or fan casing to the wall partition or window shall be such as to provide a secure fixing without damage to the fan or wall.

Suitably designed guards shall be fitted to the inlet and the outlet side to prevent accidental contact. No flammable material shall be used in the construction of fan. Moulded parts, if used, shall be of such materials as to withstand the maximum temperature attained in the adjacent component parts.

The fan shall have protective insulation or be capable of being earthed. A fan with protective insulation may be of all insulated construction or have either double insulation or reinforced insulation. Each fan should be provided with a 10 sq.mm mesh bird screen. The sheet used for the cowl should be 14 G and Motors shall be TEFC, IP-54.

5.20 Spares and consumables

The List of spares and consumables required for satisfactory and trouble free operation of the plant along with unit rates and recommended quantity shall be submitted by the tenderer.

SCHEDULE E. MAINTAINANCE REQUIREMENTS

1 MAINTAINANCE REQUIREMENT

The Contractor shall, at all times maintain the Project Components in accordance with the provisions of this Agreement, Applicable Laws and Applicable Permits.

The Contractor shall repair or rectify any Defect or deficiency set forth in 2.0 (Repair/Rectification of Defects and Deficiencies) of this Schedule-E within the time limit specified therein and any failure in this behalf shall constitute non-fulfilment of the Maintenance obligations by the Contractor. Upon occurrence of any breach hereunder, the Employer shall be entitled to effect reduction in monthly lump sum payment as set forth in Clause 14.6 of this Agreement, without prejudice to the rights of the Employer under this Agreement, including Termination thereof.

All materials, works and construction operations shall conform to the Specifications for Road and Bridge Works (Fifth Revision, April 2013), issued by the Ministry of Road Transport & Highways (MoRT&H) and the relevant IRC publications. Where the Standards and Specifications for a work are not given, Good Industry Practice shall be adopted to the satisfaction of the Employer's Engineer.

All relevant materials, works and construction operations shall conform to CPHEEO Manual on Operation and Maintenance of water supply systems, 2005, MoUD, GOI and Good Industry Practice to the satisfaction of Employer's Engineer for Potable water supply rising mains and distribution networks, Recycle rising mains and distribution networks including valves, specials, flow meters etc.

All relevant materials, works and construction operations shall conform to CPHEEO Manual on Sewerage and Sewage treatment systems 2013 Part-B ; Operation and Maintenance and Good Industry Practice to the satisfaction of Employer's Engineer for Industrial effluent pumping mains and networks, Sewer pumping mains and networks including manholes, flow meters etc.

All relevant materials, works and construction operations shall conform to CPHEEO Manual on Operation and Maintenance of water supply systems, 2005, MoUD, GOI and Good Industry Practice to the satisfaction of Employer's Engineer for Potable and Recycle underground level storage reservoirs.

All relevant materials, works and construction operations shall conform to CPHEEO Manual on Sewerage and Sewage treatment systems 2013 Part-B; Operation and Maintenance and

Good Industry Practice to the satisfaction of Employer's Engineer for storm water drain networks and outfalls.

Maintenance of street lighting is inclusive of all roadway illumination equipment. The equipment consists of poles, luminaires, brackets, photocells, lamps, relays, conductors, ducts, hand-wells, vaults, and associated hardware.

2 REPAIR/RECTIFICATION OF DEFECTS AND DEFICIENCIES

The obligations of the Contractor in respect of Maintenance Requirements shall include repair and rectification of the Defects and deficiencies specified in Appendix E-I of this Schedule-E within the time limit set forth therein.

3 OTHER DEFECTS AND DEFICIENCIES

In respect of any Defect or deficiency not specified in Appendix E-I of this Schedule- E, the Employer's Engineer may, in conformity with Good Industry Practice, specify the permissible limit of deviation or deterioration with reference to the Standards and Specifications, and any deviation or deterioration beyond the permissible limit shall be repaired or rectified by the Contractor within the time limit specified by the Employer's Engineer.

4 EXTENSION OF TIME LIMIT

Notwithstanding anything to the contrary specified in this Schedule-E, if the nature and extent of any Defect or deficiency justifies more time for its repair or rectification than the time specified herein, the Contractor shall be entitled to additional time in conformity with Good Industry Practice. Such additional time shall be determined by the Employer's Engineer and conveyed to the Contractor and the Employer with reasons thereof.

5 EMERGENCY REPAIRS/RESTORATION

Notwithstanding anything to the contrary contained in this Schedule-E, if any Defect, deficiency or deterioration in the Project Components poses a hazard to safety or risk of damage to property, the Contractor shall promptly take all reasonable measures for eliminating or minimizing such danger.

6 DAILY INSPECTION BY THE CONTRACTOR

The Contractor shall, through its engineer, undertake a daily visual inspection of the Project Components and maintain a record thereof in a register to be kept in such form and manner as the Employer's Engineer may specify. Such record shall be kept in safe custody of the Contractor and shall be open to inspection by the Employer and the Employer's Engineer at any time during office hours.

7 PRE-MONSOON INSPECTION / POST-MONSOON INSPECTION

The Contractor shall carry out a detailed pre-monsoon inspection of all bridges, culverts and drainage system before [1st June] every year in accordance with the guidelines contained in IRC: SP35. Report of this inspection together with details of proposed maintenance works as required on the basis of this inspection shall be sent to the Employer's Engineer before [10th June] every year. The Contractor shall complete the required repairs before the onset of the monsoon and send to the Employer's Engineer a compliance report. Post monsoon inspection shall be done by [30th September] and the inspection report together with details of any damages observed and proposed action to remedy the same shall be sent to the Employer's Engineer.

8 REPAIRS ON ACCOUNT OF NATURAL CALAMITIES

All damages occurring to the Project Components on account of a Force Majeure Event or default or neglect of the Employer shall be undertaken by the Employer at its own cost. The Employer may instruct the Contractor to undertake the repairs at the rates agreed between the Parties.

The Contractor shall repair and rectify the Defects and deficiencies specified in this Schedule-E within the time limit set forth in the table below.

Table 1: DEFECTS AND DEFICIENCIES

Nature of Defect or Deficiency		Time Limit For Repair/Rectification
ROADS		
(a)	Carriageway And Paved Shoulders	
(i)	Breach or blockade	Temporary restoration of traffic within 24 hours; permanent restoration within 15 (fifteen) days
(ii)	Roughness value exceeding 1,800 mm in a stretch of 1 km (as measured by a calibrated bump integrator)	120 (one hundred and twenty) days
(iii)	Pot holes	24 hours
(iv)	Any cracks in road surface	15 (fifteen) days
(v)	Any depressions, rutting exceeding 10 mm in road surface	30 (thirty) days
(vi)	Bleeding/skidding	7 (seven) days
(vi)	Any other defect/distress on the road	15 (fifteen) days
(vi)	Damage to pavement edges	15 (fifteen) days
(ix)	Removal of debris, dead animals	6 hours

(b)	Granular Earth Shoulders, Side Slopes, Drains And Culverts	
(i)	Variation by more than 1 % in the prescribed slope of camber/cross fall (shall not be less than the camber on the main carriageway)	7 (seven) days
(ii)	Edge drop at shoulders exceeding 40 mm	7 (seven) days
(iii)	Variation by more than 15% in the prescribed side (embankment) slopes	30 (thirty) days
(iv)	Rain cuts/gullies in slope	7 (seven) days
(v)	Damage to or silting of culverts and side drains	7 (seven) days
(vi)	De-silting of drains	24 hours
(vi i)	Railing, parapets, crash barriers	7 (seven) days (Restore immediately if causing safety hazard)
(c)	Road Side Furniture Including Road Sign And Pavement Marking	
(i)	Damage to shape or position, poor visibility or loss of retro-reflectivity	48 hours
(ii)	Painting of km stone, railing, parapets, crash barriers	As and when required/Once every year
	Damaged/missing road signs requiring replacement	7 (seven) days
(iv)	Damage to road mark ups	7 (seven) days
(d)	Road Lighting	
(i)	Any major failure of the system	24 hours
(ii)	Faults and minor failures	8 hours
(e)	Trees and Plantation	
(i)	Obstruction in a minimum head-room of 5 m above carriageway or obstruction in visibility of road signs	24 hours
(ii)	Removal of fallen trees from carriageway	4 hours
(iii)	Deterioration in health of trees and bushes	Timely watering and treatment
(iv)	Trees and bushes requiring replacement	30 (thirty) days
	Removal of vegetation affecting sight line and road structures	15 (fifteen) days
(f)	Other Project Facilities and Approach Roads	
(i)	Damage in approach roads, pedestrian facilities, truck lay-byes, bus-bays, bus-shelters, electrical, water, sanitation and service roads	15 (fifteen) days
(ii)	Damaged vehicles or debris on the road	4 (four) hours

(iii)	Malfunctioning of the mobile crane	4 (four) hours
BRIDGES		
(a) Superstructure		
	Any damage, cracks, spalling/ scaling - Temporary measures - Permanent measures	- within 48 hours - within 15 (fifteen) days or as specified by the Employer's Engineer
(b) Foundations		
(i)	Scouring and/or cavitation	15 (fifteen) days
(c) Piers, Abutments, Return Walls and Wing Walls		
(i)	Cracks and damages including settlement and tilting, spalling, scaling	30 (thirty) days
(d) Bearings (Metallic) of Bridges		
(i)	Deformation, damages, tilting or shifting of bearings	15 (fifteen) days Greasing of metallic bearings once in a year
(e) Joints		
(i)	Malfunctioning of joints	15 (fifteen) days
(f) Other Items		
(i)	Deforming of pads in elastomeric bearings	7 (seven) days
(ii)	Gathering of dirt in bearings and joints; or clogging of spouts, weep holes and vent-holes	3 (three) days
(iii)	Damage or deterioration in kerbs, parapets, handrails and crash barriers	3 (three) days (immediately within 24 hours if posing danger to safety)
	Rain-cuts or erosion of banks of the side slopes of approaches	7 (seven) days
(v)	Damage to wearing coat	15 (fifteen) days
	Damage or deterioration in approach slabs, pitching, apron, toes, floor or guide bunds	30 (thirty) days
(vi)	Growth of vegetation affecting the structure or obstructing the waterway	15 (fifteen) days
Potable Water and Recycle Water Network		
(a) Transmission mains / Rising mains		
(i)	Bursts in the transmission mains / rising mains of water supply system	6 hrs from occurrence
(b) Distribution Network		
(i)	Bursts in the distribution network pipelines	4 hrs from occurrence

(ii)	Flushing of distribution network pipelines	Once in 6 months
(c)	Sluice Valve/Air Valve/Reflux Valve	
(i)	Faults and minor failures	6 hrs
(ii)	Faults and major failures	24 hrs
(iii)	Preventive maintenance for valves	Once in 6 months
(d)	Property Connection	
(i)	Leakages in pipeline	2 hrs
(ii)	Faults and major failures	6 hrs
Underground level Storage Reservoir		
(i)	Leakages	6 hrs
(ii)	Paint	Once in a year
(iii)	Cleaning and Disinfection	Once in 2 months
Sewerage Network and Industrial Effluent Collection Network		
(a)	Sewerage Network	7 (seven) days
(i)	Leakages in network pipeline	2 hrs
(ii)	Faults and minor failures	8 hrs
(iii)	Flushing of sewerage network (where velocity is < 0.6 m /seconds for present flow)	Once in 15 days
(b)	Man-Holes	
(i)	Damages to Man-Holes	24 hrs
(ii)	Overflow of Manholes	2 hrs
(iii)	Cleaning of manholes	Once in 3 months
(c)	Rising main	
(i)	Leakages in network pipeline	8 hrs
(ii)	Major damages in pipeline or replace	24 hours
(iii)	Preventive maintenance for valves	Once in 6 months
(d)	Property Connection	
(i)	Leakages in pipeline	2 hrs
(ii)	Faults and major failures	6 hrs
Street Lighting		
(a)	Pole	
(i)	Leakages current	2 hrs
(ii)	Foundation crack minor	12 hrs
(iii)	Foundation crack major	4 hrs
(iv)	Brackets	8 hrs
(v)	Access panel, Junction Box (Street Lighting Partition) and its Accessories	4 hrs
(vi)	Damaged Pole requiring replacement	4 days
(b)	Conductor /cable	8 hrs
(c)	Luminaires & its Accessories	

i)	LED Luminaire found faulty (such as Flickering, completely not working (Failure), Lux level reduced from the pre-defined level, luminaire having moisture / water drops, etc.), complete luminaire to be replaced with original make / model and not to be repaired	4 hrs
ii)	Driver	4 hrs
iii)	Reflecting element	4 hrs
	Housing	4 hrs
(d)	Control & Protection	
	Street Lighting Gateway - SLG & its Accessories	4 hrs
	Street Lighting Controller - SLC & its Accessories	4 hrs
	Central Management System - CMS & its Associated Components	2 hrs
iv)	Communication failure a) between CMS and/or SLG/SLC b) between SLG and SLC c) between SLC and LED Luminaire's Driver	4 hrs
(e)	Power	
i)	Supply (Lighting Distribution Board Onwards)	2 hrs
ii)	Fault	2 hrs
	Lighting Distribution Board - LDB & its Accessories	2 hrs
(f)	Earthing	
	Any fault related to Earthing Units and its Associated Components	8 hrs

Table 2: General Preventive Maintenance Checks Suggested for Maintenance of Project

General Preventive Maintenance Checks	
(a)	The following checks to be performed daily by the Contractor's personnel
(i)	Whether there is a change in the sound of a running pump / motor, abrupt changes in bearing temperature and seal leakage?
(ii)	The pump / motor capacity, pressure, power consumption and vibration level to check if outage is required to address deterioration of specified performance values.
(iii)	Rise in temperature of bearings in motor, in moving parts and other units, etc.
(iv)	Working of gauges, sensors and other flow measuring devices
(v)	Average power factor, kWH consumed
(b)	The following checks to be performed weekly by the Contractor's personnel
(i)	Pipeline, valve and flow meters leakage
(ii)	Functioning of non-return valve
(iii)	Tightness of all electrical connections of all unit panels etc.
(iv)	Tightness all cable connections
(v)	Temperature rise due to loose connections
(vi)	Operation of valves and sluice gates
(vi)	Current and voltages in all electrical equipment
(vi)	Average power factor, kWH consumed
(ix)	Lights on/off
(x)	Leakage current for all power distribution
(c)	The following checks to be performed monthly by the Contractor's personnel
	Battery voltage, battery charger, topping of distilled water, tightness of terminations etc.
(ii)	Gland packing
(iii)	Wear and tear of moving parts
(iv)	Adoption of Electrical energy conservation methods and energy consumption
(v)	Electrical contacts
(vi)	Motors
(vi)	Meggering of electrical equipment
(vi)	Watering of earthen pits
(d)	The following checks to be performed quarterly by the Contractor's personnel
(i)	Relay testing and calibration if possible of meters, gauges, instruments
(ii)	Speed of motors
(iii)	Level gauges and flow meters signals
(iv)	Cleaning, checking/tightening of L.T. Circuit / Panel
(v)	Auxiliary DB, Capacitor bank
(vi)	Battery and Battery charger
(e)	The following checks to be performed bi-annually by the Contractor's

(i)	Free movement of stuffing box glands, gland bolts to be cleaned & lubricated and packing to be inspected to determine whether it requires replacement.
(ii)	Pump / motor alignment should be checked and corrected if necessary.
	Grease lubricated bearings should be checked to see that they contain the correct amount of grease and that it is still of suitable consistency
(f)	The following checks to be performed annually by the Contractor's personnel
	Vibration should be reviewed. If the pump / motor is tending towards unacceptable vibration levels:
	• The bearing should be removed, cleaned and examined for flaws and wear • The bearing housing should be carefully cleaned • Rolling element bearings should be examined for scratches and wear • Immediately after cleaning, rolling element bearings that are considered
(ii)	Shaft sleeve and shaft should be examined for wear.
(iii)	When coupling halves are disconnected for an alignment check, the vertical shaft movement of a pump with sleeve (journal) bearing should be checked at both ends with packing or seals removed. Any movement exceeding the original design clearance should be investigated to determine the cause. Endplay allowed by bearings should also be checked. If it exceeds that recommended by the manufacturer, the cause should be determined and corrected.
	Stuffing boxes should be repacked and the pump & motor should be realigned and Reconnected
(v)	Overhauling requirement of all equipment
(vi)	Improvement required if any in operation of plant
(vi)	Testing and Calibration of all instruments
(vi)	Transformer cleaning, checking silica gel, oil checking filtering/replacing, checking buchholz relay, checking pressure release valve, checking winding temperature indicator's sensor and NO/NC contacts, checking oil temperature indicator's

9 OTHER MAINTENANCE REQUIREMENTS

9.1 MECHANICAL WORKS-PUMPING STATION

GENERAL

This section applies to carry out maintenance of the facility in meeting its objective. The section pertains to the specifications of infrastructure component and equipment including materials used for maintenance, the workmanship, period for maintenance, maintenance of records, and

responsibilities maintenance period. The Contractor shall be responsible for providing continuous improvement in the infrastructure system operation, instrumentation system, communication system, 33kv/433v substations, SCADA, Plant and Machineries, all ancillary buildings, project area, for period of 30 days, and to prevent any further sudden failure or breakdown through maintenance works on plant operation. It is essential that Employer and contractor need to have sufficient information on operational issues under normal and emergency condition.

9.2 DUTIES AND RESPONSIBILITIES

The Contractor shall maintain the works on a regular and systematic basis in compliance with maintenance requirements set forth in this document.

- Client will provide administrative support. Rest all Responsibility lies with the Contractor.
- The contractor shall ensure satisfactory maintenance of the whole works so that the entire infrastructure system operation provides reliable, consistent performance and is economical at all times.

9.3 DEFINITION OF MAINTENANCE

Maintenance covers all the techniques and systems which, by means of regular monitoring of equipment and scheduled maintenance procedures, prevent failures and, in the event of problems, enable repairs to be carried out with the minimum disruption of the process. Maintenance is therefore a combination of technical, administrative, and management activities. Maintenance consists of preventive and corrective procedures.

9.4 PREVENTIVE MAINTENANCE

Preventive maintenance consist of all the regular work carried out in order to sustain the conditions necessary or smooth operation of the plant and to keep the performance of the equipment as close as possible to its original performance level. Its purpose is to reduce the probabilities of failure or deterioration of equipment of the plant. In simple terms, preventive maintenance involves the elementary operations such as lubrication, mechanical servicing, electrical and instrumentation servicing.

9.5 CORRECTIVE OR REMEDIAL MAINTENANCE

Corrective or remedial maintenance consists of all work needed to re-establish the conditions necessary for an apparatus or set of equipment to operate properly subsequent to failure or deterioration of the results produced by the equipment.

It includes the following operations,

- Dismantling or equipment,
 - Replacement of parts
 - The work may be scheduled for the short or medium term in accordance with the checks carried out as part of the preventive maintenance procedure, the number of hours an apparatus has been operating, or an alarm factor (abnormal noise, repeated cut-out, weakening of the insulation, etc), or may be dictated by an unexpected breakdown.
 - Maintenance work
- i. The work consists of inspection work and maintenance work as mentioned below:
 - ii. Inspection work, includes physical appearance, inspection and measurement with testing equipment to verify and survey that the entire infrastructure components' performance operation is normal or not.
 - iii. The inspection work shall be daily executed by each technical specialist as a routine and / or regular inspection and shall be recorded every each time. The evaluation on the collected data shall be immediately reviewed by the chief operational engineer to instruct the staff member for operation on the same day and /or make a plan of detail inspection and/or make repair schedule to make sure continuous plant operation without any problem.
 - iv. Maintenance work, for which main task-work shall include activities, such as lubrication, overhaul, replacement of parts, repair, adjustment, detail examination and test, cleaning, to maintain the system in a good condition, performance consistent and low cost operation based on a regular and preventive maintenance schedule including attending sudden Equipment breakdown and to achieve high operational efficiency.

9.6 SPECIFICATIONS

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to commencement of the maintenance period and must be incorporated in the O&M manual. Without being limited by this clause, during Maintenance period the Contractor shall use appropriate material for repairs even if material required for such repairs has not been approved earlier, and no delay in making such repairs shall be subjected to such limitation. However, subsequent to use of such material the Contractor shall submit proposals for the approval of specifications of such material. The approved material will subsequently form a part of the O&M manual. The comprehensive information as detailed in Table shall be submitted to the Engineer.

Table: List of Execution Schedule

Items	Description
Maintenance of facilities	List of unit process, infrastructure components, Capacity of Plant, equipment machineries etc, Method / Frequency of maintenance.
Counter measure against accident and risk management	Damage prediction, Simulation of public relations, Method of recovery, Contact address, Rescue activity and emergency team.
Renewal	Replace of pipes, Replace of equipment & Facilities.
Organization and administration	Executive organization chart, Segregation of duties, List of staff member, Experience, Health certificate of staff member, type of insurance, Criminal record, Personnel name of taking record and make soft data, method of data control, Operation and maintenance cost.

9.7 ACTIVITIES DURING MAINTENANCE PERIOD

General

Within the framework of the Contractor's responsibilities given above, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities which otherwise are required as per term and conditions of Contract or to fulfill the Contractor's responsibilities or are essential as per good industrial practices. The Contractor shall be responsible for, but not limited to, the following:

- Providing the required staff, but not less than the minimum specified numbers / level, during maintenance period and additional staff as per requirement during periodic maintenance and in emergencies.
- Providing all required spares, tools, tackles & Equipment and consumables required for functioning of plant and equipment.

- Maintenance of 33kV/433v substations, etc., at the pump house, administrative buildings etc. (all works constructed in this Contract) in neat and clean condition.
- Entering into AMC contracts with system / equipment suppliers such as Pumps, Hoists and cranes, Valves and actuators, and all proprietary equipment and others as necessary. The AMC contract shall include preventive maintenance and emergency corrective maintenance programmers, so that breakdowns can be kept to absolute minimum in frequency and duration.

Establish work control procedures including preventive and corrective maintenance so that the entire system shall work in automatic mode and/or semi automatic at all times.

- Maintenance of the lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures within 24 hours.
- Repair history of all Civil, mechanical, electrical and instrumentation control equipment, and communication instruments;
- Logbooks through PLC system;
- Daily log of operations of all the important equipment such as pumps, electrically actuated valves, etc., with time tag;
- Daily / hourly consumption data, (monitoring and recording) of both potable and Recycled water system including assessment of initial UFW.
- Daily list of alarms with time tag;
- Logbook format and the data to be included in the logbook shall be decided during commissioning in consultation with department;
- Last periodic maintenance done for all equipment/buildings of the system;

In addition to maintenance of above logbooks, the Contractor is required to maintain one inspection book. The complaints entered in the complaint register must be investigated and remedial measures must immediately be taken.

- Providing required spares, special tools and test equipment and maintaining adequate inventory of required accessories or equipment itself for repair of equipments. The Contractor may use spares and tools and tackles supplied with the Contract as required by him. However at the end of the Contract the Contractor shall hand over the full spares, tools and tackles as supplied with the Contract by replacing the used items with fresh supplies of the same specifications.
- Providing manpower for the required repairs of all facilities along with the manpower and materials for repair of the roads, buildings and project area utilities etc.

- Maintaining the drinking water supply, recycled water system, waste collection system, Drainage system facilities in the entire Integrated Industrial Township at Greater Noida area.
- Maintaining stores for the electrical, mechanical and instrumentation and control equipment.

The maintenance of stores will include but shall not be limited to:

- o Loading / unloading of materials received and issued for works;
- o Proper arrangement of material in stores to ensure its safety and easy availability;
- o Maintaining store areas in a neat and tidy condition;
- o Keeping records and accounting for the incoming materials,
- o Keeping records and accounting for the consumed materials.

The Contractor shall be solely responsible for the safety and security of the goods in the store and will be responsible for any loss or damages in stores for any reason. He may opt for insurance cover against the value of the goods to be stored without any additional costs on the Department.

- Periodic routine maintenance of structures/buildings and others built in the Contract. Such maintenance must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be maintained and adequate plantation, horticultural activities must be taken up to maintain the total environment of the campus / building pleasant.
- Updating and periodic submissions of the operation and maintenance manual as defined in specifications for O&M works. The Contractor shall take up all periodic maintenance works provided in the approved O&M manual.
- Submission of monthly report.
 - o Co-ordination with other contractors and/ or agencies responsible for the maintenance of the system.
 - o The Engineer shall be entitled to audit any aspect of the system and the contractor shall ensure remedial action as directed.
 - o Safety reporting: Brief reports of all accidents and hazardous incidents including descriptions of causes, extent of injuries, action taken, and precautions instituted to prevent repetition of such events.
- Insurance: The Contractor shall, without limiting his or the Employer's obligations and responsibilities, insure;

- o The work together with material and plant for incorporation therein, to the full replacement cost (term “cost” in this context shall include profit).
- o The Contractor’s equipment and other things brought onto site by the Contractor, for a sum sufficient to provide for their replacement at the site.
- o The insurance shall be in the joint names of the Contractor and the Employer at the Contractor’s cost and shall cover the Employer and the Contractor against all losses or damages from whatsoever cause arising from the start of the Maintenance until the date of completion of Maintenance period in respect of the facility or any section or part thereof as the case may be.
- o Any amount not insured or not recovered from the insurer shall be borne by the Contractor.
- o Insurance shall cover for civil works.

Contractor care of plant works

The Contractor shall take full responsibility for the care of the entire infrastructure system and other allied systems during the contract period till it is handed over to the Employer. If any loss or damage occurs to the system, during the period for the contractor is responsible, the contractor shall rectify such loss or damage, at his cost.

Experience & qualification of staff

- Requirements

Maintenance staff shall have best experience, their health condition and education in addition to possessing best knowledge, abilities and skills.

- Knowledge and abilities

- o Knowledge of entire infrastructure system operation and its unit operation;
- o Knowledge of the method, materials, and equipment of system;
- o Knowledge of maintenance, and servicing of pumps and other plant equipment and machinery;
- o Abilities to make repairs and/or adjustments to plant equipment and to keep records and prepare reports;
- o Abilities to read and interpret gauges and recording devices used;
- o Abilities to work efficiently with others.

- Safety and Health

- Electricity

- o All the electrical equipments shall be handled and operated by a trained and authorized person only. All the equipment shall be checked for its proper earthing and loose connections prior to start the equipment. Naked wire, loose connections and faulty connections shall be repaired immediately prior to start for operation.
 - o Electrical sockets and switch shall not be touched by bare or wet hands. If there is any live wire found naked or on wet ground, main switch shall be turned off first then the wire shall be repaired or moved.
 - o For any electrical works proper insulated tools shall be used. Do not try to use tools made for other purpose; it may be hazardous.
- Fall protection

Only authorized person shall work at high place, people working at high level shall be very careful and protect himself from fall and injuries. Protective gears such as gloves, safety belts shall be worn and safety belts shall be tied to proper location prior to start the work. If anybody feels dizzy and drowsy he should not work at high and should come down immediately.

 - o Wherever possible a ladder shall be used. Ladder shall be in stable condition and proper slope of ladder is 4 vertical and 1 horizontal and it shall properly secured at base.
 - o All the opening shall be secured properly by barrier of hand rail to avoid unauthorized person getting in. Wherever covers are provided for opening those covers shall keep closed all the time, except for maintenance time.
- Entering inside tank
 - o If worker should enter inside of deeper manholes or tanks precaution shall be taken.
 - o Manholes cover shall be open and wait for fresh air to circulate.
 - o Prior to enter - oxygen level inside the tank shall be checked otherwise it may be hazardous. If oxygen is not enough a ventilating fan should use to supply fresh air inside.
 - o Only permitted person shall work inside, while a person is working inside there must be next person watching outside; unless he appoints next person he should not leave from duty. While men working inside manholes must keep open. And manholes shall be protected from outsiders to go inside.
 - o If person inside feels drowsy, dizzy or unusual feeling he should come out immediately. He should rest and take a fresh air.

- o If the worker is collapsing inside, do not immediately enter inside for rescue him as you may be next victim of accident. Prior to rescue make sure that oxygen is enough inside, report immediately to person In-charge. Try to rescue the person from outside,
- Health check up
 - o Water can be scrapped and become a carrier of water borne disease if it is handled by an ill person. That's why personal health is an important factor to keep the water potable. Any person not feeling well shall report to their superior and shall be go through proper health checkups.
 - o All workers should go through medical check up, and the result of check up shall be reported to the Engineer.
- General personnel's cleaning
 - o Persons working shall maintain a high level of personal hygiene. This includes clean work clothes, skin, fingernails, and hair. They should wash their hands properly by using soap and clean water prior to handle the works.
- Uniform
- All workers at site work shall wear helmet, safety shoes, regular uniform to avoid any accident by rotating equipment's.

Lubrication

The Contractor, in the operation and maintenance manuals, shall furnish a complete schedule of recommended oils and other lubricants. The number of types of lubricants shall be kept minimum. In case of grease lubricated bearings for electric motors, lithium base grease is preferred. The Contractor shall indicate the brand name of indigenously available equivalent lubricants, with their complete duty specifications, in the O&M manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in O&M manual.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be used.

All lubricant systems shall be designed so as not to cause a fire or pollution hazard. The Contractor shall supply flushing oil for such lubrication system when an item of plant is ready for preliminary running.

Spare Parts

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed. All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

9.8 OPERATIONS AND MAINTENANCE MANUAL

The Operation & Maintenance manual shall establish guideline for infrastructure operator to understand the system to operate this system successfully.

The guideline shall also provide basic idea on, how to operate the system so as to manage with less consumption of energy; less cost of maintenance expenses; a long life of equipment; protection against accident and damage of system. The operators have to be well conversant with the manual and the guidelines stipulated therein. In practice, the system operation and unit operation of each component needs to be continuously adjusted and modified. The comprehensive manual shall be submitted to the Engineer before the operation and maintenance period, as specified. It shall be periodically updated to incorporate the “best practices” experience gained while carrying out the O&M activities, broadly on the principals listed below:

Table 0-1 Typical Operation & Maintenance Manual

Items	Description
1. General	1) Background of project 2) Plan and design condition. 3) Planned infrastructure capacities. 4) Design pressure (Pipeline) 5) Component of the system (Item, Specification, Quantity, Remarks) 6) Detail of facilities (Name of facility, units, No. structure, capacity, Remarks) 7) Detail of mechanical & electrical (Name, Specification, S.No./Tag No., Quantity, Remarks)

	8) Detail of pipe line route (Flow diagram including valves /gates S.No /Tag No., Specification, Quantity, Remarks)
2. System operation (Civil / Mech/ Elec / SCADA.)	1) Infrastructure System drawings (Plan and profiles of Roads, water supply, Sewage, Storm water system, Plan view of pump house, flow diagram, single line diagram, electrical operation /control flow diagram, location/depth of water level sensor, flow control sensor system, others) 2) Outline of Main facility 3) Concept of operation 4) Concept of selection of facility 5) Operation procedure (photograph with explanation) 6) Preparation before start operation 7) Starting of system operation 8) During regular operation 9) Emergency operation
3. Component detail and full operation (Civil / Mech/ Elec / SCADA.)	1) Outline of all components 2) Concept of selection of component 3) Concept of auto-manual operation 4) Preparation before start of operation 5) Starting of operation 6) During regular operation 7) Emergency operation
4. Equipment detail (Mech / Elec.)	1) Outline of all equipment 2) Specification, dimensional drawings, performance curve, dimension of water level sensor 3) Preparation before start of operation 4) Starting of system operation 5) During regular system operation 6) Emergency system operation
5. Maintenance work summary	1) Inspection (System, Facility, Unit operation, others) 2) Maintenance (System, Facility, Unit operation, others) 3) Replace/repair (System, Facility, Unit operation, others) 4) Modification (System, Facility, Unit operation, others) 5) Troubleshooting (photograph with explanation)

6. List of data sheet/chart (For daily and /or periodic report)	1) Operational chart (description/number of worker/allocation) 2) Instruction manual for equipment 3) Record of system operation (Pressure, Q, time, rotation, noise) of all components 4) Record of material control 5) List of accessory/spare parts 6) List of Manufacture/supplier 7) List of Contractor/ subcontractors 8) Emergency control (Accident etc) 9) List of key control
7. Safety & Health	1) Electricity 2) Fall protection. 3) Entering inside tank (lack of oxygen/ being filled with gas poisoning) 4) Health check-up (staff member/workers) 5) General personnel's cleaning 6) Uniform 7) Site cleaning 8) Security control

- Up-dating any changes in the procedures set out in the O&M manual, as deemed necessary based on any limitations observed during the maintenance period, including incorporating additional procedures for maintenance of other repairs / break downs not incorporated in the maintenance manual but faced during O&M period.
- Procedures for repair of leaks / burst in different types of pipes must be provided, with supporting drawings. The O&M manual must be updated if any differences are observed during Maintenance period.
- Frequency of spares used in maintenance of valves (air-valve, sluice valves and butterfly valves), against corrosion must be recorded for updating the contents of the manual.
- Records of trouble shooting points and details of events causing trouble (breakdowns) during maintenance of pump houses must be maintained and used for updating the contents of the manual.
- Records of trouble shooting points and details of events causing troubles (break down's) during maintenance of pumps / motors / measuring equipment(s), / electric panel and accessories there in must be maintained and used for updating the contents of the manual.

- Records of trouble shooting points and details of events causing trouble (breakdowns) during maintenance 33kv/433v sub-station must be maintained and used for updating the contents of manual.
- Records of Inventory used must be maintained and the relevant portion of O&M manual must be updated to list out the inventory requirements for maintaining the system.
- The provisions in the manual must incorporate every aspect of good practices even if not elaborated here or in other parts of the bid document. The provisions in the approved operation and maintenance document shall be valid and binding for both the parties during operation and maintenance along with the additions and deletions made.
- The manual so prepared must be updated after the end of maintenance, giving effect to the experience gained and the observations made during the maintenance period.
- At the time of handing over after completion of Maintenance period, all the Plant and equipment, including standby equipment, must be in good working order to the satisfaction of the Employer.
- Before handing over of the plant to the Employer at the end of Maintenance, the contractor shall submit the following documents:
 - (i) Four sets of Operation and Maintenance manuals, together with vendor's manuals, fully updated to take account of the experience gained during the contract.
 - (ii) Report summarizing the history of the maintenance of the system during the contract, together with details of the optimized methodology for maintaining the system as developed by the contractor during the contract.
 - (iii) The inventory of spares and tools etc. held in stock showing that he has replenished the spares and tools consumed during the contract.
 - (iv) The proposals, outline of the training modules and programmes, for the training of the Employer's staff.

The contractor shall correct these documents to incorporate any comments from the Engineer and any additional information as required by the Engineer. The final submission of these document shall not be later than 10 days prior to due date of handing over the system to the Employer. 10 days prior to completion of Maintenance works, the Engineer and the contractor shall make a joint inspection of all civil structures, buildings, Plant and Equipment etc at the pump house to assess the condition of these items and agree a list of remedial works and replacements. The contractor shall carry out all remedial works and provide, install and set to work such replacements at his expense to the satisfaction of the Employer as per agreed time schedule.

Facilities To Contractor

The Contractor will be permitted to use the premises developed under the Contract for use by his staff during maintenance period to the extent agreed and approved by the Engineer.

Payments

The Contractor, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfil the entire responsibilities as described above. His bid price, in the Schedule of Prices, shall include all costs for carrying out all Maintenance responsibilities.

Format

Suggested formats to be followed for proper maintenance recording are given below. The format can be finalized during execution stage.

9.9 INSTRUMENTATION, CONTROL & AUTOMATION (ICA)

- **General Maintenance**

A comprehensive maintenance program is critical to attaining long-term reliable performance of SCADA Systems / ICA systems. Periodic device calibration, preventive maintenance, and testing allow potential problems to be identified before they can cause mission failure. Prompt corrective maintenance assures reliability by minimizing downtime of redundant components.

The contractor has to enter in to AMC contracts with system / equipment suppliers of ICA, as necessary.

- **Preventive Maintenance**

The SCADA system should be part of the overall preventive maintenance (PM) program for the facility. Preventive maintenance schedules for SCADA components and subsystems should be coordinated with those for the mechanical / electrical systems they serve to minimize overall scheduled down time.

Many components of SCADA systems, such as dead-bus relays, are not required to function under normal system operating modes. For this reason the system should be tested periodically under actual or simulated contingency conditions. These tests should approach as closely as possible the actual off- normal conditions in which the system must operate. For example, SCADA for Dual Redundant system should be tested by interrupting the utility source as far upstream of the normal service as possible.

Periodic system testing procedures can duplicate or be derived from the functional performance testing procedures.

The SCADA software maintenance should include timely updates of any new versions from the supplier and testing to verify proper installation on the SCADA computer. In addition, software antivirus updates should be maintained. This should be performed any time after the computer is connected to the Internet or the antivirus patch should be downloaded as and when the updates are available. Normal operation requires that the SCADA computer not be connected to the Internet.

Faulty Instruments, sensors, transmitters, communication modules, computer hardware should be replaced with new components. Repair of the failure items would not be accepted. Instruments, modules would have to replace with a new instruments and components.

- **Concurrent Maintenance**

Concurrent maintenance is defined as testing, troubleshooting, repair or replacement of a component or subsystem while redundant component(s) or subsystem(s) are serving the load. The ability to perform concurrent maintenance is critical to attaining the specified reliability / availability criteria for facilities and must be designed into the SCADA system. Where SCADA components are associated with equipment that has redundancy and therefore are not themselves redundant, their maintenance should be scheduled to occur during maintenance of the associated equipment. SCADA components and controllers that are redundant must be capable of being taken out of service, repaired or replaced and tested without interfering with the operation of the redundant component.

- **Reliability Centered Maintenance**

Reliability-Centered Maintenance (RCM) is an approach for developing an effective and efficient maintenance program based on the reliability characteristics of the constituent parts and subsystems, economics, and safety. RCM provides a logical, structured framework for determining the optimum mix of applicable and effective maintenance activities needed to sustain the operational reliability of systems and equipment while ensuring their safe and economical operation and support.

A significant by product of the application of SCADA systems to the control of facilities is the large amount of operational data made available through the trending and data storage features of the SCADA. This operational data can be used for automated performance monitoring of mechanical and electrical systems that can support a RCM approach

- **Maintenance Documentation**

The contractor should perform an O&M analysis to determine the O&M data required to support maintenance of the SCADA system. This analysis should be coordinated with Employer to determine maintenance parameters and O&M data that are available. Typical O&M data requirements include but not limited to the following items:

- (i) System documentation as defined in FDS, FAT & SAT documents
- (ii) Minimum spare parts list.
- (iii) Recommended spare parts list.
- (iv) Recommended onsite test equipment.
- (v) Recommended O&M training.
- (vi) Recommended O&M to be performed by contractor

- **Spare Parts Stocking**

An adequate on-site stock of spare parts is essential to obtaining high availability of ICA systems. All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed. All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labeled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

Minimum recommended stocking levels include the following. These quantities may need to be increased for components which are used in large numbers in the facility:

- (i) Manufacturer's recommended spare parts list.
- (ii) One each of all line replaceable boards or modules.
- (iii) Six each power and control fuses used in the system.
- (iv) Tools required to terminate coaxial or fiber optic cables.

- **Automation:**

- (i) Laptop computer loaded with software required to access controllers. Licenses for all software installed on the system.
- (ii) Permission to modify program code.
- (iii) Spare cables for connecting computer to controllers.
- (iv) PLC CPU, Power supply module, 1 DI, DO, AI, AO modules, Communication module, protocol converter etc..
- (v) PLC batteries, fuses, etc.

- **Utilities & Consumables**

The contractor has to provide consumables for printers e.g.: Ink cartridges (color & B/W), A4, A3, A1 size of paper, dot-matrix print paper. Downtime of the above system should not exceed more than 2 hours.

- **Technical Support**

The Contractor should specify functional areas of the operating system and/or equipment where a Technical representative will be furnished by the manufacturer for training, test, checkout, validation, or pre-operational exercises. Ongoing Maintenance of SCADA system software may require technical support from the system vendor or from agency technical personnel not located at the facility. Commercial SCADA software typically has provisions for remote modem access that permit this type of support from the vendor's location or an agency central engineering group. Such remote access provisions represent a vulnerability to "hacking" and must be used with great caution. They should be monitored when in use and physically disconnected when not in use. Password protection policies for all SCADA systems, including PLC's, shall be in compliance with Established policies and to be agreed with the employers representative. These policies require that the default password that came from the control supplier be changed when placed into operation at the facility.

9.10 SEWERAGE

Maintenance requirement

The system shall be maintained upto the Satisfaction of the Engineer In charges as per relevant standards. Suitable number of personal shall be deployed as per the standards. Periodic maintenance shall also be carried out for normal wear and tear of the system to the satisfaction of the Engineer In charge.

9.11 STORM WATER DRAINAGE

Maintenance requirement

The system shall be maintained upto the Satisfaction of the Engineer In charges as per relevant standards. Suitable number of personal shall be deployed as per the standards. Periodic maintenance shall also be carried out for normal wear and tear of the system to the satisfaction of the Engineer In charge.

9.12 INFORMATION AND COMMUNICATION TECHNOLOGY MAINTAINENCE

GENERAL

This section applies to carry out maintenance of the facility in meeting its objective. The section pertains to the specifications of infrastructure component and equipment including materials used for maintenance, the workmanship, period for maintenance, maintenance of records, and responsibilities maintenance period. The Contractor shall be responsible for providing continuous improvement in the infrastructure system operation, instrumentation system, communication system, SCADA, Plant and Machinerics, all ancillary buildings, project area

and to prevent any further sudden failure or breakdown through maintenance works on operation.

DUTIES AND RESPONSIBILITIES

The Contractor shall maintain the works on a regular and systematic basis in compliance with maintenance requirements set forth in this document.

- Client will provide administrative support. Rest all Responsibility lies with the Contractor.
- The contractor shall ensure satisfactory maintenance of the whole works so that the entire infrastructure system operation provides reliable, consistent performance and is economical at all times.

DEFINITION OF MAINTENANCE

Maintenance covers all the techniques and systems which, by means of regular monitoring of equipment and scheduled maintenance procedures, prevent failures and, in the event of problems, enable repairs to be carried out with the minimum disruption of the process. Maintenance is therefore a combination of technical, administrative, and management activities. Maintenance consists of preventive and corrective procedures.

PREVENTIVE MAINTENANCE

Preventive maintenance consist of all the regular work carried out in order to sustain the conditions necessary or smooth operation of the plant and to keep the performance of the equipment as close as possible to its original performance level. Its purpose is to reduce the probabilities of failure or deterioration of equipment of the plant. In simple terms, preventive maintenance involves the elementary operations such as lubrication, mechanical servicing, electrical and instrumentation servicing.

CORRECTIVE OR REMEDIAL MAINTENANCE

Corrective or remedial maintenance consists of all work needed to re-establish the conditions necessary for an apparatus or set of equipment to operate properly subsequent to failure or deterioration of the results produced by the equipment.

It includes the following operations,

- Dismantling or equipment,
- Replacement of parts

The work may be scheduled for the short or medium term in accordance with the checks carried out as part of the preventive maintenance procedure, the number of hours an

apparatus has been operating, or an alarm factor (abnormal noise, repeated cut-out, weakening of the insulation, etc), or may be dictated by an unexpected breakdown.

- **Maintenance work**

The work consists of inspection work and maintenance work as mentioned below:

- Inspection work includes physical appearance, inspection and measurement with testing equipment to verify and survey that the entire infrastructure components' performance operation is normal or not.
- The inspection work shall be daily executed by each technical specialist as a routine and / or regular inspection and shall be recorded every each time. The evaluation on the collected data shall be immediately reviewed by the chief operational engineer to instruct the staff member for operation on the same day and /or make a plan of detail inspection and/or make repair schedule to make sure continuous plant operation without any problem.
- Maintenance work, for which main task-work shall include activities, such as lubrication, overhaul, replacement of parts, repair, adjustment, detail examination and test, cleaning, to maintain the system in a good condition, performance consistent and low cost operation based on a regular and preventive maintenance schedule including attending sudden Equipment breakdown and to achieve high operational efficiency.

SPECIFICATIONS

The specification of materials used for repairs shall be the same as have been used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to commencement of the maintenance period and must be incorporated in the O&M manual. Without being limited by this clause, during Maintenance period the Contractor shall use appropriate material for repairs even if material required for such repairs has not been approved earlier, and no delay in making such repairs shall be subjected to such limitation. However, subsequent to use of such material the Contractor shall submit proposals for the approval of specifications of such material. The approved material will subsequently form a part of the O&M manual. The comprehensive information as detailed in Table A shall be submitted to the Engineer.

SCHEDULE F – APPLICABLE PERMITS

(See Clause 3.1.7 (a))

1. APPLICABLE PERMITS

The Contractor shall obtain, as required under the Applicable Laws, the following Applicable Permits:

- a) Permission of the State Government for extraction of boulders from quarry;
- b) Permission of Village Panchayat and Pollution Control Board for installation of crushers;
- c) License for use of explosives;
- d) Permission of the State Government for drawing water from river/reservoir;
- e) License from inspector of factories or other competent authority for setting up batching plant;
- f) Clearance of Pollution Control Board for setting up batching plant;
- g) Clearance of Village Panchayats and Pollution Control Board for setting up asphalt plant;
- h) Permission of Village Panchayats and State Government for borrow earth;
- i) All statutory permissions and approvals from Village Panchayats and State Government in respect of RCC ducts for power supply network (including for safety etc.);
- j) Any other permits, clearances, or approvals required under Applicable Laws.

Applicable permits, as required, relating to environmental protection and conservation shall have been procured by the EMPLOYER in accordance with the provisions of this Agreement.

SCHEDULE G – FORM OF BANK GUARANTEE

(See Clause 7.1.1, 7.5.3 and 19.2)

Annexure I – Performance Security

(See Clause 7.1.1)

.....

Employer.....,
New Delhi-110001, India

WHEREAS:

- (A) -----[name and address of contractor] (hereinafter called “the Contractor”) and [name and address of the EMPLOYER], (“the EMPLOYER”) have entered into an agreement (the “Agreement”) for the work of “Design & Construction of Roads & Services/Utilities for Integrated Manufacturing Cluster (IMC) at Hisar in Haryana under Amritsar Kolkata Industrial Corridor (AKIC) Project on Engineering, Procurement and Construction (EPC) basis” on Engineering, Procurement and Construction (“EPC”) basis, subject to and in accordance with the provisions of the Agreement.
- (B) The Agreement requires the Contractor to furnish a Performance Security for due and faithful performance of its obligations, under and in accordance with the Agreement, during the Construction Period and Defects Liability Period (as defined in the Agreement) in a sum of Rs. Crore (Rupees Crore) (the “Guarantee Amount”).
- (C) We, ...through our branch at (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) by way of Performance Security.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful performance of the Contractor’s obligations during and under and in accordance with the Agreement, and agrees and undertakes to pay to the Employer, upon its mere first

- written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.
2. A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.
 3. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
 4. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
 5. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Agreement or to extend the time or period for the compliance with, fulfillment and/or performance of all or any of the obligations of the Contractor contained in the Agreement or to postpone for any time, and from time to time, any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released

from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Agreement or for the fulfillment, compliance and/or performance of all or any of the obligations of the Contractor under the Agreement.
7. Notwithstanding anything contained herein before, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The Performance Security shall cease to be in force and effect, 3 months after completion of the Defects Liability Period as set forth in Clauses 7.1
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.

11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end **** month in the year ***** or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this day of 20..... at

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (i) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annexure II – Form for Guarantee for Withdrawal of Retention Money

(Schedule-G)

(See Clause
7.5.3)

.....,
EMPLOYER,
New Delhi-110001, India

WHEREAS:

[Name and address of contractor] (hereinafter called “the Contractor”) has executed an agreement (hereinafter called the “Agreement”) with the [name and address of the EMPLOYER], (hereinafter called “the EMPLOYER”) for the “**Design & Construction of Roads & Services/Utilities for Integrated Manufacturing Cluster (IMC) at Hisar in Haryana under Amritsar Kolkata Industrial Corridor (AKIC) Project on Engineering, Procurement and Construction (EPC) basis**” on Engineering, Procurement and Construction (the “EPC”) basis, subject to and in accordance with the provisions of the Agreement.

- a. in accordance with the Clause 19.18 of the Agreement, whenever the amount of the retention money (hereinafter called “Retention Money”) held by the EMPLOYER exceeds 1% (one per cent) of the Contract Price, the Contractor may, at its option, withdraw the Retention Money after furnishing to the EMPLOYER a bank guarantee for an amount equal to the proposed withdrawal.
- b. We, ...through our branch at (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) for the amount of Rs. (..... in words) (the “**Guarantee Amount**”).

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably undertakes to pay to the

EMPLOYER, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the Guarantee Amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

2. A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER

and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.

3. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Retention Money and any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference

to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Retention Money.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The guarantee shall cease to be in force and effect 90 (ninety) days after the end of the Completion Period specified in Clauses 17.1 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect up to the end **** month in the year ***** or until it is released earlier by the

EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this day of 20..... at

SIGNED, SEALED AND DELIVERED

For and on behalf of the Bank by:

(Signature)

(Name)

(Designation)

(Code Number)

(Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

Annexure III – Form for Guarantee for Advance Payment

(Schedule-G)

(See Clause 19.2)

.....,
..... EMPLOYER,
New Delhi-110001, India

WHEREAS:

- (A) [name and address of contractor] (hereinafter called “the Contractor”) has executed an agreement (hereinafter called the “Agreement”) with the [name and address of the EMPLOYER], (hereinafter called “the EMPLOYER”) for the **“Design & Construction of Roads & Services/Utilities for Integrated Manufacturing Cluster (IMC) at Hisar in Haryana under Amritsar Kolkata Industrial Corridor (AKIC) Project on Engineering, Procurement and Construction (EPC) basis”** on Engineering, Procurement and Construction (the “EPC”) basis, subject to and in accordance with the provisions of the Agreement.
- (B) in accordance with the Clause 19.2 of the Agreement the EMPLOYER shall make to the Contractor an interest bearing advance payment (hereinafter called “Advance Payment”) equal to 10% (ten per cent) of the contract price for mobilization expenses and acquisition of equipment; and that the Advance Payment shall be made in three installments subject to the Contractor furnishing an irrevocable and unconditional guarantee by a scheduled bank for an amount equal to the 110% amount of each installment to remain effective till the complete and full repayment of the installment of the Advance Payment as security for compliance with its obligations in accordance with the Agreement; and the amount of (first/second/third) installment of the Advance Payment is Rs. **** cr. (Rupees ***** crore) (the “Guarantee Amount”).
- (C) We, ...through our branch at (the “Bank”) have agreed to furnish this bank guarantee (hereinafter called the “Guarantee”) for the Guarantee Amount.

NOW, THEREFORE, the Bank hereby, unconditionally and irrevocably, guarantees and affirms as follows:

1. The Bank hereby unconditionally and irrevocably guarantees the due and faithful repayment on time of the aforesaid installment of the Advance Payment under and in accordance with the Agreement, and agrees and undertakes to pay to the EMPLOYER, upon its mere first written demand, and without any demur, reservation, recourse, contest or protest, and without any reference to the Contractor, such sum or sums up to an aggregate sum of the guarantee amount as the EMPLOYER shall claim, without the EMPLOYER being required to prove or to show grounds or reasons for its demand and/or for the sum specified therein.

2. A letter from the EMPLOYER, under the hand of an officer not below the rank of [.....of EMPLOYER], that the Contractor has committed default in the due and faithful performance of all or any of its obligations for the repayment of the installment of the Advance Payment under and in accordance with the Agreement shall be conclusive, final and binding on the Bank. The Bank further agrees that the EMPLOYER shall be the sole judge as to whether the Contractor is in default in due and faithful performance of its obligations during and under the Agreement and its decision that the Contractor is in default shall be final, and binding on the Bank, notwithstanding any difference between the EMPLOYER and the Contractor, or any dispute between them pending before any court, tribunal, arbitrators or any other authority or body, or by the discharge of the Contractor for any reason whatsoever.
3. In order to give effect to this Guarantee, the EMPLOYER shall be entitled to act as if the Bank were the principal debtor and any change in the constitution of the Contractor and/or the Bank, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the Bank under this Guarantee.
4. It shall not be necessary, and the Bank hereby waives any necessity, for the EMPLOYER to proceed against the Contractor before presenting to the Bank its demand under this Guarantee.
5. The EMPLOYER shall have the liberty, without affecting in any manner the liability of the Bank under this Guarantee, to vary at any time, the terms and conditions of the Advance Payment or to extend the time or period of its repayment or to postpone for any time, and from time to time, any of the rights and powers exercisable by the EMPLOYER against the Contractor, and either to enforce or forbear from enforcing any of the terms and conditions contained in the Agreement and/or the securities available to the EMPLOYER, and the Bank shall not be released from its liability and obligation under these presents by any exercise by the EMPLOYER of the liberty with reference to the matters aforesaid or by reason of time being given to the Contractor or any other forbearance, indulgence, act or omission on the part of the EMPLOYER or of any other matter

or thing whatsoever which under any law relating to sureties and guarantors would but for this provision have the effect of releasing the Bank from its liability and obligation under this Guarantee and the Bank hereby waives all of its rights under any such law.

6. This Guarantee is in addition to and not in substitution of any other guarantee or security now or which may hereafter be held by the EMPLOYER in respect of or relating to the Advance Payment.
7. Notwithstanding anything contained hereinbefore, the liability of the Bank under this Guarantee is restricted to the Guarantee amount and this Guarantee will remain in force for the period specified in paragraph 8 below and unless a demand or claim in writing is made by the EMPLOYER on the Bank under this Guarantee all rights of the EMPLOYER under this Guarantee shall be forfeited and the Bank shall be relieved from its liabilities hereunder.
8. The guarantee shall cease to be in force upto the end of the original Completion Date of the contract, as set forth in Clause 19.2.6 of the Agreement.
9. The Bank undertakes not to revoke this Guarantee during its currency, except with the previous express consent of the EMPLOYER in writing, and declares and warrants that it has the power to issue this Guarantee and the undersigned has full powers to do so on behalf of the Bank.
10. Any notice by way of request, demand or otherwise hereunder may be sent by post addressed to the Bank at its above referred branch, which shall be deemed to have been duly authorized to receive such notice and to effect payment thereof forthwith, and if sent by post it shall be deemed to have been given at the time when it ought to have been delivered in due course of post and in proving such notice, when given by post, it shall be sufficient to prove that the envelope containing the notice was posted and a certificate signed by an officer of the EMPLOYER that the envelope was so posted shall be conclusive.
11. This Guarantee shall come into force with immediate effect and shall remain in force and effect for up to the end **** month in the year ***** or until it is released earlier by the EMPLOYER pursuant to the provisions of the Agreement.

Signed and sealed this day of 20..... at

SIGNED, SEALED AND

DELIVERED For and on behalf of

the Bank by: (Signature)

(Name)

(Designation)

(Code

Number)

(Address)

NOTES:

- (i) The bank guarantee should contain the name, designation and code number of the officer(s) signing the guarantee.
- (ii) The address, telephone number and other details of the head office of the Bank as well as of issuing branch should be mentioned on the covering letter of issuing branch.

SCHEDULE H. TESTS ON COMPLETION

1.0 SCHEDULE FOR TESTS

The Contractor shall, no later than 30 (thirty) days prior to the likely completion of construction, notify the Employer's Engineer and the Employer of its intent to subject the project components to Tests, and no later than 10 (ten) days prior to the actual date of Tests, furnish to the Employer's Engineer and the Employer detailed inventory and particulars of all works and equipment forming part of Works.

The Contractor shall notify the Employer's Engineer of its readiness to subject the project components to Tests at any time after 10 (ten) days from the date of such notice, and upon receipt of such notice, the Employer's Engineer shall, in consultation with the Contractor, determine the date and time for each Test and notify the same to the Employer who may designate its representative to witness the Tests.

2.0 TESTS

Visual and physical test: The Employer's Engineer shall conduct a visual and physical check of construction to determine that all works and equipment forming part thereof conform to the provisions of this Agreement.

Riding quality test: Riding quality of each lane of the carriageway shall be checked with the help of a calibrated bump integrator and the maximum permissible roughness for purposes of this Test shall be 1800 (Eighteen Hundred) mm for each kilometer.

Water Tightness test: All hydraulic structures, such as sewer lines network, joints, manholes etc. or any other liquid containers shall have to be tested for water tightness. The water tightness test shall be conducted as specified in IS: 4127-1967.

Water Tightness test for Manhole: The entire height of the manhole shall be tested for water tightness as per CPHEEO Manual, by closing both the incoming and outgoing ends of the sewer/industrial and filling the manhole with water and the drop in water level not more than 50 mm per 24 hours shall be permitted.

Hydraulic Test: Fill the pipeline with water after it has been laid; bleed off any trapped air. Subject the lowest element in the system to a test pressure that is 1.5 times the design pressure, and check for any leakage. When, in the opinion of the engineer, local conditions require that the trenches be backfilled immediately after the pipe has been laid, apply the pressure test after backfilling has been completed but not sooner than a time which will

allow sufficient curing of any concrete that may have been used. Typical minimum concrete curing time are 36 hours for early strengths and 7 days for normal strengths.

Water Tightness test for GSR:- The contractor shall be fully responsible for the water tightness of the tank, the tank shall be taken as water tight of the depression in water level after filling the tank of full supply level not more than 12.20 mm in 24 Hrs. and no leakages are observed.

Visual and physical test for Street lighting system covering pole, luminaire, power supply, grounding, communication between luminaire to control panel and central control system. Installation testing including lighting performance verification.

Other tests: The Employer's Engineer may require the Contractor to carry out or cause to be carried additional tests, in accordance with Good Industry Practice, for determining the compliance of the project components with Standards and Specifications.

Environmental audit: The Employer's Engineer shall carry out a check to determine conformity of the project components with the environmental requirements set forth in Applicable Laws and Applicable Permits.

Safety Audit: The Employer's Engineer shall carry out, or cause to be carried out, a safety audit to determine conformity of the project components with the safety requirements and Good Industry Practice.

3.0 AGENCY FOR CONDUCTING TESTS

All Tests set forth in this Schedule-K shall be conducted by Contractor or such other agency or person as it may specify in consultation with the Employer's Engineer/Employer.

4.0 COMPLETION CERTIFICATE

Upon successful completion of Tests, the Employer's Engineer shall issue the Completion Certificate in accordance with the provisions of this document.

5.0 CIVIL

5.1 TESTS ON COMPLETION

5.1.1 Hydraulic Testing of Liquid Retaining Structures

In addition to the structural test of structures, the liquid retaining structures shall also be tested for water tightness test at full supply level as described in 12.1.1 and 12.1.2 of latest revision of IS 3370 (Part I).

On completion of the structure and before its commissioning, the contractor shall carry out a water tightness test for the maximum water head condition i.e. with the water standing at Full Supply Level (FSL). This test shall be carried out preferably in dry season in accordance with the procedure given below:

The water tightness test shall be carried out when the construction of liquid retaining structure is completed and when it is possible to fill the structure and ensure that uniform settlement of the structure as a whole or as directed by the Engineer. Before the filling operations are started the structure shall be inspected by the Engineer and the Contractor's Representative and the condition of surfaces of walls, contraction joints shall be noted, and it shall be ensured that the jointing material filled in the joint is in position and all openings are closed. The Contractor shall make necessary arrangement for ventilation and lighting of the structure by way of floodlights, circulators etc. for carrying out proper inspection of the surfaces and inner conditions if so desired by the Employer. Records of leakages starting at different levels of water in the reservoir, if any, shall be kept.

The liquid retaining structure once filled shall be allowed to remain so for a period of seven days before any readings of drop in water level are recorded. The level of the water shall be recorded against the subsequent intervals of 24 hours over a period of seven days. The total drop in surface level over a period of seven days shall be taken as an indication of the water tightness of the structure, which for all practical purposes shall not exceed 20 mm. Also there shall be no indications of the leakages around the opening or on the walls.

If the structure does not satisfy the condition of test and the daily drop in water level is decreasing, the period of test may be extended for a further period of seven days and if the specified limit is then reached the structure may be considered as satisfactory.

The external faces of structure shall not show any signs of leakage and shall remain apparently dry over the period of observation of seven days after allowing a seven day period for absorption after filling.

In case the drop in level exceeds the permissible level limit and signs of leakage with the stipulated period of test, the Contractor shall carry out such additional works and adopt such measures as may be directed by the Engineer to reduce the leakage within the permissible limits. The entire rectification work that shall be carried out in this connection shall be at the Contractor's cost. The water required for subsequent testing shall be supplied to the Contractor free of cost, if the same is available near the site. Contractor shall have to make arrangement for filling emptying the structure at his own cost.

If the test results are unsatisfactory, the Contractor shall ascertain the cause and make all necessary repairs and repeat the water retaining structures test procedures, at his own cost. Should the re-test results still be unsatisfactory after the repairs, the structure will be condemned, and the Contractor will dismantle and reconstruct the structure, to the original specification, at his own cost.

During testing and during defect liability period the impression marks created due to seepage shall be rectified and made good.

No separate payment shall be made for water tightness test and the cost thereof shall deemed to be covered in the rates quoted for the works.

6.0 WATER SUPPLY

6.1 HYDRAULIC TESTING OF PIPE LINES

The testing conditions for the pipelines are summarized as follows:

- Maximum hydrostatic test pressure for HDPE pipes shall be 12.0 Kg/sq cm.
- Maximum hydrostatic test pressure for DI K-7 pipes shall be 10.0 Kg/sqcm.
- RCC and DWC pipes shall be tested as specified in the relevant IS codes
- Pressure test with addition of make-up water
 - Pressure: Test pressure
 - Duration: 3 hrs
- Test criteria for DI/HDPE/DWC/RCC pipes: $Q = 1.0$ litre per km per 10mm of pipe per 30 m test pressure per 24 hrs.

All pressure testing at site should be carried out hydrostatically. The pipes shall be accepted to have passed the pressure test satisfactorily, if the quantity of water required to restore the test pressure does not exceed the amount 'Q', calculated by the above formula.

If it is required to test a section of a pipe line with a free end, it is necessary to provide temporary support against the considerable end thrust developed by the application of the test pressure. The end support can be provided by inserting a wooden beam or similar strong material in a short trench excavated at right angle to the main trench and inserting suitable packing between the support and pipe end.

On completion of a satisfactory test any temporary anchor blocks shall be broken out and stop ends removed. Backfilling of the pipeline shall be completed.

6.2 FAILURE TO PASS THE TESTS

All pipes or joints which are proved to be in any way defective shall be replaced or remade and re-tested as often as may be necessary until a satisfactory test shall have been obtained. Any work which fails or is proved by test to be unsatisfactory in any way shall be redone by the Contractor.

7.0 MECHANICAL WORKS

7.1 SITE ACCEPTANCE TEST DOCUMENT

Fifty six (56) days prior to commencement of Tests on Completion the Contractor shall supply a Site Acceptance Test (SAT) Document for approval. This shall comprise four copies of the details of the inspection and test procedures to be carried out in testing the Works.

The SAT Plan shall provide comprehensive details of the tests to be carried out, the purpose of each test, duration of test, tolerance limits, the equipment to be used in carrying out the test and the methods to be adopted in carrying out the tests. The SAT shall provide space within the documentation for results of the tests to be added and for each test and for the SAT as a whole to be signed off by the Contractor and the Engineer.

The SAT shall categorise tests as follows:

- Dry tests;
- Wet tests which can be further sub-divided into:
- Hydraulic tests;
- Process tests.

Dry tests are those tests carried out without process fluid being present. Hydraulic wet tests are those tests carried out with water in order to prove the hydraulic capability of the Works. Process wet tests are those tests carried out with water as the feed stock to prove the process capability of the Works. All dry tests and wet tests shall comply with relevant approved International standard / code. It shall be assumed that the co-operation of other contractors in the carrying out of Tests on Completion will not be unreasonably withheld.

7.2 TESTS ON COMPLETION

7.2.1 General

The purpose of Tests on Completion shall be to demonstrate and confirm that the Works can fulfil all the mechanical, electrical and process requirements of the Specification. Commissioning Tests which shall be deemed to be the "Tests on Completion" shall be carried out.

Prior to the commencement of Tests On Completion the Contractor shall submit for approval the following:

- Site Acceptance Test Documents;
- As-Built Drawings;
- Operation and Maintenance Manuals.

Tests on Completion shall not be commenced until the aforementioned documents are approved. The initial charges of oil, grease, generator fuel oil etc. necessary for Tests on Completion shall be kept ready and to be provided by the Contractor.

The cost of chemicals used for the Tests on Completion shall be met by the Contractor. The inspection and tests which will be carried out shall consist of the following:

- Manual Commissioning Tests (Clause i)
- Manual Operation Tests (Clause ii)
- Automatic Commissioning Tests (Clause iii)

All pipe work shall be hydrostatically tested at site to a pressure equal to minimum 1.5 times the maximum working pressure likely to be encountered in the system.

The Contractor shall carry out all tests on the Plant and shall supply four copies of all test results to the Engineer. The test report shall include recordings of power and plant performance/ behaviour pattern. All tests shall be to the approval of the Engineer who may require them to be repeated, prolonged or modified as may be necessary to ensure that any or all items of Plant conform with the Contract.

All measuring instruments used for these tests shall have previously been certified by an independent testing authority like IDEMI/ERTL or as approved by Engineer. For tests on Main Pumps and Main Motors the above certification can be carried out not more than one month prior to the test and to the satisfaction of the Engineer. The Engineer reserves the right to impound any instrument for further verification before approving the test results.

For tests on all equipment, instruments calibration shall comply with the following:

- a) For companies having ISO certification

The calibration and its validity for the instruments shall be as per the relevant procedures for testing of the company having ISO certification.

- b) For companies not having ISO certification

The instruments used for the test shall be calibrated not more than one year prior to the test. The instrument shall have a valid calibration certificate as on the date of the test.

The Engineer shall be permitted to inspect all Plant which is undergoing tests and may himself conduct tests. Where it is necessary for the Engineer to make arrangements for the supply of water, power, etc., for any testing, the Contractor shall not commence the tests until after these arrangements have been made on or after a date agreed by the Engineer and the Contractor shall make no claim for delay to such testing on this account.

If any item of plant fails during or after testing to achieve its intended duty or otherwise proves defective, it shall be modified or altered or replaced with higher capacity/rating plant item as necessary and re-tested and re-inspected as required by the Engineer. Vibration/noise level tests shall be carried out at site which will form basis for acceptance of the equipment. If the Contractor is not in a position to meet the requirements given below as per ISO 10816 – 1995, the equipment may either be rejected or the Contractor shall carry out all necessary modifications to keep vibrations within the acceptable limits specified.

Equipment	Noise Level dBA at 1.86 m from Equipment	Velocity of Vibration mm/sec
All rotating equipment not having reciprocating parts with motor kW less than or equal to 15 kW	85	1.12
All rotating equipment having reciprocating parts with motor kW more than 15 kW and less than or equal to 75 kW	85	1.8
All rotating equipment not having reciprocating parts with motor kW greater than 75 kW	85	2.8
All equipment having reciprocating parts	85	-

The Contractor shall have a minimum of two commissioning engineers, one for system and the other for electrical/instrumentation works on site during all tests in order to both demonstrate the system and to correct any faults which may occur.

7.3 MANUAL COMMISSIONING TESTS

Manual Commissioning Tests shall be such preliminary trials, tests and retests on individual items of system or complete systems as required by the Engineer in order to demonstrate that the system as a whole is ready to undergo the Manual Operation Tests and that these will take place with minimum interruption.

The Manual Commissioning Tests shall demonstrate not only the items of system under normal operation, but also their response to abnormal and emergency conditions. The

Engineer will notify to the Contractor which items of system will be tested and the extent to which they will be tested in order to fulfill the requirements of the Specification. Leakage tests at 1.5 maximum working pressure shall be carried out on all erected pipe work prior to the Manual Commissioning Tests. Pump curves shall be available for the Manual Commissioning Tests and all instruments essential for the tests shall have been calibrated.

7.4 MANUAL OPERATION TESTS

When the Manual Commissioning Tests have been completed so that the items of system have been demonstrated to the satisfaction of the Engineer, the Contractor shall commence the Manual Operation Tests. These tests shall demonstrate the correct operation of the whole system whilst using the minimum quantity of automatic control and monitoring equipment. Such equipment shall be at least that required both for the maintenance of safety and for the normal mode of operation of the system.

The system will be required to demonstrate satisfactory operation at all design flow rates. The tests shall be of seven consecutive days' duration; if the supply of water should fail or other matters interfere outside the Contractor's control, the tests may be of such number of broken days as the Engineer considers is the equivalent. The exact date of commencement shall be subject to the approval of the Engineer and shall be dependent on the following conditions having been met:

- (i) All relevant items of system in approved working order;
- (ii) All items of system correctly identified with labels.

7.5 AUTOMATIC COMMISSIONING TESTS

The Automatic Commissioning Tests shall be such preliminary trials, tests and retests on individual items of system or complete system as are required by the Engineer in order to demonstrate that the system as a whole is ready to undergo the Tests of Completion and that these will take place with a minimum of interruption.

At least one week before the commencement of these tests, the Engineer will notify the Contractor which items of system will be tested and the extent to which they will be tested in order to fulfill the requirements of the specification.

7.5.1 Dry Test Requirements

- (iii) General

As a minimum requirement the following dry tests shall be carried out as a general requirement:

- a check on speed, rotation direction, vibration and noise level.
- a general inspection to check for correct assembly and quality of workmanship;
- a check on the presence of lubricant, cooling medium, electrolyte, etc.;
- a check on adequacy and security of Plant fixing arrangements;
- a general check to ensure that all covers, access ladders, water proofing, guard railings etc are in place;
- a check on damp-proofing, rust-proofing and vermin-proofing and particularly the sealing of apertures between building structures, chambers etc and the outside;

(i) Civil and Building Works

As a minimum requirement the following dry tests shall be carried out on the civil engineering and building works:

- check for the presence of foreign bodies in pipe work and structures.

(ii) Mechanical Works

As a minimum requirement the following dry tests shall be carried out on the mechanical systems:

- carry out preliminary running checks as far is permitted by circumstances in order to ensure smooth operation of system.

(iii) Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:

- Insulation resistance measurement of equipment, accessories, cabling/wiring etc.
- Dielectric tests on equipment, accessories, cabling/ wires etc.
- Phase sequence and polarity
- Voltage and current ratios
- Vector group
- Resistance measurement of winding, contacts etc.
- Continuity tests
- Calibration of indicators, meters, relays, etc.
- Control and interlock checks
- Settings of equipment and accessories
- Checking of accuracy/error
- Checking of operating characteristics, pick-up voltages and currents, etc.

- Operational and functional tests on equipment, accessories, control schemes, alarm/trip/indication circuits, etc.
- Measurement of guaranteed/approved design values including lighting levels, earth resistance measurement, etc.
- Complete commissioning checks of the system

(iv) Hydraulic Wet Test Requirements

Hydraulic wet tests shall be carried out on completion of dry tests and shall comply with relevant approved engineering international standard / code. Water shall be used for hydraulic wet tests. The purpose of the tests is to prove as far as is practical the hydraulic performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is hydraulically loaded to its rated throughput for a period of at least four hours.

In order to ensure a sufficient supply of water to carry out these tests the Contractor shall provide facilities for the disposal off Site in an approved manner not less one third of the Works rated output.

- In order to remove doubt the following tests inter alia shall be carried out:
- pressure testing of all piped systems laid direct in ground in accordance with the relevant standards;
- Fill all structures and check for leaks;
- Running of all pumped systems in order to check for:
 - correct functionality;
 - absence of leaks;
 - correct running temperatures
 - smoothness of running and the absence of undue vibration or stress;
- Check drive running currents.
- Carry out calibration of instruments where appropriate;
- Demonstrate correct functionality of electrical, control and instrumentation systems.
- A check on flow rate, speed, noise, vibration, water hammer, supports of pumps and pipeline.

The Contractor shall simulate where practical the conditions that will prevail when operating as a process in order to demonstrate the correct functionality of process control loops etc. During these tests a check on the performance of system shall be made, as far

as site facilities will allow, to compare its site performance with the factory test data and to identify any constraints on performance due to site conditions.

(v) Safety Audit

After satisfactory completion of hydraulic wet tests and prior to introduction of process fluid to the system a safety audit shall be carried out to ensure compliance with the necessary requirement for safety and for operation of system. The safety audit shall be documented. The safety audit document shall be approved by the Engineer.

8.0 TAKING OVER

No item of Plant will be certified for Taking Over by the Employer unless it has successfully passed one of the "Tests on Completion". A Taking over certificate for Plant shall not be issued unless 10 copies of the instruction manuals for operation and maintenance of the plant and 10 copies of all completion (As-built) drawings with soft copies of plant and civil structure have been received to the satisfaction of the Engineer. The instruction manual complete including SCADA system for operation and maintenance of plants shall be in two parts:

Part I

It should detail operation of entire system giving sequence of operation, DO's and DONT's very clearly specified. The operation manual shall be user friendly so as to guide the operator faultlessly in operating the system.

Part II

It should deal with maintenance of each component of the system, sub-system etc. in full details giving details of construction, material, manufacturer's item code No., dismantling and assembly procedures, dimensions, routine checks to be carried out, signals and observation by predictive maintenance gadgets that can prompt maintenance, overhauling of sub-systems/systems. The drawings shall give complete details of the systems, sub-systems like dimensions cross-sectional views, assembly details, photos etc. Maintenance schedules as specified by the manufacturers for each component of the system and for entire system shall be furnished.

Taking over Certificate may be issued for sections of the system; these will not be issued for individual items of plant, but only for complete system as the Engineer decides if appropriate. A Taking Over Certificate defines the start of the Maintenance period but its issue does not relieve the Contractor of his obligation to complete commissioning.

The Engineer may be by agreement with the Contractor, agree upon a single commencing date for the commencement of the Maintenance Period for the whole of the Works. The 2nd season Test on Completion shall be carried out in the Maintenance Period. In case of failure of the plant to pass the 2nd test, the Contractor shall carry out all required modifications in the plant in order to achieve the guaranteed performance requirements, at his own cost. The plant shall subsequently be re-tested under the relevant season and the performance confirmed.

9.0 MAINTENANCE PERIOD

The Maintenance Period defined in conditions of contract shall commence from the date of issue of the Taking over Certificate. Notwithstanding the foregoing the Engineer may, by agreement with the Contractor, agree upon a single commencing date for the commencement of the Maintenance Period for the whole of the Works.

10.0 PERFORMANCE CERTIFICATE

The conditions for issuance of a Performance Certificate as detailed in the Conditions of Contract shall inter alia comprise:

- the completion of maintenance of the Works to the satisfaction of the Engineer;
- the O & M Manuals have been updated following operational experience and as approved by the Engineer;
- all defects identified prior to Taking Over and defects identified during the maintenance of the Works have been rectified;
- all Tests After Completion have been completed to the satisfaction of the Engineer;
- all training detailed in the Employer's Requirements has been completed.

11.0 SEWERAGE SYESTEM

11.1 TESTING AT WORK SITE- CONCRETE PIPES

I. Sampling and inspection

- In any consignment, all the pipes of same class and size and manufactured under similar conditions of production shall be grouped together to constitute a lot. The conformity of a lot to the requirements of this Specification shall be ascertained on the basis of tests on pipes selected from it.
- The number of pipes to be selected from the lot shall be in accordance with column 1 and 2 of Table 9 of IS: 458.
- Pipes shall be selected at random. In order to ensure randomness, all the pipes in the lot may be arranged in a serial order and starting from any pipe, every "rth" pipe be

selected till the requisite number is obtained, “r” being the integral part of N/n where “N” is the lot size and “n” is the sample size.

- The number of pipes selected for testing shall be in accordance with Table 15 of IS: 458 and tested in accordance with methods described in IS: 3597. These pipes shall be selected from pipes that have satisfied the requirements mentioned in the above clause. All the pipes shall be inspected for dimensional requirements, finish and deviation from straight. A pipe failing to satisfy one or more of these requirements shall be considered as defective.
- A lot shall be considered as conforming to the requirements of IS: 458 if the following conditions are satisfied.
- The number of defective pipes (those not satisfying one or more of the requirements for dimensions, finish and deviation from straight) shall not be more than the permissible number given in Column 3 of Table 9 / 15 of IS: 458.
- All the pipes tested for various tests as per IS: 3597 shall satisfy corresponding requirements of the tests.
- In case the number of pipes not satisfying requirements of any one or more tests, one or two further sample of same size shall be selected and tested for the test or tests in which failure has occurred. All these pipes shall satisfy the corresponding requirements of the test.
- All result of tested data must be prepared by CONTRACTOR at site so that the ENGINEER-IN-CHARGE shall make decision of “fail or pass” at once. All cost for the test shall be borne by the CONTRACTOR.

II. Storage

Each stack of pipes shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible. Storage shall be done on firm level and clean ground and wedges shall be provided at the bottom layer to keep the stack stable. The stack shall be in pyramid shape or the pipes lay lengthways and crosswise in alternate layers. The pyramid stack shall be made for smaller diameter pipes for conserving space in storing them. The height of the stock shall not exceed 1.5 m.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals.

III. Leakage test before commissioning

After laying and jointing of pipes is completed the pipe line shall be tested at work site as per the following Specifications and as directed by ENGINEER-IN-CHARGE. All

equipment for testing at work site shall be supplied and erected by the CONTRACTOR and shall be rectified by him / her to the full satisfaction of ENGINEER-IN-CHARGE. Water used for test shall be removed from pipes and not released to the excavated trenches.

After the joints have been thoroughly jointed and have been checked by ENGINEER-IN-CHARGE and before backfilling the trenches, the entire section of the pipeline shall be proved by CONTRACTOR to be water tight by filling in pipes with water at a Constant Head of 2.5m above the top of the highest pipe in the stretch and heading the water up for the period of one hour. The testing apparatus used for the purpose shall normally be fixed on the upstream end and should be got approved by ENGINEER-IN-CHARGE. CONTRACTOR if required by ENGINEER-IN-CHARGE shall dewater the excavated pit and keep it dry during the period of testing. The loss of water over a period of 30 minutes should be measured by adding water from a measuring vessel at regular intervals (not more than 1 minute) and noting the quantity of water required to maintain the original water level. Any leakage including excessive sweating which causes a drop in the test water level will be visible and the defective part of the work should be removed and made good.

All of results of test and inspection data must be prepared by CONTRACTOR at site so that the ENGINEER-IN-CHARGE shall make decision of “fail or pass” at once. All cost for the inspection shall be borne by the CONTRACTOR.

IV. SEWER MANHOLE

The entire height of the manhole shall be tested for water tightness by closing both the incoming and outgoing ends of the sewer and filling the manhole with water and drop in water level not more than 50mm per 24 hours shall be permitted. The CONTRACTOR at his own cost shall arrange the required water for testing and other requirements.

SCHEDULE I- INSURANCE

- 1. Insurance:** Already specified in Volume-1 of Tender document

SCHEDULE J- GUIDELINES FOR HEALTH SAFETY & ENVIRONMENT PLAN

1.0 HEALTH, HYGIENE AND CONTAMINATION OF WATER SUPPLIES

The Site shall be an area of 'restricted operation'. Exemptions may be granted at the discretion of the Employer for short-term operations involving no risk of contamination.

- (a) All personnel shall be medically accepted.
- (b) Strict discipline shall be maintained concerning personal hygiene.
- (c) Vehicles, plant, tools and protective clothing shall be kept clean and may require regular disinfection.

To obtain medical acceptance, the Contractor shall require his employees and those of his sub-contractors to undergo medical screening, to ensure that they are not harboring waterborne pathogenic organisms, before commencing 'restricted operations'. It will be necessary for all potential employees and supervisors who may have contact with the 'restricted operations' to take a copy of the completed questionnaire together with two color passport size photographs to the Medical Officer for Environmental Health of the District Health Authority where the person resides. The Medical Officer shall consult the person and return the questionnaire to the Contractor. The Contractor shall then forward the questionnaires and photographs of those he wishes to employ to the Employer for approval. Approval in the form of a blue identity card shall be issued in the approved cases. The card is valid for the duration of the Contract or one year whichever is lesser. Contracts of duration greater than one year of 'restricted operations' carried out in the maintenance period will require reassessment of employees.

Should an employee contract any illness, looseness of bowels or gastric disorder he must immediately cease work on 'restricted operations', return his identity card, avoid contact with other employees, undergo medical screening and gain fresh approval before continuing work on the 'restricted operations' site. Works involving both 'restricted' and non-restricted operations shall either require (1) all employees to be medically accepted or (2) separate messing facilities, storage for protective clothing, tools, vehicles and plant for the two types of employees.

2.0 SAFETY AND SECURITY ON SITE

The Contractor shall at all times maintain a safe system of working and shall comply with all enactments, regulations and working rules relating to safety, security, health and welfare of all persons who may be affected by his work.

In particular he shall ensure that only persons who are properly trained for their duties are employed, and that the correct tools and procedures are used.

Nothing which has been written into or omitted from this Employer's Requirements shall be taken to relieve the Contractor from his obligations under this clause. No clause in this Employer's Requirements shall prevent the Contractor from drawing the attention of the Employer's Engineer to any feature of the Works which is not consistent with normal safety practices nor prevent him putting forward proposals at any time which would increase the safety of the installations. Not later than four weeks before work commences on the Site, the Contractor shall submit to the Employer his comprehensive proposals relating to the safety, health and welfare of all his personnel on the Site.

The Contractor shall appoint a suitably qualified representative as Safety Officer who shall be responsible for the implementation of site procedures as per relevant standards which shall include but not be limited to:

- (a) safety;
- (b) working in hazardous areas;
- (c) permit to work;
- (d) fire and smoking regulations;
- (e) first aid;
- (f) warning signs;
- (g) trenching scaffolding and other construction structures;
- (h) safety barriers;
- (i) protective clothing and equipment;
- (j) safety training;
- (k) safety meetings and inspections;
- (l) health and welfare.

The proposals shall be appropriate for all grades of labor and personnel who will work on or visit the Site on behalf of the Employer or Contractor.

The Employer's Engineer shall have the power to stop any activity or work in any area where there is a breach of the published site safety rules such that health or life is put at risk. The Contractor shall, in addition, comply with the Safety Policy of the Employer. The Contractor shall ensure that all other contractors working on the Site are not working in an unsafe manner so as to endanger themselves, the Contractors

personnel, other personnel or the Plant. The Contractor shall bring any violation of Site safety rules by others to the attention of Employer in writing.

3.0 FIRST AID AND LIFE-SAVING APPARATUS ON SITE

The Contractor shall provide on the Site such life-saving apparatus as may be appropriate and an adequate and easily accessible first aid outfit or such outfits as may be required in any government ordinances, factories acts, etc, published and subsequently amended from time to time. In addition, an adequate number of persons permanently on the Site shall be instructed in their use, and the persons so designated shall be made known to all employees by the posting of their names and designations in a prominent position on Site

4.0 ELECTRICAL SAFETY ON SITE

The Contractor shall be responsible for the electrical safety of all Plant supplied and installed. Whilst any equipment is being installed or tested, the Contractor shall ensure that all necessary precautions are taken to safeguard personnel working on site. If necessary, this shall include fencing off areas which are considered to pose a risk, and erecting warning notices.

The Contractor shall be responsible for ensuring that the electrical installation is carried out by suitably trained competent personnel and that the work is carried out in a safe manner.

The Contractor shall be responsible for the operation on the Site of a permit to work system during the period of electrical equipment installation and testing. This system shall regulate the installation, the energisation and the use of electrical Plant installed and the method of work adopted.

5.0 NOISE

The Contractor shall ensure that the operations entailed in the construction of the Works do not cause annoyance to others working on the Site or to persons living adjacent to the Site.

6.0 WARNING AND SAFETY SIGNS

During construction of the Works statutory safety signs, shall be adequately provided throughout the Works, both indoors and outdoors. These safety signs shall cover mandatory, prohibition, warning, emergency, fire-fighting and general notices. All signs shall be positioned around the Works at highly visible points. Provision of signs

and the positions of signs shall be subject to the Employer's approval. Special attention shall be given to areas designated hazardous

7.0 ENVIRONMENTAL PROTECTION

The Contractor shall minimize, as far as is practically possible, the effects of all his and his Subcontractors' activities upon the environment and shall implement and monitor measures to prevent:

- (a) Contamination of surfaces, ground, groundwater, surface water and rivers,
- (b) Emissions to air, including smells, gases, smoke, and dust.
- (c) Unsanitary or unsafe storage or discharge to drain, sewer and surface waters,
- (d) Unsanitary or unsafe storage or discharge of solid wastes,
- (e) Noise,
- (f) Visual intrusion, and
- (g) Excessive energy and water consumption.

These requirements shall be met through the constant and careful attention of the Contractor's management of all Site and off-site activities, and by instruction to all staff and labor in these matters. The Contractor shall appoint an Environmental Control Manager for the Works, who shall be responsible for preparing an Environmental Management Plan and ensuring its implementation by the Contractor after obtaining approval of the Employer.

Implementation shall include for monitoring and reporting on the results of the above measures. Monitoring reports shall be in writing and submitted on a monthly basis as part of the monthly report referred to above. The report shall include a listing and summary of daily monitoring results on all aspects listed above. All potentially affected areas of the Site, other areas used for or affected by the works and all adjacent or affected waterways shall be monitored and where instructed by the Employer tested. The Environmental Management Plan (EMP) shall identify the potential environmental impacts from various construction and operations and maintenance activities to be undertaken in the Contract and set out in detail the approach he will adopt in mitigating these environmental impacts to ensure that the residual impacts are minor and confined to a short period. The EMP shall consider but not be limited to the following:

- The methods of materials delivery, storage, usage and disposal; equipment usage; and site activities to ensure they have minimal impact on the environment,
- Only environmentally safe products and practices shall be adopted in performing his works, and
- The Contractor shall comply with all of the statutes regarding environmental effects.

The EMP shall provide separate descriptions of its proposals for minimizing any adverse environmental impacts / effects during the construction phase and subsequent operations and maintenance phase. The EMP shall be provided in draft form within 28 days from the Notice to Commence, and shall be updated from time to time by the Contractor as agreed or required by the Employer to ensure the objectives of environmental protection are fully met.

8.0 SAFETY PLAN

The Contractor shall prepare a Safety Plan and submit the same to the Employer for review within 28 days of receiving the Notice to Commence. The Safety Plan shall be followed at all times by the Contractor and shall contain adequate control measures, in accordance with the relevant protection of property and local laws and regulations as well as internationally accepted good practice, for the prevention of accidents, fires and public nuisance. The Safety Plan shall be implemented properly and diligently throughout the execution of the Works.

Contractor's Safety Plan shall make safety provision for, among other things:

- (a) The Deep excavations and collapsing sides in trench excavations,
- (b) Scaffolds and overhead working,
- (c) Working in confined spaces,
- (d) Working in water,
- (e) Contractor's Equipment, especially cranes,
- (f) Hand held power tools,
- (g) Electrical equipment,
- (h) Hazardous chemicals, gases and fuels,
- (i) The use of protective clothing, and
- (j) The provision of first aid facilities.

The Safety Plan shall be developed to ensure zero fatal accidents and zero hazardous incidents / occurrences in all construction works. The Safety Plan shall include descriptions of the company's standard policies and procedures regarding its site organization and procedures, methods and frequency of conducting safety audits at the Site(s), record keeping and reporting, providing safety training for its personnel (including subcontractors), issue and mandatory use of safety equipment, and details of the qualifications and experience of the Bidder's proposed safety officers to be deployed at the Site(s). The Contractor shall appoint a Full Time Safety Manager for the Works having experience in this field, who shall be responsible for implementing the Safety Plan. He shall be supported by at least two safety officers who are qualified

for such safety works. The Contractor shall ensure that his staff and labour and his Subcontractors are all fully trained in and aware of good and safe working practices. The Contractor shall ensure that all precautions are taken to safeguard the general public and construction / operating staff from any danger.

All temporary and partially completed works shall be protected by way of barriers, lights, notices and the like. All excavations and the like are to be protected by barriers at all times and adequately illuminated at night. Warning and diversion signs concerning roadwork shall be suitably placed to give motorists ample warning. During the movement of heavy vehicles across roads or onto roads, men, bearing red flags, shall be in attendance to warn other road users and to generally control traffic in a safe manner. The Safety Plan shall also consider requirements for warning and protection for other risks including overhead and underground cables, pipes or obstructions, or voids, openings, pits and trenches. The Contractor shall ensure that all appropriate measures are implemented.

The Safety Plan shall include a policy statement signed by the CEO or equivalent authority of the Organization declaring that safety and loss prevention shall be given the highest practicable priority in all aspects of the Contract

SCHEDULE K - CHECK LIST FOR HAND-OVER AT THE END OF CONSTRUCTION PERIOD

1.0 CHECK LIST FOR HAND-OVER AT THE END OF CONSTRUCTION PERIOD

1.1 GENERAL

This section applies to procedure(s) on how to transfer the works after the completion of Construction period (after necessary testing and commissioning of the system up to the satisfaction of the Employer) by the Contractor

- a) Internal road network including culverts,
- b) Water supply Transmission and Distribution system including service reservoirs
- c) Waste water collection system including Intermediate sewage pumping stations
- d) Storm water drainage and rain water harvesting systems
- e) Power supply transmission and distribution system including substations
- f) All Mechanical, Electrical systems required for the infrastructure works.
- g) All ancillary buildings in the project area.

The procedure for Handover shall be verified through the final examination by the Engineer. A completion approval Certificate shall be issued after the successful final examination and submission of the completion documents before the contract deadline.

1.2 DUTIES AND RESPONSIBILITIES

- (a) All the Responsibility lies with Contractor:
- (b) All cost for the examination / test / training, and preparation of any document of the activities shall be the Contractor's responsibility.
- (c) Official certificate:
- (d) All test certificates shall be issued by authorized organization with qualified personnel with his signature.
- (e) Receiving inspection
All equipment and construction material installed in site shall be inspected by the Engineer to verify whether damaged or not. Rejected items shall be replaced by the Contractor at his own cost.
The typical examination shall consist of as follows:
 - i. Appearance test / Visual examination
 - ii. Check attached invoice
- (f) Conduct first training:

The Contractor shall provide the first training program to client's staff member for one months before acceptance inspection. The typical training program is as follows:

- i. Study of Operation and maintenance manual
 - ii. Operation skill / technology (Mechanical and Electrical) including normal and emergency operation
 - iii. Maintenance, repair skill / technology (Mechanical and Electrical)
 - iv. Recordkeeping and maintenance of records
 - v. Safety & Health
 - vi. Evaluation of the program (examination)
 - vii. Others requested by the Engineer
- (g) Conduct joint completion inspection:
- (h) To verify the plant condition and its performance before operation, joint inspection will be carried out using up-dated Operation and, maintenance manual. The typical inspection items shown table below.
- (i) Submission of the report of completion documents:

The contractor shall submit the completion document after passing the final examination before the deadline on the contract time.

The typical report consists of relevant documents as shown in Table below

These data shall be provided in soft and hard copies in proper professional format.

Table: Typical Items to be examined at the End of Construction Period

Items	Description
Appearance test / Visual examination (Damage/crack, differential settlement, soil settlement, peel off painting, missing / lost, leakage of water /solution /gas, corrosion, decolonization, condition of maintenance, others)	All Road network, Civil structures, Water and wastewater pipelines, Storm water drainage, building including interior/exterior, fence/gate, stairs, others. All Mechanical & Electrical equipment /accessories, others. All Pipeline valves and others All SCADA system, Instrumentation and control equipment, others
Performance examination	Check Sequence, or Manual operation including water level sensors / protections, others

(Selection of operation mode, selection of facilities, flow / water level, overflow, leakage of water, heating, vibration / noise level, speed of rotation, smoothness, accuracy, setting value, condition, others)	Check specification of all Mechanical equipment including pressure gauges, valves, others Operational characteristics of all Electro-Mechanical Equipments in Pump stations etc Check specification of all Electrical equipment, others Check specification of all pipe line including valves, others Check specification of all accrual condition after troubleshooting, others Check for the actual losses in the water transmission and water distribution system. Check for the actual residual pressures in the water distribution system. Working condition of the Waste water collection system including septicity conditions if any. Strom water drainage working conditions, condition of storm inlet arrangements and water stagnations conditions during rainy season. Performance of Culverts / bridges during a storm event and also during heavy vehicular movement.
Verification of rectified works (System, leakage, crack, damage, soil settlement, corrosion, others)	Check a list of all defect items, tendency, repeating, others Check a list of all miss operation and maintenance items, others Check all factors of defect / miss operation, others Verification of action on the take measures, others Verification of all rectified works with the reports and photo, others Check emergency works and its factor, action plan, others Check actual condition after rectified works, others
Operation skill (staff member, others)	Format for preparation of daily report and summary reports on O/M activities, time and motion of staff member , others Interview of Experienced operators in the respective fields regarding troubleshooting, others Paper test (basic knowledge, safety, others)
Spare parts and others	Check inventory list (parts, others) Check the quantity of inventory, others Check maintenance tools and equipment, vehicles, others

2.0 SPECIFICATIONS

The specification of materials suggested for repairs shall be the same as used in the original work. Specifications for any materials which were not used during construction shall be approved by the Engineer prior to HANDOVER. Without being limited by this clause, the Contractor shall suggest appropriate material for repairs even if material required for such repairs has not been approved earlier, However, subsequent to suggestion of use of such material the Contractor shall submit proposals for the approval of specifications of such material.

3.0 CHECK LIST

3.1 General

Within the framework of the Contractor's responsibilities given above, the Contractor shall carry out the following activities. However, these shall not limit the requirement for other activities which otherwise are required as per terms and conditions of the Contract or to fulfill the Contractor's responsibilities or are essential as per good industrial practices. The Contractor shall hand over the components of works in good working condition for the following, but not limited to:

- a) All required consumables required for functioning of infrastructure works with inventory of material.
- b) All Electrical Equipments such as 33kV/11KV/ 433V Transformers, LT Switchgears / MCCs, Control Stations, Cables, Earthing, etc., pumping station, administrative buildings, etc.(all works constructed in this Contract) in neat and clean condition
- c) All required consumables required for functioning of infrastructure works with inventory of material.
- d) All Electrical Equipments such as 33kV/433V Transformers, LT Switchgears / MCCs, Control Stations, Cables, Earthing, etc., pumping station, administrative buildings, fire station unit etc.(all works constructed in this Contract) in neat and clean condition
- e) Lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures.
- f) Records for:
 - a. Repair history of all mechanical, electrical and instrumentation control equipment, and communication instruments;
 - b. Daily log of operations of all the important equipment such as electrically actuated valves, etc., with time tag;
 - c. Daily list of alarms with time tag;
 - d. Logbook format and the data to be included in the logbook;

- e. Last periodic maintenance done for all equipment / buildings of the system;
- g) Required spares, special tools and test equipment and adequate inventory of required accessories or equipment itself for repair of Pipe line system (including water and sewage system), electrical, mechanical, instrumentation and control system, pipe and the communication system. However at the end of the Contract the Contractor shall hand over the full spares, tools and tackles as supplied with the Contract by replacing the used items with fresh supplies of the same specifications.
- h) Repair of the roads, buildings and campus area utilities.
- i) Water supply facilities, Waste water collection facilities and all its units.
- j) Record of stores for the electrical, mechanical and instrumentation and control equipment.
The records will include but shall not be limited to:
 - a. Loading / unloading of materials received and issued for works;
 - b. Proper arrangement of material in stores to ensure its safety and easy availability;
 - c. Maintaining store areas in a neat and tidy condition;
 - d. Keeping records and accounting for the incoming materials,
 - e. Keeping records and accounting for the consumed materials.
- k) Structures / buildings of the project areas and others built in the Contract must ensure adequate cleanliness, ventilation, illumination and structural safety. In addition to this, the general hygienic standards must be in acceptable condition and adequate plantation; horticultural activities must be well maintained to give pleasant environment of the project area.
- l) Updated operation and maintenance manual as defined in specifications for O&M works.

3.2 Infrastructure system

The Contractor shall hand over all components of the works in good working condition for the following, but not limited to:

- a) Manpower requirement chart along with organizational chart with responsibility matrix for and maintenance of the entire Infrastructure components in the project area.
- b) All required spares for daily maintenance of the road system including road furniture works like bitumen, paints, signals and requisite O&M manual on the traffic management plans, road safety measures, etc.
- c) All required spares for daily maintenance of the water supply system including feeder systems works like pipe line operations and maintenance, UFW reduction programs and requisite O&M manuals, etc. Tools and Equipments required for the routine operation and maintenance of the system

- d) All required spares for daily maintenance of the Waste water collection system including pumping station works operations and maintenance and requisite O&M manuals, Tools and Equipments required for the routine operation and maintenance of the system.
- e) All required spares for daily maintenance of the Storm water collection system including storm inlet works operations and maintenance and requisite O&M manuals, etc
- f) All Pump house facilities including pipes, valves pumps, sluice valves, dismantling joints, nonreturn valves, pressure gauges, flow meters, dewatering pumps, HV/LV switchgear room, PLC control, MCC's, Cables ,Earthing , all motors and valves in the system.
- g) PLC, including the hardware, software and all instruments, in good working condition.
- h) Entire control system and instruments as per the manufacturer's recommendations.
- i) Communication cables and power supply cables.
- j) All instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, and laboratory instruments along with all other equipment.
- k) Calibration of all measuring /metering equipment or as recommended by the manufacturer. The calibration at manufacturer's works shall be done only in case of major failure/ repairs of the instruments.

Preparation and Submission of daily and monthly customized report formats produced by the local SCADA system

- l) Provision of all required consumables for printing.
- m) Details of all moving parts, steel structures and the RCC structures.
- n) Lubrication of all gears of reduction motors, motorized valves, and other parts of the system.
- o) Check all valves for their manual and electric operation. Operation of valves must be checked from local control console, switchgear and through PLC system.
- p) Make all circuits and buildings good all electrical, mechanical and instrumentation equipment, substation equipment, lighting, and earthing system associated works
- q) Painting of the exposed mild steel components of pipeline, ladders, railings etc.
- r) Make good surrounding areas of the works free from shrubs, weeds, grass and other unwanted vegetation.
- s) Ensure safety accessories, e.g. gloves, shoes, first aid box, etc.
- t) Ensuring fire and safety equipment.

3.3 Lubrication for pump stations

The Contractor, in the operation and maintenance manuals, shall furnish a complete schedule of recommended oils and other lubricants. The number of types of lubricants shall be kept to a minimum. In case of grease lubricated bearings for electric motors, lithium base grease is preferred. The Contractor shall indicate the brand name of

indigenously available equivalent lubricants, with their complete duty specifications, in the O&M manual. The Contractor shall also furnish the schedule of quantities for each fill, frequency of filling and annual requirement in O&M manual.

Where lubrication is effected by means of grease, preference shall be given to a pressure system which does not require frequent adjustment or recharging. Frequent, for this purpose, means more than once in a month. Where more than one type of special grease is required, a grease gun for each special type shall be used. All lubricant systems shall be designed so as not to cause a fire or pollution hazard. The Contractor shall supply flushing oil for such lubrication system when an item of plant is ready for preliminary running.

3.4 Spare Parts

All spare parts used for the equipment in the maintenance of the system must be from the manufacturer of the equipment or, if the equipment itself has been made with parts from other manufacturers, the parts must be of the same make as used in the equipment supplied and installed.

All spare parts shall be packed for long storage under the climatic conditions prevailing at the Site. Each spare part shall be labelled on the outside of its packing with its description, number and purpose and, if more than one spare is packed in a single case, a general description of the case contents shall be shown on the outside and a packing list enclosed.

4.0 Electrical System

The Contractor shall hand over the following at the end of the Period

- a) As built drawings based on all modifications suggested. All Electrical Drawings like Single Line Diagrams, Control Circuits Equipment Layout, Cable Layout, and Cable
- b) Schedules, earthing Layouts
- c) Details of Protective Relay Settings and time relay settings including any changes, Details of Oil Changes / Filtration of Transformers, Records of any changes made in the System suggested etc should be maintained.
- d) Equipment wise maintenance record for O&M Period. Motor wise Power consumption Details and over all power consumption detail of plant, equipments etc.
- e) Details of IR Test of all Equipments like HT/LT Panels, HT/LT Motors, Transformers, Switchgears, and Cables etc.
- f) Log book showing details Electrical faults that have occurred in the plant and record of corrective actions taken.
- g) Equipment wise technical data given by equipment supplier, Documents showing Bill of Materials and Operation & Maintenance Manual (hard copy or soft copy).

- h) List of mandatory spares that are to be maintained at stores and their actual availability in plant, if it is below same has to be replenished.
- i) Details of Measurement of Earth resistance, Earth Pit wise and Overall Values during the O&M Period.
- j) Details of Illumination Levels required during the O&M Period along with details of changes, required if any.

4.1 Electrical Checks to Be Done During Handover

- a) Contractor to provide a test schedule & format to be approved by engineer before commencing any test.
- b) Checking of all electrical equipment, items etc as per bill of materials. Visual checking and tracing out the circuit based on revised as built drawings.
- c) Visual Operational checks of all Equipment & Protections have to be done.
- d) Transformer oil samples testing have to be done during taking over.
- e) Earth Resistance of individual, Combined Pits for Substations should be checked during Hand over.

5.0 Instrumentation, Control and Automation System

The Contractor shall hand over the following documents/drawings/manuals/programs at the end of Construction Period

- a) As built drawings approved by the employer's representative based on all modifications. All ICA Drawings like P&ID, System configuration diagram (PLC & SCADA architecture), Instrument installation drawings, Instrument cable schedule, and cable layouts should be maintained and should be handed over.
- b) Handing over document / manuals shall include on a minimum 3 sets of softcopies and 3 sets of hard copies. The hard copies shall be spiral bounded clearly indicating the version/revision submitted. All the contents shall be indexed. The contents of handing over document/manual shall be clearly legible and shall include original manufacturer's literature minimum, and in-corporate any changes as per site conditions.
- c) Detailed drawing and manual of the PLC installed. Manual shall include the PLC series installed along with complete details on I/O modules, Ethernet switch, Relay modules, and converters (if any).
- d) A complete manual including operating instructions and troubleshooting techniques of the PLC and accessories installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- e) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the ODMS installed illustrated with examples. This shall be provided along with the standard manufacturer's literature.

- f) A complete manual shall be provided which shall include operating instructions and troubleshooting techniques of the interface control panel to Central Monitoring unit, illustrated with examples. This shall be provided along with the standard manufacturer's literature.
- g) Interoperability testing tool / software shall be provided along with relevant manuals and operating instruction with examples.
- h) Latest PLC program back-up, SCADA software back-up with license, SCADA database backup, reports and alarm back-up, Historical archived data containing reports and alarms and ODMS data and configuration set-up shall be provided.
- i) All software's used under ICA shall be handed over along with their original licenses.
- j) Complete list of database /addresses shall be provided clearly indicating the spare tags for PLC, SCADA and ODMS software's.
- k) List of mandatory spares that are to be maintained at stores for complete ICA package and their actual availability in plant, has to be provided.
- l) Any password's set to access the internal PLC program; interface control panel shall be provided and demonstrated.
- m) All passwords (PLC, Interface control panel & SCADA and other software / hardware) shall be provided in a sealed envelope and addressed to the Engineer In Charge.
- n) PLC, SCADA and ODMS package shall be updated with the latest software version / patch before handing over. The same has to be demonstrated to the Engineer in Charge.
- o) Latest licensed version of windows operating system along with MS –Office or equivalent software which is prevailing at that point of time shall be installed on SCADA machines and other machines installed and integrated with the SCADA and ODMS package. The same shall be demonstrated to the engineer.
- p) Contractor shall conduct a training session for the client's staff which shall include PLC configuration, trouble shooting techniques, SCADA configuration and troubleshooting techniques, ODMS configuration and troubleshooting techniques, diagnostic techniques and troubleshooting techniques for wireless technology employed for communication.
- q) The training session shall be of duration of minimum Five (5) working days at a stretch.
- r) Manufacturer's literature / Manuals for flow meters, level transmitters, switches, pressure transmitters etc and analytical instruments installed.
- s) Instrument wise, PLC and SCADA wise and ODMS maintenance record during complete O&M Period shall be provided.
- t) A complete and updated list of all manufacturers/system integrators/contractors of ICA with contact numbers shall be provided. The same shall also be made available on site for ready reference.

- u) The latest versions of all drawings of ICA, which will include cable termination details, I/O mapping, database details etc shall be provided in PDF format and editable format and loaded in the operator machine available on site. The same shall be demonstrated to the engineer.

6.0 ICA Checks to Be Done During Handover

- a) Contractor to provide a test schedule and format to be approved by the engineer before commencing any of the tests.
- b) Functional Checking of all ICA equipment including flow meters, pressure and level instruments, vibration monitoring instruments, and wireless equipment being used for communication.
- c) Loop checks shall be conducted.
- d) All instrument cabling shall be inspected for continuity. If found faulty, the same shall be replaced and demonstrated.
- e) All instrumentation cable conduits shall be checked for damage. If found faulty, they should be rectified or replaced and sealed to the satisfaction of the engineer
- f) Visual operational checks of PLC panel, SCADA system and interface control panel.
- g) Licensing feature of PLC, SCADA software and hardware, ODMS software and other hardware shall be demonstrated.
- h) Functional check of set points change at HMI and it's downloading to PLC's concerned.
- i) Hot-standby feature of PLC and hot swappable feature of I/O modules shall be demonstrated. If found to be faulty / non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client.
- j) Dual-redundant server feature of SCADA shall be demonstrated. If found to be faulty / non-operational, shall be rectified and if required replaced to normal working condition and demonstrated to the client.
- k) Functional check of ODMS software in conjunction with SCADA shall be conducted.
- l) Functional check of data received / transmitted from remote stations shall be conducted in conjunction with SCADA.
- m) Functional check of interface control panel to Centralised Monitoring station in conjunction with other units shall be conducted.
- o Historical archiving of all data shall be demonstrated.
- o Availability of memory for smooth operation of PLC, SCADA and ODMS machines shall be demonstrated. If found to be in-adequate, the same shall be rectified / archived and demonstrated.

- o If any instruments and automation equipment are found to be faulty during the above tests, the same shall be rectified or replaced as necessary.

7.0 Ancillary Works

- a) Make gardeners and plantation in the campus area green, neat and tidy with removal of shrubs, weeds, grass and unwanted vegetation and make pruning, trimming and cutting of old big trees from the Area along with including pumping station locations, office building locations etc as directed by the Engineer.
- b) Make good and in working condition for lighting fixtures and lighting circuits, water supply facilities in project area, offices and other residential buildings.
- c) The Contractor shall carry out ordinary repairs to buildings / pump stations. The repairs may include but not limited to the following items:
 - o Easing of doors and windows, monsoon repairs to roofs, attention to drains, rain water spouts, attention to plinth protection.
 - o External white or color wash, external or internal painting, internal distempering, renewal of approach roads within the campus.

8.0 Wireless Communication System

- a) Make a good wireless communication system to ensure reliable and easy communication to and from all infrastructure components.
- b) Replacement of batteries, faulty sets and all other non-functional equipment to ensure trouble-free communication if required.

9.0 Operations and Maintenance Manual

The comprehensive manual (six sets) shall be submitted at the end of the construction period, as specified. It shall be updated based on the principals broadly listed in O&M section. These manuals shall be made available during both the first and second training module conducted by the contractor.

10.0 Payments

The Contractor, at the time of bidding, will be responsible to ensure the completeness and adequacy of his Bid Price to fulfill the entire responsibilities as described above. His bid price, as quoted in the Schedule of Prices, shall include all costs for hand-over.

11.0 Format

For proper maintenance and recording of all the infrastructure works, the formats are given in O & M section. All the O & M record should be submitted in soft editable form.

12.0 Completion Certificate

A joint inspection shall be arranged by the contractor to assess the condition of civil structure, electrical & mechanical equipment and instrumentation equipment. Based on this inspection, a list of remedial, repair and replacement for the components shall be

prepared by employer. The contractor shall carryout such remedial works at his own cost. Again, joint inspection shall be arranged by the contractor for certification completeness of remedial work as well as restoring the condition of all civil work to its original appearance.

The contractor shall submit the entire required document to employer for review and comments. The contractor shall resubmit the document incorporating the comment. The employer shall issue a completion certificate to the contractor on his request within 30 days after the take back of the works by the employer subject to the above documents and obligation are met by the contractor before 90 days prior to hand over of the project area.

Integrated Manufacturing CLUSTER HISAR

**Design & Construction of Roads & Services/Utilities for
Integrated Manufacturing Cluster (IMC) at Hisar in Haryana
under Amritsar Kolkata Industrial Corridor (AKIC) Project on
Engineering, Procurement and Construction (EPC) basis**



**VOLUME-II
SCOPE OF WORKS & TECHNICAL SPECIFICATIONS
PART-B**

CONTENTS

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SCOPE OF WORK SCHEDULE B.

B.1. POWER SUPPLY SYSTEM

B.1.1. SCOPE

This specification covers design, manufacture, supply, testing at Manufacturers works, packing and forwarding, delivery to site with inland transit insurance, unloading, handling and safe storage of materials at site, installation, testing and commissioning and handing over of Electrical Equipment & systems along with mandatory spares and accessories as enumerated below including operation & maintenance of 5 (five) years including 5 (five) years of defect liability for the proposed Electrical works of Integrated Manufacturing Cluster (IMC) under Amritsar- Kolkata Industrial Corridor (AKIC) project for National Industrial Corridor Development Corporation (NICDC). Contractor shall supply the equipment in accordance with the Specifications, Data sheets and other requirements provided in this document or in the annexures enclosed herewith. Preliminary drawings are attached for reference only and Detail engineering will be done by Contractor.

The enclosed drawings give the basic scheme, layout of substation, substation buildings, associated services etc. **In case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general.** However, the Bidder has to follow Dakshin Haryana Bijli Vitran Nigam (DHBVN) specification and all drawings/ documents to be approved from DHBVN.

The electrical scope is to provide the complete electrical system including civil works, complete in all respects and covers design, engineering, procurement / manufacturing of electrical equipment, supply, inspection and testing at works, packing, transportation to site, storage, installation, testing, commissioning, handing-over in complete working order of all the equipment's including all items as per contract, spares, manuals, etc. and to undertake subsequent DLP and O&M. Any work required to provide a complete and fully functional and safe system shall be deemed to be included whether mentioned here or not.

Incoming 220kV Overhead transmission line from the source substation till the site Main Receiving Station, 220kV Gantry Structure with Conductor and Conversion Equipment & Accessories, 220kV Main Receiving Station (MRS) with all necessary equipment's & systems, necessary supporting structure and related civil works shall be provided and executed by HVPNL and shall not be considered as a part of this Tender. The EPC Contractor battery limit shall start from the outgoing of 33kV breakers located inside the 220kV MRS.

The detailed scope of works shall be as follows;

The electrical infrastructure is planned in alignment with the below Acts, codes, rules, regulations, and guidelines:

- IE Act, 1910
- IE (supply) Act, 1948
- IE rules, 1956
- CBIP manual
- REC distribution codes and manuals
- BIS standards
- NBC
- IGBC
- DHBVN/UHBVN regulations
- HVPNL rules and regulation

Besides the above good engineering practices, earlier experience and expertise in similar electrical infrastructure planning exercises are adopted.

The power demand is estimated as about to 240 MVA as per the land use of 1575. 74 acres. However, the contractor shall design the electrical system to cover the entire area along with proposed land use plan which shall be get it approved by engineer in charge.

The scope shall include design, construction, testing, commissioning, maintenance of Substations, power supply distribution networks including SCADA and advance Metering Infrastructure in the entire project area

The major electrical component such as 33 kV/11 kV substations, 11/0.433 kV CSS, 33 kV and 11 kV VCBs and RMUs, 33 kV Cables from MRS to DSS and to the plots, 11 kV and LT cables to the plots.

- (a)** Design, supply, installation, testing and commissioning of Five (5) numbers of 33/11kV Distribution Substation (DSS) (each 2 x 12.5 MVA with N-1 redundancy), with following equipments & systems, Necessary supporting structure and related civil works as per Specifications, Data sheets & Single Line Diagram Dwg. No. DRAWING NO: - NICDC-IMC-ELE-DRG-DSS-2001 to 2005.

Civil Works for Building Construction, Cable trench, Transformer Foundation, DG Foundation, Chain Link Fence with Gate, Access Roads, U/G water Tank, all piping, plumbing & air conditioning works as necessary for the proposed power supply system of IMC Hisar.

- i. Supply, laying, testing and commissioning of 33kV HT Cables from MRS up to DSS and to the dedicated load requiring 33kV supply voltage system / plots including cable joints and terminations.

- ii. 33kV Indoor type Gas Insulated Switchgear (GIS).
- iii. 33/11 kV Power Transformers with RTCC panels in DSSs.
- iv. Nitrogen injection fire prevention system for Power Transformers.
- v. 3 Phase, 11kV Indoor AIS Switchgears.
- vi. 33kV & 11kV Cables and Terminations Within DSS.
- vii. 11/0.433 KV Station/Auxiliary transformer
- viii. 100kVA LT DG Set with all accessories for each substation as per prevailing specifications/standards.
- ix. 415V Main LT Distribution Board, ACDB Panel for DSS.
- x. 11kV Capacitor Bank.
- xi. Power & Control Cabling System for DSS.
- xii. Cable Tray and accessories for DSS
- xiii. Earthing and Lighting Protection system of DSS with necessary Earthing pits, including necessary clamps, nuts, bolts, etc all including welding, bolting, bituminous/GI painting and associated civil works.
- xiv. Lighting/Emergency Lighting Panels for DSS
- xv. 2 x 100% rated Battery associated with 2 x 100% Float cum Boost Charger, etc. and DC Distribution Board.
- xvi. Redundant UPS and associated DBs.
- xvii. RCC cable duct, cable/wiring management system, cable termination including lugs and glands, cable racks with necessary fire barriers, fire & Waterproof sealing and coating systems, Hume Pipes, Man holes and flexible conduits for the cabling work and all other cable accessories inside for DSS
- xviii. Substation Automation System (SAS) with self-healing features and RTUs for DSS including associated 33kV & 11kV networks.

- xix. Lighting system for DSS Building and Outdoor area.
- xx. Indoor Lighting Fixtures with necessary accessories;
 - i. Conduiting
 - ii. Point Wiring
 - iii. Lighting Control switches
 - iv. Receptacle Units/Socket Outlets for Indoor installations
 - v. MCB DBs
- xxi. Outdoor/ External LED Lighting Fixtures with Poles and necessary accessories.
- xxii. Supply, installation, testing and commissioning of Ceiling fans, Air conditioners (ACs) and Exhaust fans with all accessories.
- xxiii. Supply, installation, testing and commissioning of Plumbing & Fire Fighting System, Complete with all accessories & associated Equipment for DSS
- xxiv. EOT Crane for 33kV GIS Hall including Rail & all other material required for smooth working of Crane and with tools as per requirement.
- xxv. Supply, installation, testing and commissioning of the Substation CCTV Surveillance system, Complete with all accessories & associated Equipment.
- xxvi. Roof Top Solar (RTS) system for DSS
- xxvii. Relay Co-ordination for entire Electrical system under scope as specified above with reference to upstream and downstream distribution systems.
- xxviii. MS Supporting structures for panel mounting, cable trench & Trays, cable laying, lighting fixture etc.
- xxix. Safety & Fire Protection Equipment as per statutory requirements including following
 - i. Fire Bucket, Stand, Rubber Mat
 - ii. Fire Extinguisher (Wall and Trolley Mounted)

xxx. Furniture for Control Room Building including following

- i. Almira (Major & Minor)
- ii. Tables (Executive) & Control Desk
- iii. Executive Chairs (Revolving)
- iv. Steel Racks (Minor & Major)
- v. Stool and Benches
- vi. First Aid Box
- vii. Shock Treatment Chart
- viii. Water Cooler
- ix. Danger Boards

xxxi. Substation Name Boards

xxxii. Rainwater harvesting system for the Substation Buildings.

(b) Design, supply, installation, testing and commissioning of 33kV & 11KV Ring Main System (RMU), 11/0.433 kV Compact Substation (CSS) with outdoor LT Panels, EV Chargers with following equipment & systems, Necessary supporting structure and related civil works as per Specifications, Data sheets & Single Line Diagram Dwg. Nos. (NICDC-IMC-ELE-DRG-SLD-1001 to 1006) and Dwg Nos. NICDC-IMC-ELE-DRG-CABLE-3001 for Overall equipment layout.

- (i) Supply, installation, testing and commissioning of 33kV & 11kV Ring Main Units (RMUs) (adequate quantity for the entire project area as directed by Engineer In charge for IMC Hisar).
- (ii) Supply, installation, testing and commissioning of 11/0.433kV Compact Substations complete with RMU transformer, LT switchgears etc. (adequate quantity for the entire project area as directed by Engineer In charge for IMC Hisar).
- (iii) Supply, laying, testing and commissioning of 33kV HT Cables from MRS to the dedicated load requiring 33kV supply voltage system / plots including cable joints and terminations and 11kV HT Cables from DSS to the dedicated load requiring 11kV supply voltage system / plots including cable joints and terminations.
- (iv) The plots requiring LT supply shall be fed from CSSs.

- (v) The HT cables shall be terminated in the RMUs and LT supply in Feeder Pillars
 - (vi) The location of the 33 KV & 11KV RMUs is shown in the power layout drawings
 - (vii) EV Chargers (Fast & Slow) Tentative Quantity 30KW -Four (4) Numbers and 7.2 KW Seven (7) Numbers
 - (viii) RCC Cable trenches along all the road networking including GI cable tray for 33kV, 11 kV and 1.1kV cable and OFC and instrumentation complete in all respects, cable/wiring management system, cable termination including lugs and glands. Cable will be laid in tier formation through the cable trenches.
 - (ix) Earthing system.
- (c) Design, supply, laying, testing and commissioning of 33kV & 11kV HT & 1.1 kV LT cabling system including control & instrumentation cables including following items:
- (i) HT, LT power & control cables including cable joints and terminations with necessary glands & lugs.
 - (ii) The internal power distribution will be implemented through an underground cabling system with RCC power cable duct covering approximately 50 km of the total network length along the roads. The RCC duct Size shall be designed as per the power supply network design. The preliminary design carried out by the employer indicates minimum of 1350X1800 mm on 45 m Row and the rest of the roads it shall be minimum of 1200X1500 mm except 32 m RoW where it was suggested as minimum 900X900 mm. 45m RoW, 36 m RoW, 32 m RoW and 24m RoW shall have RCC duct on both the sides and 18 m Row may have on One side with a provision of utility crossing to access the plots located on the other side of road or both sides of road and Typical Cross Section shall be discussed with Employer's engineer. Rest of network shall be installed using earthen trenches. HT & LT power cable laying thru cable trench and DWC pipe duct & manhole system.
 - (iii) Cable trays and accessories.
 - (iv) Adequate utility crossing to the other side of the plots by using appropriate RCC pipe shall be considered.
 - (v) The complete System from MRS to DSS, DSS, 33 kV and 11 KV distribution system shall be designed on N-1 redundancy criteria through ring configuration such that failure of any one feeder, cable section, RMU, or switching element shall not interrupt power supply to the downstream substations/load centers.

- (d)** Design, supply, installation, testing and commissioning of LED based Smart Street Lighting System including following items:
- (i) Supply, installation, testing and commissioning of 11/0.433 kV Compact Substations for street lighting system.
 - (ii) Outdoor LT Feeder Pillars.
 - (iii) Octagonal type street light pole (PU painted).
 - (iv) LED fixtures.
 - (v) Street Light feeder pillars.
 - (vi) Smart Group Lighting Control & Monitoring System for Street Lighting (GCMS).
 - (vii) LV cabling system thru DWC pipes including end terminations.
 - (viii) Earthing system.
 - (ix) Civil pole foundations.
- (e)** Liaison with DHBVN, HVPNL, CEIG and any other statutory regulatory body as relevant for getting complete approval of Electrical installation works is in the scope of Contractor and included in tender. The cost to be borne by the contractor.
- (f)** If, the equipment specification is not provided in Tender, in that case BIDDER shall refer specification of HVPNL and DHBVN with prior approval of Engineer in- charge.
- (g)** Design and Construction of DWC pipe duct & manhole system, RCC cable trenches & necessary arrangement for drain out of storm water & exhaust system. Manholes at shall be provided at regular intervals in consultation with Employer's Engineer. HT XLPE, LV and control and instrumentation cables shall be laid on cable tray of RCC cable trench.
- (h)** All civil works related to Supply, Installation, testing & commissioning of the above Electrical Equipment.
- (i)** Supply & installation of Fencing of complete plot of DSS. Civil Works for fencing & gate, cable trench, substation building as stipulated in civil scope of works.
- (j)** Fiber optic network will be laid along the roads **which will be part of Instrumentation works**. Communication from this fibre optic network to each plot's RMUs/ CSSs/ Substation will be in this tender's scope.

- (k) This specification is the minimum requirement and should be read in conjunction with relevant latest IS/IEC/DISCOM/DHVBVN/HVPSNL specifications, requirements, rules and regulations. The bidder to refer most stringent specification. Any additional requirements shall be offered by BIDDER as per DISCOM/DHVBVN specifications, requirements, rules and regulations, the same shall be indicated in the BID write up and a separate Bill of Quantities (BOQs) for additional or modified items shall be submitted along with the BID write up.
- (l) The EPC Contractor shall get prior approval on design & drawings, specification & Data sheet of **all power** items such as Power Transformer, 33kV GIS including RMUs, HV Cables, Bus Duct, 11kV AIS including RMUs, CSS, LT Cable / Panels and Monopoles etc. from **DHVBVN and** Engineer In-charge of before manufacturing/Procurements. Cost of approval from DHVBVN to be borne by the contractor.
- (m) Any consideration of statutory requirement shall be carried out without any cost/**time** impact/ change or escalation of the Contract Price.
- (n) The Owner shall carry out inspection and testing at manufacturer's works for this contract. No equipment shall be delivered without prior written confirmation from the Engineer In-charge. In case factory inspection is carried out then all travelling and lodging- boarding expenses for maximum three persons total from Owner / DHVBVN side shall be borne by the Contractor, also all expenses related to testing shall be to Contractor account.
- (o) CONTRACTOR shall make his own arrangement of 415 V, 50 Hz, TPN Construction Power supply at site to carry out all the site activities.
- (p) CONTRACTOR shall use suitable size of cables and sub-distribution boards. All material like cables, switch-fuse units, sub-distribution boxes, etc. required for further distribution shall be arranged by CONTRACTOR.
- (q) All consumable such as welding, drilling, gas etc. as required shall be included in Contractor scope.
- (r) Electrical for STP, CETP, WTPs consisting of 33KV/11 kV VCB, 11/.433 kV CS-S, LT switch boards, DG sets, cables etc. complete as required.

- (s) DG sets for critical loads of substations, street lighting, WTPs, CETP, STP and pump house load if any. Dedicated DG sets shall be provided for each substation and treatment plants.
- (t) Civil work is complete in all respect.
- (u) SCADA & ICT Network
 - All substations, utilities, and smart infrastructure shall be integrated into a centralized SCADA system including Advance Metering Infrastructure (AMI)
 - All the components should designed and implemented with requisite ICT components by taking into consideration of overall integration of ICT components
 - OFC/ICT cabling shall be used for system communication and data transfer.
 - OFC to support SCADA, telecom, and internet connectivity.
- (v) The Contractor shall be fully responsible to ensure that the whole of the Works, including each individual component, is designed and constructed in a manner so that the System as a whole operates as a fully integrated system which is capable of achieving the required output in an efficient and economical manner, and to include all plant, equipment and accessories required for the safe and satisfactory operation of the facilities. To achieve this, the Contractor shall ensure that each individual component performs in a manner which is complimentary to that of all other components. Any accessories which are not specifically mentioned in the specifications, but which are usual or necessary for completion of the Works and successful performance of the System and facilities shall be provided by the selected Bidder within the tendered cost. The Contractor shall, to the maximum extent practical and feasible, endeavor to standardize on the manufacture and supply of plant and equipment so as to minimize the operation and maintenance requirements. The Contractor shall ensure that the designs are "maintenance-friendly" and that all items of plant and equipment are designed and installed in a manner which will facilitate routine and periodic maintenance operations. The Contractor shall check the design criteria/calculations (if any) included in the Bid Documents and satisfy itself regarding their accuracy and adequacy. Further, if Contractor believes that the minimum design and sizing requirements are not adequate to meet the minimum performance requirements specified, then Contractor shall make whatever upward adjustments to the design and sizing it deems necessary to meet the performance requirements and include these in the Bid Price.

B.1.2. QUALITY CONTROL PLAN

The Quality Control Plan shall list and define in sequential order all process control activities, inspection and tests proposed to be performed on the equipment/ material starting from component procurement and from testing stages to product dispatch. The Quality Control Plan shall indicate and identify the applicable standards, detailed description with diagram the procedure, acceptance criteria, extent of check and record to be generated.

B.1.3. INSPECTION

- (a) PURCHASER may inspect all the supply components/ equipment/ systems at VENDOR's works. All type test certificates of the bought-out items and internal test certificates shall be furnished at the time of inspection.
- (b) Type/ Routine tests according to relevant standards shall be performed in the presence of PURCHASER representative if agreed.
- (c) All necessary measuring and testing equipment shall be arranged by the VENDOR or its Sub- VENDOR at the time of inspection as well as during commissioning at site without any cost implication to the PURCHASER. All such instruments shall be calibrated from Authorized agencies not older than a year from the date of inspection.
- (d) The Owner shall carry out inspection and testing at manufacturer's works for this contract. No equipment shall be delivered without prior written confirmation from the Engineer In-charge. In case factory inspection is carried out then all travelling and lodging- boarding expenses for maximum three persons total from Owner / DHBVN side shall be borne by the Contractor, also all expenses related to testing shall be to Contractor account.

B.1.4. DESIGN CRITERIA

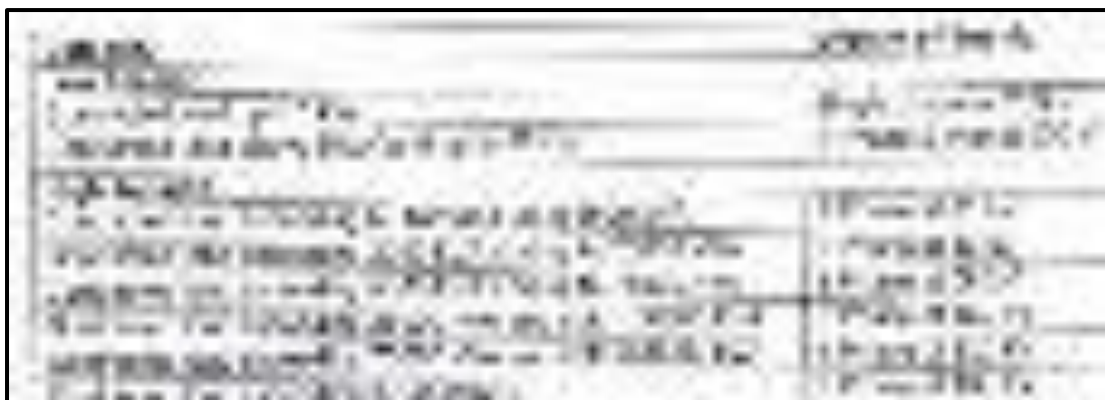
B.1.4.1. SYSTEM DESCRIPTION- PRIMARY POWER SOURCE

The proposed 220kV MRS substation will be fed from 400/220kV, Kirori Substation through either 220kV double circuit transmission lines or underground cables. Presently two feeders are considered from 400/220kV Kirori source substation. The transmission lines / UG cables shall be terminated inside the boundary limits of the IMC area. Transmission lines/ UG cabling work from source substation to MRSS plot boundary, 220kV Gantry Structure with Conductor and Conversion Equipment & Accessories, 220kV Main Receiving Station (MRS) with all necessary equipments & systems, Necessary supporting structure and related civil works will be in the scope of HVPNL.

These incoming lines shall be routed in IMC plot boundary depending upon the location/ direction of the substation with reference to the plot. It is expected that the incoming lines shall be provided thru UG cables up to MRS plot boundary by HVPNL. However, in case of Overhead lines, the conversion yard for incoming source shall be installed by the HVPNL within or near to MRS plot boundary including lightning arrestor, bus post insulator and cable sealing end within a fenced compound.

B.1.5. POWER SUPPLY ARRANGEMENT

According to existing power supply code prescribed by Haryana Electricity Regulatory Commission Supply Code, following are the norms adopted for the selection of the power supply voltage level.



The ultimate power demand for IMC is approximately 240 MVA. The power supply system for IMC is planned at 220kV level considering availability of 220kV sources near the site. Distribution is proposed to be carried out thru 33kV and 11kV system. Estimated distance from 400/220kV Kirori substation to MRS is 21 km.

B.1.6. 220/33KV GIS SUBSTATION

The same shall be in the scope of HVPNL.

B.1.7. 33KV CENTRALIZED SWITCHGEAR AT MRS

The same shall be in the scope of HVPNL. However, following loads will be fed by these panels:

- Industrial consumers having maximum demand of exceeding 2000 KVA and upto 25000 KVA requiring direct 33kV supply including the required redundancy.
- 33/11kV Distribution Substation (DSS) including the required redundancy.
- 33kV Capacitor Banks & Auxiliary transformers

All the distribution from 220 kV GIS Substation to DSS, and up to the load shall be carried out by underground XLPE armoured cables HT Cables of respective voltage grade laid in RCC cable trench/DWC pipes.

Industrial consumers having maximum demand of exceeding 2000 KVA, shall be supplied directly from 33 kV Panel board located in 220 kV GIS through underground cables.

The consumers with a demand up to 2000 KVA shall be supplied at 11 kV while that up to 25000 KVA shall be supplied at 33 KV as per Dakshin Haryana Bijli Vitran Nigam guidelines.

B.1.8. 33KV VOLTAGE SUPPLY SYSTEM

For consumers having demand more than 2 MVA and less than 25 MVA shall be supplied directly from 33 kV GIS Panel board located in 220 kV GIS through underground HT Cables.

All the feeders of 33kV shall feed the consumers in ring networks for better reliability and maximum load in 33kV ring will be restricted to about 10-12MVA.

These rings for each Zone shall be drawn from 33kV GIS switchgear located at MRS. The rings shall constitute one 33 kV Ring Main Unit (RMU) with two Load Break Switch (LBS) and one VCB Circuit breakers for each consumer as detailed in SLD.

In order to maintain redundancy two feed of the 33 kV incomers shall be drawn from 220 kV MRS substation so that in case one feed fails the second feed can continue the power supply.

B.1.9. 33/11 KV DISTRIBUTION SUBSTATION (DSS)

The 33/11 kV Distribution Substation (DSS) shall be proposed to step down the voltage level to 11 kV and distribute it through Ring Mains to 11 kV consumers having demand less than 2 MVA. The location of the Distribution substations shall be near to the load centre.

All the feeders of 11kV will feed the consumers in ring networks for better reliability and maximum load in 11kV ring will be restricted to about 5-6MVA.

These rings for each Zone shall be drawn from 11kV switchgear located at respective 33/11 kV DSS. The rings shall constitute one 11 kV Ring Main Unit (RMU) with two Load Break Switch (LBS) and one VCB Circuit breaker for each consumer as detailed in SLD.

Each DSS shall constitute of 33 kV GIS and 11 kV AIS HT switchgear (adequate quantity of 11 KV VCBs outgoings as directed by Engineer In charge for IMC Hisar), 3 Nos. 12.5 MVA power transformers, 11/0.433 kV **station**/Auxiliary transformers, DC system, LV system, DG Set and SCADA system.

Total 3 # 12.5 MVA, 33kV/11kV power transformers shall be provided considering N-1 redundancy.

In order to maintain redundancy two feed of the 33 kV incomers shall be drawn from 33kV Switchgear at MRS substation so that in case one feed fails the second feed can continue the power supply.

B.1.10. 11KV/0.433KV COMPACT SUBSTATIONS (CSS)

11kV/0.433kV CSS shall comprise of 11kV RMU (Consisting of 2 load Break Switches and 1 no VCB as per SLD) with dry type distribution transformer and LT switchgear to feed the LT consumers, common services load like open space lighting, pumping stations, street lighting and other loads, etc. N-1 distribution scheme will be provided for redundancy to LT load by providing redundant CSS.

The power distribution for each parcel of land and common services within the IMC Hisar shall be supplied through 33KV, 11kV & 0.415kV underground cables laid in Cable trench and DWC pipe duct and manhole system.

B.1.11. GENERAL DESIGN CRITERIA

The proposed power distribution system shall be designed in accordance with this specification, taking into account all possible factors affecting the choice of the system to be adopted, such as required continuity of supply, flexibility of operation, operational costs, reliability of supply from available power sources, total load and the concentration of individual loads.

All the components of the electrical system shall be sized to suit the maximum load under the most severe operating conditions. Accordingly, the maximum simultaneous consumption of power, required by continuously operating loads shall be considered and an additional margin shall be taken into account for intermittent service loads, if any. The

amount of electrical power consumed by each area shall be calculated for its operation at the design capacity.

All the system and Equipment shall be designed with a reference ambient temperature of 50 Deg C.

Sizing of 33kV GIS Switchboard at Distribution Substation (DSS)

For sizing following points shall be considered:

- a) Two breakers shall be considered for each ring main from separate bus sections.
- b) Separate outgoing breakers shall be considered for auxiliary transformers, capacitor bank. (as per SLD).
- c) Adequate spare feeders shall be provided on each bus sections (at least 1 no. on each bus section).
- d) All protections shall be as per Single Line Diagram.
- e) Separate CTs shall be considered with PS Class for all unit protections, such as bus differential, and transformer differential.
- f) All outgoing feeders shall be rated for ring capacity i.e. during outage of any outgoing feeder; entire load can be supplied through single feeder.
- g) Protective relays shall be of numerical type with latest version with non-volatile memory and shall be suitable for communication with data acquisition system. Relay shall support functions like remote relay parameterization, disturbance recorder, time stamping etc. It shall be possible to set or operate the relay from the front facia. Lock out relay shall be provided separately, and it shall be conventional type with hand rest facility. All numerical relays shall be on IEC 61850 Protocol. Relays should have feature of MIMIC display.
- h) The Contractor shall furnish recommended relay settings with backup calculations. Entire Relay co-ordination shall be carried out in ETAP latest available version.
- i) Specific requirements shall be as per enclosed specification.

Sizing of 11kV AIS Switchboard at Distribution Substation (DSS)

For sizing following points shall be considered:

- a) Two breakers shall be considered for each ring main from separate bus sections.
- b) Separate outgoing breakers shall be considered for capacitor bank & **station**/auxiliary transformers.

- c) Adequate spare feeders shall be provided on each bus sections (at least 1 no. on each bus section).
- d) All protections shall be as per Single Line Diagram.
- e) Separate CTs shall be considered with PS Class for all unit protections, such as bus differential, and transformer differential.
- f) All outgoing feeders shall be rated for ring capacity i.e. during outage of any outgoing feeder; entire load can be supplied through single feeder.
- g) Protective relays shall be of numerical type with latest version with nonvolatile memory and shall be suitable for communication with data acquisition system. Relay shall support functions like remote relay parameterization, disturbance recorder, time stamping etc. It shall be possible to set or operate the relay from the front facia. Lock out relay shall be provided separately, and it shall be conventional type with hand rest facility. All numerical relays shall be on IEC 61850 Protocol. Relays should have feature of MIMIC display.
- h) The Contractor shall furnish recommended relay settings with backup calculations. Entire Relay co-ordination shall be carried out in ETAP latest available version.
- i) Specific requirements shall be as per enclosed specification.

Sizing of 33kV and 11kV RMU:

- a) Each RMU shall consist of two load break switch and one / two / three VCB as per SLD.
- b) The Load break switch shall be rated for the ring capacity irrespective of its location/ sequence in the loop i.e. while feeding from one end of the Loop, the switch shall be capable to withstand the entire load current of the Loop.
- c) The protection relay shall be communicable as per the SCADA and smart grid requirement.
- d) Specific requirements shall be as per enclosed specification.

Sizing of 11kV /433 V Station / auxiliary transformer:

For sizing of distribution transformers following points shall be considered.

- a) Load List shall be as per requirement.
- b) Load Factor for individual load and diversity (Working / Standby) within the similar type & purpose of load shall be considered for calculating the running loads.
- c) Efficiency (0.9) and Improved Power Factor with APFC Panels (Power Factor=as per

DHVBN Guidelines/Specs)

- d) For all lighting loads Load factor shall be 1.
- e) Overall Diversity factor shall be considered for calculating the final demand from the total running loads.
- f) Maximum loading of all transformers shall not exceed 90% with considering future demand and 5% spare capacity.
- g) 2 no's 11/0.433KV station/auxiliary transformers for each DSS with N-1 redundancy

Sizing of 415V Switchgear for substations and Common Utilities:

- a) 415 V, 3 phases, 4 wires solidly grounded AC supply to feed all LT loads.
- b) The 415V switchgear & its components will be designed as per actual fault level calculation.
- c) Switchgear will comprise Air Circuit Breakers, MPCB/MCCB, Contactor controlled feeders for motors etc.
- d) The main bus shall be designed based on the load rating as well as the actual fault level at the location of the board with 10% tolerance.
- e) The current density of the busbar shall be as per DHBVN specifications.
- f) Earth bus of the panel shall be sized suitable for the above fault level.
- g) ACBs shall be considered for switchgear ratings above 630A and MCCB shall be considered upto 630A
- h) All ACBs and MCCBs shall be rated for Bus fault level with $I_{cs}=I_{cu}=I_{cw}=100\%$ for ACB and $I_{cs}=I_{cw}=100\%$ for MCCBs.
- i) MCB shall not be used as power distribution at any LT Switchgear. MCBs shall be considered only for Lighting panels and Raw power distribution feeders i.e. feeders below 10kW load.
- j) Motors less than 15 kW
 - Overload protection by three phase thermal (bimetal) relay.
 - Single phasing preventer.
- k) Motors 15 kW up to 132kW
 - Electronic motor protection relay providing the following protection for
 - Overload;
 - Earth fault;
 - Phase currents out of balance.
 - Single phasing preventer.
- l) 415V Motor Starters

All the Motor starters shall be VFD to optimize consumption.

- m) 15% spare capacity shall be considered on each bus/ panel for future.
- n) Specific requirements shall be as per enclosed specification.

Sizing of 33kV, 11kV & LV Cables:

- a) HV Cables shall be 33000/11000V earthed grade, single/multi-core, stranded and compacted Aluminium conductor, extruded XLPE insulated (dry cured), extruded semi conducting compound screen with a layer of non-magnetic metallic tape screen, extruded PVC inner sheath (Type ST-2), armoured and extruded overall sheath with Fire Retardant Low Smoke (FRLS) PVC compound (Type ST-2). The cables shall conform to IS-7098 Part -II.
- b) LV multicore cables for use on 415 V and 240 V power supply system shall be XLPE type with Aluminium conductors for sizes 6 Sqmm and above and PVC insulated Copper Conductors for sizes below 6sqmm. The cables shall conform to IS-7098 Part -I.
- c) The Control cables shall be copper conductor, insulated with extruded PVC compound type C, provided with inner sheath and outer sheath of extruded black PVC compound type ST-2.
- d) All power cables will be selected to carry the corresponding full load current under site conditions. In addition, the following main aspects will also be considered while deciding the final size.
 - Maximum ambient design temperature 50°C.
 - Maximum allowable temperature rise under normal full load condition based on the material of cable insulation (XLPE/ PVC).
 - Maximum short circuit current and its duration (fault clearing time).
 - De-rating factors with respect to the Method of cable laying i.e. outdoor/ indoor in air; underground/ buried/ trench with removable cover; depth of burial/ duration for trenches, no. of cables in a group –touching each other or separated by a distance; no of tiers of tray/ no of cables in a tray.
 - Voltage drops with reference to Length of the cable. The maximum cumulative voltage drop of the system from the power transformer to the individual consumer load shall not exceed 5%. The drop till the HT network shall not be more than 1.5%.
 - The cable for motor will be limited to a dip of 15% during starting.
 - De-rating factors, resistance and reactance values for cable sizing shall be considered from the published data of the offered make. The referred technical

catalogue shall be submitted as reference along with the calculations for approval.

- e) Standardization of cable sizes shall be preferred.
- f) Grades of Cables that will be utilized in this project shall be;
 - 33000/11000V(E) Power Cables
 - 1100 V Power Cables
 - 1100 V Control Cables
 - 600 V Instrumentation Cables

Selection of Control Cables

- a) Current transformer leads shall be checked for the lead burden vis-a-vis the current transformer VA capacity and knee point voltage. Minimum 2.5 sq mm conductor cables shall be used for connection of CT to load.
- b) In case 2.5 sq. mm conductor (cu) impose unacceptably high burden on CTs, 4.0 sq. mm conductor shall be used. The conductor material shall be copper.
- c) Voltage transformer leads shall be checked for voltage drop which shall be limited to within 1% for all cases other than tariff metering. For tariff metering the voltage drop shall be limited to 0.2%, if applicable.
- d) In case the voltage drops in PT circuit with 2.5sq.mm conductors exceeds the above values, higher conductor sizes shall be used.
- e) The following control cables are proposed to be utilized in this project;
 - All interlocks cables are core cables of 1.5 or 2.5Sq.mm.
 - All analog & digital signal cables are twisted pair cables of 0.5 or 0.75 Sq.mm.
 - For communicating the signals to long distance Optic fiber cable shall be used.

Cable Routing

- a) The first consideration in cabling system layout is to keep the distance between the source and the load as short as possible. Many other important factors will also be taken into account to arrive at the lowest cost system that operates within the reliability, safety, economy, and performance factors that are required.
- b) Route selected must not pass close to sources that produce significant heat like steam pipes, etc. Also, the route must not interfere with utility systems like Water, HVAC, etc. and civil structures.
- c) The cable tray sizes shall be selected on the basis of the number and sizes of cables to be carried with the due consideration to the following cable laying arrangements.
 - All HT power cables are laid in a single layer with 1D Spacing between each

other.

- All LT power cables are laid in a single layer touching each other.
 - All control cables are laid in three layers touching each other.
 - Power and control cables are laid in separate trays for the purpose of segregation.
- d) The following cable systems are followed in separate cable trays in a tier at substations, utility buildings/areas in the order given below, starting from the top tray:
- Instrument related cables
 - 1.1kV Grade control cables
 - 1.1kV Grade related power cables
 - 33/11 kV Power cables
- e) All the cables from MRS to DSS, Plots, all the HT loops of 33 kV and 11 kV, LT cables for streetlights etc. outside any building shall be laid in Cable trench and DWC pipe duct & manhole system.
- f) Within buildings, the cables shall be laid in prefabricated galvanized steel, perforated type cable trays, suitably supported by painted steel cable tray supports either in the concrete trenches or supported from wall/ ceiling/ columns etc. as per site condition. Separate cable trays will be used for 415V power cables and control cables.
- g) All road crossings shall be carried out with cables laid in a RCC Hume pipes. Proper encasing shall be considered for pipes laid below 1m depth from FGL.
- h) Power and control cables in 33 kV substations shall be laid in cable trays mounted on support structures in built-up cable trenches.

Sizing of Battery & Battery Charger

- a) 48V DC System shall be provided with two (2) x 100% rated battery bank associated with 2 x 100% float & float cum boost charger (F+FC) and one DC switchboard at DSS & SS.
- b) Sizing of DC chargers shall be carried out as per IEEE standards considering all the loads & requirements of all the panels in the MRS building, requirements for future panels and equipment.
- c) The battery shall be rated on 10-hour basis and for the specified 50-degree ambient temperature. The battery shall have maximum recharge time of 8 hours.
- d) Battery AH capacity shall be design for 20 % higher than required load for future.
- e) 15% spare capacity shall be considered.
- f) Specific requirements of the DC system shall be as per enclosed specification.

Sizing of Grounding System

- a) The safety earthing and lightning protection system will be generally designed on the basis of following codes and standards.
- IS 3043 - 2006: Code of practice for Safety Earthing.
 - IS/IEC 62305, Part-2 & 3-2013: Protection against lightning.
 - IEEE 80 – 2013: IEEE Guide for Safety in Sub-station Earthing.
 - Central Electricity Authority (CEA) Regulations – 2010
 - IEEE 1100 - 2005- Electronic Earthing.
 - IEEE – 142 - 2007: IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems.
- b) Measurement of soil resistivity at site by Wenner's four electrode method as per IS: 3043 – 1987 shall be carried out.
- c) The maximum values of earth fault current for the design of the earthing system will be considered based on system requirement as follows:

Table B-27 Fault levels of different Voltage level systems

S.N.	System	Fault Level & duration
1.	220 kV	40 kA for 1 sec (To be confirmed with HVPNL)
2.	33 kV	31.5 kA for 1 sec
3.	11 kV	25 kA for 1 sec
4.	415 V	25 kA for 1 sec

- d) Following factors shall be considered for sizing the earthing conductor.

a)	Design Ambient Temperature	50°C
b)	Allowable temperature rise for steel welded joints	500°C
c)	Fault clearing time	1 seconds
d)	Overall earthing resistance for 220 KV Substation	less than 1 ohm or as per PTCC requirement
e)	Overall earthing resistance for other Substation	less than 1 ohm
f)	Time factor for calculating maximum allowable Step and touch potential	1 Second

g)	Duration of shock for determining the allowable body current.	0.5 Second

- e) The galvanizing of the earthing material will be done as per IS2629-1985.
- f) Copper Bonded Rod 3 Mtr length (10 feet approx.), 17mm diameter (minimum Copper Bonding shall be 0.25mm suitable for 36kA Short Circuit Current) along with Earth enhancement material of 30Kg. Copper Bonded Earth Rod made from high tensile low carbon steel and each rod should molecularly bonding 99.9% pure electrolytic copper to the low carbon steel core in accordance with national and international standards such as BS6651, BS7430 and UL467. The Scope also includes construction of heavy-duty earth chamber with load bearing capacity and Cast-Iron hinged cover/ FRP cover to ensure the safety of earthing system.
- g) Buried earthing conductors around the periphery of each building shall be installed at a minimum depth of 600mm at a distance of approximately 1500 mm from the building edge.
- h) Earthing leads of transformer neutral will be connected to two separate earth electrodes. The earthing leads of transformer body will be directly connected to main earth grid.
- i) **Earthing of Substations**
 - Earthing conductors in 33 kV substation shall be laid in the form of a grid/mesh. Spacing between the conductors, depth of burial, number of parallel conductors etc. will be decided such that step and touch potentials are within safe limits. The maximum permissible step and touch potentials will be calculated in accordance with IEEE 80-2000.
 - Fault current diversion factor shall be calculated as per defined in IEEE 80-2000.
 - The earthing conductors in the substation and outdoor areas shall be installed at a minimum depth of 600mm.
 - The equipment like PTs, CTs, etc shall have two distinct earth connections to grid. LAs shall have separate earth pits.
- j) For equipment earthing, two earthing leads shall be used if rated voltage of the equipment is above 230 V and one earthing lead shall be provided for equipment rated below 230 V.
- k) The maximum values of earth fault current for the design of the earthing system will be considered based on system requirement.

- l) The neutral point of the 11/0.433kV transformers secondary windings shall be solidly earthed.
- m) **For Transformer Neutral Earthing, Copper conductors shall be used.**
- n) Materials used for earth electrodes shall be designed to suit the ground conditions and shall be Galvanized steel. Preferably the earth conductors buried in the soil are of MS material designed taking into consideration corrosion tolerance.
- o) **For GIS Substation Located at DSS**
 - Substation comprises of 33kV GIS where the earthing of the substations needs to be ensured. Three main considerations to be taken care for grounding of GIS.
 - a. Safety Concern
 - b. Earthing of Electrical components
 - c. The HF Behaviour
 - **However, the recommendations of the earthing system for GIS shall be as per the recommendations given by Vendor.**
- p) **MV/LV Substation Located at Different Locations of Project Area (Including Utilities)**
 - For outlying areas, main earthing conductor will be installed around the building periphery in the form of a ring.
 - Minimum two tap-offs will be provided for connecting with the earthing conductor inside the building connected to the earthing conductor embedded in the floor slab with approximately 50 mm concrete cover.
 - Cross conductors that divide the entire floor area into a grid will be planned to provide earthing connection to all equipment and structures by short and direct earthing leads.
 - In case, the building has more than one floor, each floor will be provided with earth grid as discussed above. All floor earthing grids will be interconnected.
 - Each RCC/Steel column of the building will be connected to the floor earthing grid in the basement / ground floor.

Earthing Design Considerations

- a) **Earth Grid Conductors sizing**
 - The main earth grid conductor sizing shall be done based on the maximum fault current that the conductor has to withstand in a given time for a specific system.
- b) **Grounding Electrodes**

- Earthing system will be designed on the basis of the fault level and soil resistivity of the system as per Indian Standards 3043. Separate earth pit shall be designed for transformer, Motors, Lighting poles and all other electrical equipment and should be connected with the earth bus of the system. Earth Mat shall be provided in switchgear room.
- c) **Equipment Grounding conductors**
- The cross-sectional areas of the conductors of the protective circuit are influenced by the limitation placed on earth loop impedances to ensure disconnection of the circuit in which an earth fault occurs in the prescribed time i.e., instantaneous disconnection and it is also necessary to ensure that the circuit protective earth conductor is protected against the thermal effects of the fault current. Thus, Equipment earth leads are sized considering maximum let through ground fault current allowed by the protective device of associated equipment and from the point of view of mechanical strength.
- d) **Electronic Equipment Earthing**
- The electronic earthing will be provided for electronic equipments. A separate earthing grid shall be formed for electronic equipments and connected to a separate treated earth pit with copper electrode. This in turn will be connected to the common earth grid.
- e) The Material for Earthing Conductors shall be as follows;

S. NO.	EARTHING CONDUCTORS	MATERIAL USED
a.	Conductors above ground	Galvanised Iron (GI)
b.	Conductors buried in ground	Mild Steel (MS)
c.	Embedded in concrete /Floor slab	Mild Steel (MS)
d.	Pipe electrodes for treated earth Pit	Galvanised iron (GI)
e.	Plate Electrode for treated earth pit	Galvanised iron (GI) / Copper (Cu)
f.	Rod electrode for Non-Treated Earth Pit	Mild Steel

Lightning Protection System

- a) The design shall be made according to IS/IEC 62305-3 for Zone-III using any or combination of three methods as follows: -
 - 1. Rolling sphere,
 - 2. Angle of protection
 - 3. Mesh method as per defined lightning protection level for zone of protection according to the risk.
- b) Separation distance shall be considered while designing the ELP as per IEC 62305-3 which is essential to avoid creepage flashover. It can be achieved either by maintaining physical separation distance or by use of High voltage insulated (HVI) cable, as a down conductor to compensate the need of the separation distance.
- c) Lightning Protection components shall be tested for natural weathering and exposure to corrosion in i.e Salt Mist Treatment test according to EN 60068-2-52 and Humid Sulphurous atmosphere treatment test according to BS EN ISO 6988. Metal compatibility shall be ensured to avoid corrosion and contact resistance at connection point.

Illumination System

- a) The basis of design shall be based on the following lighting engineering criteria:
 - (i) Lighting lux level.
 - (ii) Luminance distribution.
 - (iii) Glare restriction.
 - (iv) Direction of incidence of light and shadow effect.
 - (v) Colour appearance and colour rendering of the light source.

The lighting installation can satisfy the requirements if all the quality criteria as prescribed above is followed and executed.

- b) The illumination levels for different areas are chosen as per recommendation of IS and other governing guidelines like National Lighting Code. Depending on Plant application areas such as Equipment areas, Control rooms and Non plant application areas such as Office room, Corridors, lobby, reception, porch and other miscellaneous room/areas various lighting fixtures (industrial/decorative) are selected.
- c) Lighting Design

Following factors shall be considered while arriving at the utilisation factor to determine the number of fixtures for each area / buildings in the plant.

- (i) Maintenance Factor
 - a. Air-conditioned clean interiors like

- control rooms/houses : 0.8
- b. Industrial areas with normal interiors : 0.7
- c. Outdoor street lighting : IS 1944
- (ii) Reflection factor for wall/ceiling
 - a. White and very light colours : 0.7
 - b. Light colours : 0.5
 - c. Middle tints : 0.3
 - d. Dark colours : 0.1
- (vi) Utilisation factor considering the room index at applicable surface reflection factors.
- (vii) The working plane shall be considered at 0.75 m from the floor level.
- (viii) Uniformity factor shall be considered as per National Lighting code.
- (ix) The illumination levels for various areas shall be considered as follows:

Area	Illumination level (Lux)
Control Room	500
Office Room	500
Switchboard Room	200
Cable Galleries	150
Corridor/ Staircase	150
Pump House/WTP	150

Outdoor plant area and Road IS 1944 (Part 1 & 2)

d) Emergency D.C. Lighting

At some of the prominent & critical areas in the off-sites and substations, normal fixtures with battery backup will be provided. These fixtures will be kept plugged in the normal AC lighting system and they will come in service automatically on failure of the normal AC supply and will provide illumination for 3 to 4 hours.

e) Light fitting proposed at various areas

The lighting is designed based on lux level as per IS 3646. The lighting fixtures will be selected based on architectural point of view. The light fixtures selected are listed below:

AREA	TYPE OF LIGHT FITTINGS
Control rooms	LED luminaire with mirror optic decorative recessed type with adjustable reflector
Switchgear Room	LED luminaire Surface / Suspended Mounted Luminaire
Electrical rooms having PDB,	LED Luminaire with Batten type fitting

AREA	TYPE OF LIGHT FITTINGS
MCC, VFD panels, PLC, Fresh Air Fan room / AC Plant room	
Staircases of Substations	LED Luminaire with surface mounted fitting

f) Smart Street Lighting System Design

The illuminance level for road lighting in India shall be as per IS 1944 (Part 1 & 2): 1970 Code of Practice for lighting of public thoroughfare. The layout for street lighting system shall be planned in such a way that uniformity ratio as required by IS: 1944 for Group A1, A2 & B1 type of roads are maintained.

Road classification and lux level requirement as per IS1944 is given in below table;

The following criteria shall be followed for designing the GCMS system for the identified roads;

- Only Group ON-OFF shall be provided for the cycle lane, footpath of all roads.
- Group ON-OFF shall be provided for the carriage way of 45 / 36 / 32/ 24- meter road.
- Group ON-OFF shall be provided for the carriage way of 18-meter roads.

Design criteria for other Building Components & Services

- Ceiling fans shall be provided in offices, control rooms and they shall be connected to local lighting circuit.
- The internal lighting installation shall be installed using single core; PVC insulated copper cable enclosed in galvanized iron conduit. Lighting in external areas shall be installed using multicore armoured cable.
- Ventilation Fans

Variable speed ventilation ceiling fans shall be provided in offices, control rooms, control areas and switchgear rooms. One fan shall be provided for each 10 m² or part thereof of the area concerned.

d) Small Power Outlets

Switched single phase three pin 5 A and 15A receptacles shall be provided throughout. In offices and control rooms they shall be the decorative type and industrial type in all other areas.

Unless required to be provided in greater numbers to power specific Plant items the number of such outlets shall be as follows:

- 5 A type one outlet per 5 m or part thereof of perimeter in offices;
- 5 A type one outlet per 20 m or part thereof of perimeter in all other areas;
- 15 A type one outlet per 20 m or part thereof of perimeter in offices;
- 15 A type one outlet per 20 m or part thereof of perimeter in all other areas.
- 32 A switched three phase and neutral receptacles shall be provided in Switchgear room, where appropriate.

e) The location of outlets shall be approved by the Engineer. The spacing of 5 A and 15 A outlets shall be arranged to suit the intended location of equipment, desks etc.

f) Receptacles for outside areas shall have a degree of protection of IP 55.

The system technical parameters are as following for different voltage level;

- a) The electrical system shall be designed as per relevant standards and local regulations with the stringent of the two regulations being the governing parameter.
- b) Following System Parameter have been adopted for designing the electrical system;

Nominal (Rated) System Voltage	220kV	33kV	11kV	0.415kV
Highest System Voltage	245kV	36kV	12kV	1.1kV
Lightning Impulse Withstand Voltage (1.2/ 50 microsecond)	1050 kVp	170 kVp	75 kVp	6 kVp

Power Frequency Withstand Voltage for 1 minute	460 kV rms	70 kV rms	28 kV rms	3 kV rms
System Neutral Earthing	Solidly Earthed	Solidly Earthed	Solidly Earthed	Solidly Earthed
Fault Level of System	40kA for 3 sec.	31.5kA for 3 sec.	25kA for 1 sec.	25kA for 1sec
Frequency	50 Hz	50 Hz	50 Hz	50 z

B.1.12. PERFORMANCE CRITERIA

B.1.12.1. GENERAL

- The contractor shall carry out the work in accordance with the Detailed design and Good for Construction drawings to be prepared by the Contractor.
- Preliminary Drawings, Specifications, data sheets and other documents forming part of the Contract.
- The Contractor shall be fully responsible for the performance of the selected equipment (installed by him) at the specified parameters and for the efficiency of the installation to deliver the required end result.
- The Contractor shall guarantee that the Electrical system as installed shall perform to complete satisfaction of the owner.
- The Contractor shall also guarantee that the performance of various equipment individually, shall not be less than the quoted capacity; also, actual power consumption shall not exceed the quoted rating, during testing and commissioning, handing over and guarantee period.
- Rating of all items shall be appropriate for the conditions on the particular site on which the item will be used. All the equipment shall be fit for continuous work under the most severe weather conditions of site.
- The Contractor shall hold himself fully responsible for reinstallation or replacement free of cost to Owner the following:
 - a) Any defective work or material supplied by the Contractor.
 - b) Any material or equipment damaged or destroyed as a result of defective workmanship by the Contractor.

B.1.12.2. MANUFACTURERS

- All the electrical equipments to be supplied under this contract have to be of reputed makes as approved by DHBVN/UHBVN and the employer. The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily since at least last 5 years continuously. Certificates from end users, regarding their satisfactory Performances, shall have to be submitted in this regard.
- Where manufacturers have furnished specific instructions relating to the materials used in this job, covering points not specifically mentioned in these documents, these instructions shall be followed in all cases.
- Where manufacturer's names and/or catalogue numbers are given, this is an indication of the quality, standards and performance required.
- For items not covered under the List of Approved Makes', contractor shall offer items of first-class quality, standards and performance and obtain the approval of Construction Manager/Consultants before procuring them.
- Where interfacing occurs, equipment shall be mutually compatible in all respects.

B.1.12.3. GIS SWITCHGEAR

- Gas leakage rate shall be less than 0.5% per year.
- The breakers shall be suitable for M2, E2 & C2 Class.

B.1.12.4. POWER TRANSFORMER

- Transformers shall operate without injurious heating at the rated kVA at any voltage within +/- 10 percent of the rated voltage of that particular tap.
- Transformers shall be capable of delivering the rated current at a voltage equal to 105 percent of the rated voltage without exceeding the limiting temperature rise.
- Transformer for two or more limits of voltage or frequency or both shall deliver its rated kVA under all the rated conditions of voltage or frequency or both; provided an increase in voltage is not accompanied by a decrease in frequency.
- The transformer and all its accessories like (bushing / neutral) CTs etc. shall be designed to withstand without injury, the thermal and mechanical effects of any external short circuit to earth and short circuits at the terminals of any winding for a period of one (1) sec. Transformer shall be capable of withstanding thermal and mechanical stress caused by symmetrical or asymmetrical faults on any winding.

- Transformers shall be designed for operation at a frequency of 50 Hz.
- The maximum flux density in any part of the core and yokes, at normal voltage and frequency shall be such that the flux density under overvoltage conditions as specified in technical data sheet and shall not exceed the maximum permissible values for the type of core and yoke material used. The type of material and values of flux density in the core/yoke for the 100%, 110%, 125% and 140% and the hysteresis characteristic curves shall be included in the Bid and in relevant Data Sheet (to be filled by Contractor) and shall be subject to the EMPLOYER's approval.
- In case of transformers with variable flux density the voltage variation which affects the flux density at every tap shall be kept in view while designing transformers.
- Radio interference and Noise Level:
- The transformers shall be designed with particular attention for suppression of maximum harmonic voltage, especially the third and the fifth so as to minimize interference with communication circuits.
- The noise level, when energized at normal voltage and frequency with fans running shall not exceed, when measured under standard conditions, the values specified in NEMA, TR-1.
- Transformers shall be designed for 110% continuous over fluxing with stand capability & in line with the standard requirements.
- Transformers shall operate below the knee point of the saturation curve at 110 percent voltage to preclude ferroresonance and non-linear oscillations.
- Unless otherwise stated, transformers shall be capable of operation continuously, in accordance with the applicable standard loading guide at their rated kVA and at any of the specified voltage ratios.
- Loading requirements shall be complying to the requirements as specified in IS 6600 & IS 2026 –Part 7.
- Overloads shall be allowed within the conditions defined in the loading guide of the applicable standard. Under these conditions, no limitations by terminal bushings, on-load tap changers or other auxiliary equipment shall apply.
- All rated quantities subject to the VENDOR's guarantees shall be within the tolerances given in applicable standards.
- Regulation shall not exceed 5% at 75 deg C at full load. Specific requirements for transformer temperature rise and hot spot temperature. Yearly weighted ambient temperature shall be considered as minimum 32 deg C or actual yearly weighted ambient temperature (Based on past 50 years data, whichever is higher) for all design and calculation purpose. Overloading as per IEC 60076-7 shall be possible.

- Hot spot temperature shall not exceed 95 deg C with reference to 50 deg C ambient temperature.
- Maximum temperature rise of top oil shall not exceed 50 Deg C. Maximum temperature rise of winding shall not exceed 50 Deg C. Both the maximum rise are with reference to 100 Percent loading of the transformer. SUPPLIER shall submit the relevant calculation to substantiate the same for review and approval to EMPLOYER. This shall be further demonstrated and verified during Inspection & testing at SUPPLIER's works.
- The Contractor shall guarantee the declared efficiency of the transformers.
- The maximum losses shall minimum of that of losses given in CBIP manual for transformers and BEE guidelines. In case of BEE, the transformer losses at rated voltage and frequency shall be at least BEE 4 star rating. The permissible tolerances on the guaranteed values of transformer losses shall be as per IEC 60076.

B.1.12.5. DISTRIBUTION TRANSFORMER

- Transformers shall operate without injurious heating at the rated kVA at any voltage within + /- 10 percent of the rated voltage of that particular tap.
- Transformer shall be capable of delivering rated current at a voltage equal to 105% of rated voltage.
- Transformers shall be designed for operation at a frequency of 50 Hz.
- Transformers shall be designed for 110% continuous over fluxing with stand capability. Transformers directly connected to the generators shall in addition shall have an over fluxing capability of 125% for 60 seconds and 140% for 5 seconds.
- Overloads shall be allowed within the conditions defined in the loading guide of the applicable standard. Under these conditions, no limitations by terminals, tap changers or other auxiliary equipment shall apply.
- The maximum losses shall minimum of that of losses given in ECBC (Energy conservation and Building Code) for transformers and BEE guidelines. In case of BEE, the transformer losses at rated voltage and frequency shall be at least BEE 4 star rating. The permissible tolerances on the guaranteed values of transformer losses shall be as per IEC 60076.
- Transformer shall be self-extinguishing in the event of fire or arcing and no toxic or corrosive gases shall be released.
- There shall not be any risk of cracking of the epoxy casting in the transformer.
- Transformer shall have partial discharge level of less than (10pC).

- Transformer shall be of low no load loss & low noise. Values of noise level & testing shall be as specified in IEC/applicable standards.
- Transformer shall be certified for following:
Class F1 : - "Fire Behavior"
Class C2 : - "Climatic"
Class E2 : - "Condensation and humidity"
- Vendor to confirm the suitability of the transformer for high inductive loads (high current, short time, unbalance loads).
- Transformer shall be suitable for switching with Vacuum Circuit Breakers (VCBs). Resonance frequency of the winding shall be such as to avoid resonance with the switching impulse of VCBs & overstress of the insulation.
- The sound level of the transformer shall not exceed the limit indicated by NEMA – TR1 standard under any specified operating conditions.
- The Contractor shall guarantee the declared efficiency of the transformers.
- The temperature rise shall be restricted to 40 degrees Celsius above ambient. Trip setting at full load shall be at 35 degrees Celsius above ambient.

B.1.12.6. LIGHTING FIXTURES

- There shall be 5 years replacement warranty for LED lighting fixtures.

B.1.12.7. POWER CUM MOTOR CONTROL CENTRE/APFC PANEL

- The Contractor shall give a guarantee for trouble free operation of the equipment offered under stipulated operating conditions. All measuring instruments to be used for performance test shall have certified accuracy of + 0.5 % and shall be arranged by the Contractor during the test.
- The Contractor shall give a guarantee for temperature rise inside the panel not to exceed over 85 Deg. C for Aluminium bus bars and 90 Deg. C for Copper bus bars during actual performance test at supplier's works.
- The panel shall be 4B enclosure.

B.1.12.8. HT / LT POWER CABLES AND CONTROL & INSTRUMENTATION CABLES

- The Contractor shall give a guarantee for trouble-free operation of the Cables offered under the stipulated operating conditions and fulfill guaranteed technical parameters/performance.

TECHNICAL SPECIFICATION- SCHEDULE D.

POWER SUPPLY SYSTEM

GENERAL

The general requirement include design, manufacture, testing at works, supply and delivery at site, unloading and storing the equipment at site of installation, testing and commissioning of the equipment at site of all electrical equipment's are covered under this section of this Specification.

Contractor shall supply the equipment in accordance with the specification, data sheets. Attached preliminary drawings are for reference and detail engineering will be done by Contractor.

All the electrical equipment's to be supplied under this contract have to be of reputed makes. The equipment of those Manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily since at least last 5 years continuously. Certificates from end users, regarding their satisfactory Performances, shall have to be submitted in this regard

For uniformity of appearance, all switchgear and control panels shall have a common appearance and colour.

In order to reduce the spares holding to a minimum electrical, control and instrumentation components of a similar type and purpose used throughout the Works shall, unless it can be shown by the Contractor to be impractical, be of the same Manufacturer and type / series.

All ventilation grills provided on electrical Substation building shall be provided with fly screens to prevent the entry of insects.

The technical specifications outlined in this document provide comprehensive guidelines for the supply of equipments and execution of electrical works under the purview of the State Power Transmission and Distribution Company (HVPNL & DHBVN). These standards are intended to ensure consistency, quality, and safety in all electrical installations, maintenance, and commissioning activities.

The specifications are based on best practices, industry standards, and regulatory requirements, aligning with national and international electrical codes. Adherence to these specifications is mandatory for Contractor.

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Contractor to refer the specifications of equipment as per details as tabulated below. **The detailed specifications are available on the web site of DHVBN i.e. www.dhbn.org.in. The latest specification on the date of submission of bid will be applicable.** The detailed specifications are attached as below:

S.N.	TITLE	STANDARD REFERENCE	SPECIFICATION NO.
1.	12.5 MVA, 33/11 KV POWER TRANSFORMER	DHBN	CSC-74-R-II/DH/UH/P&D/2015-16
2.	10 MVA, 33/11 KV POWER TRANSFORMER	DHBN	CSC-XXVII/DH/UH/P&D/2015-2016
3.	33KV GAS INSULATED SWITCHGEAR	DHBN	CSC-88/R-1/DH/UH/P&D/2015-16
4.	33KV RING MAIN UNITS (RMU) WITH INBUILT FPI & FRTU	DHBN	CSC-118/DH/UH/P&D/2015-16
5.	33KV/0.415KV, 100KVA COPPER WOUND (CSP TYPE)- DISTRIBUTION TRANSFORMER	DHBN	CSC-178/DH/UH/P&D/2017-18
6.	19/33 KV TR-XLPE POWER CABLES (ARMOURED)	DHBN	CSC-110/DH/UH/P&D/2015-16
7.	HEAT SHRINK JOINTS & TERMINATIONS FOR 33KV	DHBN	CSC-121/DH/UH/P&D/2015-16
8.	INSULATING MATS FOR USE UPTO 33KV	DHBN	CSC-210/DH/UH/P&D/2020-21
9.	11KV/0.415KV, COMPACT SUBSTATIONS	DHBN	CSC-129/R-1/DH/UH/P&D/2016-17

S.N.	TITLE	STANDARD REFERENCE	SPECIFICATION NO.
10.	11kV RING MAIN UNITS (RMU) WITH INBUILT FPI & FRTU	DHBVN	CSC-117/R-III/DH/UH/P&D/2018-19
11.	11 kV SWITCHGEAR PANELS VACUUM TYPE WITH 11 kV CAPACITOR CONTROL PANELS	DHBVN	CSC-81/R-V/UH/DH/P&D/2022-23
12.	11 kV BUS COUPLER WITH TRUNKING CHAMBER	DHBVN	CSC-244/UH/DH/P&D/2024-25
13.	11 kV AUTOMATICALLY SWITCHED CAPACITOR BANKS AT 33/11kV SUB-STATIONS	DHBVN	CSC-XXXXIII/DH/UH/P&D/2009-10
14.	11KV/0.415kV, 400KVA TO 1000 KVA - DRY TYPE DISTRIBUTION TRANSFORMERS	DHBVN	CSC-126/R-1/DH/UH/P&D/2016-17
15.	6.35/11 KV TR-XLPE POWER CABLES (ARMOURED)	DHBVN	CSC-111/R-II/DH/UH/P&D/2020-21
16.	HEAT SHRINKABLE / PUSH ON TYPE TERMINATIONS FOR 11KV XLPE CABLES	DHBVN	CSC-86/R-I/DH/UH/P&D/2015-16
17.	HEAT SHRINKABLE STRAIGHT THROUGH JOINTS FOR 11KV XLPE CABLES	DHBVN	CSC-85/DH/UH/P&D/2014-15
18.	RTU AND FRTU FOR SCADA OPERATION	DHBVN	CSC-134/R-1/DH/UH/P&D/2016-17
19.	REMOTE TERMINAL UNIT (RTU)	DHBVN	CSC-228/DH/UH/P&D/2021-22
20.	SCADA-DMS-OMS, WFM, LDMS, AVLE AND SOFTWARE REQUIREMENTS	DHBVN	CSC-227/DH/UH/P&D/2021-22
21.	COMMUNICATION NETWORK FOR RMUs	DHBVN	CSC-224/DH/UH/P&D/2021-22
22.	OUTDOOR LT FEEDER PANEL WITH SWITCHGEAR	DHBVN	CSC-133/R-II/DH/UH/P&D/2017-18

S.N.	TITLE	STANDARD REFERENCE	SPECIFICATION NO.
23.	NI-CD ALKALINE BATTERIES & STATIC BATTERY CHARGER FOR NI-CD ALKALINE BATTERIES	DHBVN	CSC-60/R-I/DH/UH/P&D/ 2011-12
24.	MAINTENANCE FREE EARTH FOR ELECTRICAL INSTALLATION	DHBVN	CSC-140/DH/UH/P&D/ 2015-16
25.	TRANSFORMER FENCING	DHBVN	CSC-137/R-1/DH/UH/P&D/ 2022-23
26.	LT SINGLE CORE, TWO CORE, THREE CORE, 3.5 CORE AND FOUR CORE CROSS LINKED POLYETHYLENE (XLPE) INSULATED, PVC SHEATHED (TYPE ST-2), UN-ARMoured/ ARMoured POWER CABLES.	DHBVN	CSC-201/R-I/DH/UH/P&D/ 2020-21
27.	FOUR CORE AND TWO CORE XLPE CABLES OF VARIOUS SIZES 16 SQMM, 10 SQMM & 6 SQMM	DHBVN	CSC-XXXXI/DH/UH/P&D/ 2009-10
28.	FOUR CORE AND TWO CORE PVC INSULATED & PVC SHEATHED LT ARMoured CABLES	DHBVN	CSC-XIII/R-IV/DH/UH/P&D/ 2020-21
29.	GI WIRE	DHBVN	CSC-16-R-II/DH/UH/P&D/ 2015-16
30.	LAYING & INSTALLATION OF 33KV, 11 KV AND LT UNDER GROUND CABLES	DHBVN	CSC-138/R-1/DH/UH/P&D/ 2017-18
31.	LV DG SET	HVPNL	-
32.	NITROGEN INJECTION FIRE PREVENTION & EXTINGUISHING SYSTEM (NIFP)		CLAUSE I

S.N.	TITLE	STANDARD REFERENCE	SPECIFICATION NO.
33.	FIRE ALARM & DETECTION SYSTEM		CLAUSE II
34.	UPS SYSTEM		CLAUSE III
35.	ADVANCE METERING INFRASTRUCTURE		CLAUSE IV
36.	LIGHTING AND SMALL POWER SYSTEM		CLAUSE V
37.	STREET / FLOOD LIGHTING SYSTEM WITHIN SUBSTATIONS & SMART GROUP STREET LIGHTING CONTROL & MONITOR SYSTEM (GCMS)		CLAUSE VI
38.	OCTAGONAL STREET LIGHT POLE		CLAUSE VII
39.	EARTHING SYSTEM & LIGHTNING PROTECTIONS SYSTEM		CLAUSE VIII
40.	SAFETY REQUIREMENTS		CLAUSE IX
41.	EV CHARGERS		CLAUSE X
42.	RIGID, DOUBLE WALL CORRUGATED (DWC) HIGH DENSITY POLYTHYLENE PIPE		CLAUSE XI

TECHNICAL SPECIFICATIONS OF EQUIPMENT & SYSTEM OTHER DHBVN

I. NITROGEN INJECTION FIRE PREVENTION & EXTINGUISHING SYSTEM (NIFP)

SCOPE

This specification covers the requirements of Fire Prevention; Extinguishing and Monitoring system for oil filled Power Transformer. This equipment shall be connected to each 33/11 kV Power Transformers.

The scope includes design, manufacture, testing at vendor's works; delivery to site; erection, testing & commissioning; training and handing over of Nitrogen Injection Fire Prevention and Extinguishing system complete with all accessories & fittings for the Power

transformers.

The CONTRACTOR shall ensure that fire prevention and extinguishing system offered is foolproof and reliable. Nothing in this specification shall be construed to relieve the CONTRACTOR of this responsibility.

CODES AND STANDARDS

The design manufacture and performance of the equipment shall comply with to all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. Some of the of the standards but not limited to following are,

- i) Indian Electricity Rule, 1956.
- ii) Relevant concerned regulations as laid by Tariff Advisory Committee (TAC)
- iii) Relevant clauses of Oil Industry Safety Directorate No. OISD-Std-173, 1998.
- iv) Fire protection scheme to the power transformer should have authentic certification regarding performance similar to one issued by TAC/ Research Design Standard & Organization (RDSO) /any other approved standard laboratory.

SYSTEM DESCRIPTION

Nitrogen Injection Fire Prevention and extinguishing system designed for oil filled transformers, shall prevent tank explosion and the fire during internal faults resulting in arc where tank explosion will normally take few seconds after arc generation and also extinguish the external oil fires on transformer top cover due to tank explosion and/or external failures like bushing fires, due to OLTC fires and fire from surrounding equipments.

On activation (after receiving the signal from PRV, RPRR etc.), the oil drain starts from the tank top through outlet valve to reduce the tank pressure and conservator is isolated with the operation of conservator shutter to prevent the oil flow from conservator to tank.

Nitrogen injection starts from the lower side of the tank through inlet valve to create stirring action mixing the warm and cold oil thus reducing the temperature of top oil surface below flash point to extinguish the fire.

Fire detectors provided on the transformer body shall take minimum time for detection of fire and initiate the fire protection system on receipt of other required signals.

DESIGN REQUIREMENT

The system shall operate in 'Auto'/'Remote Electrical'/'Local Manual' modes. Provision shall be available to keep the system "Out", which is necessary for preventing any mal-operation during maintenance of the transformer. The system is equipped with automatic control of fire both in prevention and in extinction mode.

Operation of the system can be done from control Box (Located in Control & Relay Panel (CRP) room) as well as locally from the Fire Extinguishing cubicle.

System shall be activated through differential or fire detector and buchholz relay in parallel with Pressure Relief Device (PRD) in prevention mode. In extinction mode system activation takes with the operation of Fire detector and buchholz relay in parallel with PRD.

Fire protection system shall operate in Auto mode on receipt of minimum three positive feedback signals, namely differential relay or fire detector, pressure relief valve or rapid pressure rise relay (RPRR) or Buchholz relay and electrical isolation of transformer through master trip relay or HV & LV circuit breaker in series, to avoid any mal-operation of system.

The Local manual operating system shall be used only in case if the system fails in Auto mode/ Remote electrical mode/ power failure.

The system shall preferably have built in facility for monitoring or display of the following.

- i) Open /Close status of valves. ii) Healthiness of all sensors.
- ii) Operation of PRV/Rapid Pressure rise relay (RPRR).

Provision shall be available for annunciation (along with audible alarm) of the following.

- i) Detection of fire due to external causes
- ii) Low nitrogen pressure.
- iii) System initiated
- iv) Tank pressure beyond the set limit
- v) Operating signal cable faulty.
- vi) Operation of conservator isolation valve (PNRV)
- vii) Supply failure.

The system shall have built-in-on-line testing facility, which will be operable without affecting the functioning of the Transformer.

The protection system shall be compatible to be hooked on to the SCADA or fire alarm system. Suitably spare contacts shall be made available for operation of fire system. The

system using microprocessor micro controller shall be preferred instead conventional method.

All valves used in system shall preferably be stainless steel ball / butterfly type. Limit switches shall be provided wherever required. The connecting cables shall be fire retardant low smoke (FRLS) armoured cable. Cables passing along the top of the transformer shall be the fire survival (FS) type.

Colour of the Control box, Fire extinguishing cubicle & Signal box shall be fire red.

SCOPE OF SUPPLY

Following are the main components/ items for the Nitrogen Injection Fire Prevention and Extinguishing system

Fire Extinguishing Cubicle (FEC) fitted with the base frame to be place on plinth suitable away from the transformer, consists of:

- i) Nitrogen cylinder with pre-set manometer regulator assembly and nitrogen release valve.
- ii) Oil drain pipe fitted with electro mechanically operated quick de-pressurisation valve up to FEC and from the FEC to oil pit.
- iii) Nitrogen injection pipe from FEC to transformer tank.
- iv) Transformer pressure reducer designed to reduce pressure and flow of nitrogen to the base of the transformer.

Control box with electrical function for activation monitoring devices and indication by LED display for the whole explosion and fire prevention system. The control box shall be located inside Control room.

Transformer Conservator Isolation Valve (TCIV) to be fitted in the conservator pipe line, between conservator and Buchholz relay which shall operate in dual mode for isolating the conservator during the abnormal flow of oil due to rupture of the tank or bursting of bushing and not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provide with handle for pad locking. This TCIV shall be provided with the proximity switch for remote alarm indication and with visual position indicator.

Fire detectors with brackets to be fixed on Transformers tank top cover for sensing fire.

Signal box fitted with brackets to be mounted on Transformer side wall for terminating cable connectors from fire detectors and TCIV.

Interface with the oil pits shall be in the scope of Contractor. The same shall be specified in the interface details.

Onsite training during commissioning of the equipment shall be given by the Contractor.

Supply, Install, Laying & fixing of FRLS/ Fire survival power/ control cables,

termination of cables, cable tags, cable glands (including supply) between panel/ equipment and field instruments shall be as follows,

- i) Fire survival cable (min 2.5 sq. mm) stranded copper conductor for connection of fire detectors on transformer top cover, in parallel and up to signal box/ marshalling box.
- ii) Fire retardant low smoke (FRLS) cable (min 2.5 sq. mm) stranded copper conductor for connection between transformer signal box/ marshalling box control to fire extinguish cubicle.
- iii) Fire retardant low smoke (FRLS) cable (min 2.5 sq. mm) stranded copper conductor for connection between control box to DC supply (DCDB) and AC supply source (ACDB) and fire extinguisher cubicle to AC supply source, signal box/ marshalling box to Transformer Conservator isolation valve connection on Transformer.
- iv) Potential free contacts from substation (by paralleling the potential free contacts of each control box located in substation) shall be wired up to Remote Terminal Unit (RTU) located in substation for remote indication (SCADA system). Cabling between RTU and control box shall be under the scope of Contractor. However, RTU shall be separately supplied by the purchaser.

POWER SOURCE

Control box : 110 V DC for system operation.

Fire extinguishing cubicle : 230 V AC, for panel illumination and space heating.

SPARES

Mandatory Spares

Contractor shall indicate the mandatory spares for the following items

- i) One (1) no. Nitrogen cylinder
- ii) 20% of the required no. of heat detectors for each transformer.

Recommended Spares

Contractor shall furnish recommended spare parts for trouble free operation of the system during the contract period.

CIVIL WORKS

Plinth for mounting of fire extinguishing cubicles as well required fire wall for safe manual operation from near the transformer shall be provided by Contractor.

DRAWINGS/ DOCUMENTS TO BE SUBMITTED FOR APPROVAL

Contractor shall furnish all equipment/ components and accessories etc. as required making the system complete and ensure trouble-free operation in all respect.

Contractor shall furnish all drawings, data sheets, installation document etc. for approval/ reference purpose before commencement of manufacturing/ execution as required. However, some the essential drawings/ documents are listed herein.

System description

- a) GA drawing of FEC, Control cabinet, Signal box
- b) Size of power & control cable with justification
- c) Civil foundation drawing for mounting of FEC
- d) Wiring diagram of control box and FEC
- e) Block diagram for control interface

The Contractor shall, furnish the complete details including bill of materials of the fire prevention and extinguishing system offered. The list of all accessories including FRLS, fire survival cable, pipes, valves, sensors, control cubicle, nitrogen gas cylinder etc. shall be listed out and furnished in the offer.

Operation / Instruction manuals for “Nitrogen Injection Fire Prevention & Extinguishing system” technical catalogues, calibration certificate shall be furnished in 4 sets in the form of hard copies and 2 sets in soft form.

A copy of TAC approved certificate.

As built drawings showing equipment disposition & cable layout shall be furnished by the Contractor after commissioning.

II. FIRE ALARM & DETECTION SYSTEM FOR SUBSTATION

APPLICABLE STANDARD

- a) IS-2189, IS-1646, IS- 034
- b) BS 5445 Part 1, 5, 7, 8, 9
- c) BS 5839 Part 2
- d) BS 3116 Part 4
- e) NFPA - National Fire Protection Association
- f) NFPA 70 - National Electrical Code (NEC)
- g) NFPA 72 -National Fire Alarm Code
- h) NFPA 101 - Life Safety Code
- i) UL - Underwriters Laboratories Standards, UL Listing
- j) EN 54 - standards
- k) IS 2189 - Code of Practice for selection, installation and maintenance of Automatic Fire detection and Alarm System
- l) NBC - Standard Building Code of India

SCOPE

Design, Engineering, Supply, Installation, Erection, Testing and Commissioning include Operation and Maintenance Fire Alarm System works.

After award of the contract, the Contractor shall be responsible to conduct site survey & accordingly estimate the actual required BOM as per site conditions.

The Contractor is required to study the drawings of the building layouts and suggest appropriate number of quantities and quote accordingly.

The Contractor shall obtain the required permits / permissions from the related authorities/ regulatory bodies as applicable before commencing the work.

Any co-ordinations amongst main Contractor, sub-contractor, client required for seamless job execution shall be carried out by awarded Contractor.

Contractor shall provide complete fire detection and alarm system for the substation building. The fire alarm system shall be microprocessor based analogue addressable intelligent system and the equipment shall confirm to UL/ NFPA/ NBCI, etc.

Following equipment shall be supplied by the Contractor:

- a) Addressable Manual Call Points
- b) Addressable Automatic Smoke Detectors
- c) Photo-electric Smoke Detectors
- d) Microprocessor Based Fire Alarm Panel with necessary indicators, interlocks, switches, audio-visual alarm, etc.
- e) Miscellaneous Components including control modules and monitor modules, etc.
- f) Power Supply Unit
- g) Cables and accessories as per enclosed specification
- h) Addressable Hooter cum strobe

Contractor shall provide necessary potential free contacts/ communication modules in the control panel to transmit signals via a communication link to remote control station.

Fire alarm panel shall be located in the Control Room with hooter, alarms, push buttons, lamps and LEDs with visual indication of fire and power supply shall be provided near the main entrance of Control Room.

GENERAL REQUIREMENTS

The design construction and operational features of all types of detectors shall be in accordance with relevant standards.

The automatic fire detectors shall be of addressable type having the following features:

- (i) Individual addressing capability at the fire alarm panel to facilitate precise pointing of fire location / detector activated.
- (ii) Discrimination between a false fire and real fire condition.
- (iii) Pre-alarm in case of detector or a section of detectors requiring maintenance.
- (iv) All types of addressable detectors / interface units shall be compatible with the fire alarm panel.

All types of detectors offered shall have in-built electronic circuit for addressing capability for individual address on the fire alarm panel. In case of manual call points where the addressing capability is not an integral part, a separate addressable interface unit shall be provided.

All types of detectors shall be suitable for connection in any particular loop / circuit with any other type of detector. In case of non-addressable type of detector, group of such detectors shall also be suitable for connection in the same loop / circuit by providing suitable addressable interface units.

Addressable manual call points

Each addressable manual call point, suitable for wall mounting, shall comprise a break glass unit enclosed in a box. The arrangement shall be such that when completely assembled, the front glass sheet keeps the pull lever actuated, as long as the glass cover is intact. In case of fire, when the glass cover is broken to give a fire alarm, the pull lever shall be automatically released by its spring action and hence the necessary signal to the fire alarm panel for annunciation of fire and its address given.

Addressable photo-electric smoke detectors

This detector, working on the light scattering principle, shall be capable of detecting visible smoke from smouldering fires long before the fire breaks out into visible flame. Smoke detectors shall be marked with their normal sensitivity and tolerance limits and listed spacing as per relevant standards. These shall be provided in control room below ceiling.

Other miscellaneous components

The fire alarm system shall comprise other miscellaneous components such as addressable interface units, fault isolator modules, monitor modules and control modules, hooters, sirens, etc. which augment the main fire alarm system. The components of the

fire alarm system will be wired using two core minimum 1mm² copper wires with overall FRLS sheathing laid in 16 SWG GI conduits, for additional safety. As an alternative, Contractor shall supply armoured cable for wiring the components and do away with the conduits.

Power supply unit

The power supply unit in the fire alarm panel shall consist of a battery charger suitable for operation on 240 V, AC single phase. The charger shall normally supply the battery trickle charging current and DC load of the fire alarm system. Fire Alarm Panel shall be provided with redundant & reliable Power supply & battery backup. Back-up/ secondary supply - Usually sealed lead-acid batteries. FDAS panel shall be backed up with its built in SMF Battery with backup for 48 Hrs under normal condition and 120 Min under alarm condition & battery charger.

Interfaces With Other Systems

The fire alarm system shall have an industry standard protocol interface suitable for hooking up to the SCADA system for the substation. All the signals, reports, alarms, etc. generated by the fire alarm system will be annunciated on the remote terminal located at remote end control station.

MICROPROCESSOR BASED FIRE ALARM PANEL

Microprocessor based fire alarm panel shall comprise of the processor, various functional modules, adequate number of loop modules for detector loops, display devices, output modules for alarm control & interlocks, communication modules for interfacing, etc., as required by the system to incorporate all the features called for in the specification. The control system shall be analogue type.

The microprocessor-based fire alarm panel shall incorporate the following features.

- a) Continuous supervision of the detector connecting lines, individual detector performance / operation and disconnection / removal of detectors. The system shall automatically reset on clearance of a fault.
- b) Individual detector addressing capability.
- c) Pre-alarm in case of any detector / detectors requiring maintenance.

- d) Facility shall be provided such that for alteration or access to the stored program the relevant codes are to be entered. The system should be protected against interference by unauthorised personnel.
- e) Compatibility with all detector / devices connected to the fire alarm panel.
- f) Logging of alarm, time and action text on printers.
- g) Programmed activation of various interlocks with fire protection system and other associated system such as ventilation and air conditioning, etc.
- h) Programmed activation of sequence of events to be carried out in case of fire in any particular protective area of the plant including activation of fire alarm sounders or evacuation alert signal.
- i) System incorporating necessary features for hooking up with plant intra-site communication system.
- j) It shall be possible to create zones or logical groups in fire alarm panel. Each zone may contain a number of devices and each of these zones shall be individually addressable.
- k) The design of the fire alarm panel shall be such as to incorporate the following features.
 - (i) The circuits shall be arranged such that a fault in the detector or an open circuit in the connecting line does not affect the operation / performance of other detectors connected in that line and does not prevent receipt of fire alarm signals on the fire alarm panel from other detectors. In case of a short circuit in the connecting line, short circuit isolating devices shall be provided such that it will affect only the section between the isolating devices.
 - (ii) Alarm verification features for smoke detectors shall be such that the detector activates the alarm within one minute if the detector is still in activated condition. In case of other type of detectors, the alarm shall be initiated within 15 seconds.
 - (iii) The maximum no. of detectors or devices in a circuit loop shall be 99. The Contractor shall clearly indicate the minimum no. of detectors that can be connected in a circuit without affecting the performance / operation of the system.
 - (iv) The fire alarm panel shall have adequate number (minimum two) of detector circuit / loops so as to cover all the areas to be protected in the sector. Provision shall also be made in fire alarm panel to add additional detector loop modules for further expansion.
 - (v) The fire alarm panel and field devices shall be suitable for Class A wiring to meet all the requirements specified for the system.

- (vi) The fire alarm panel shall automatically and periodically (at least once in 24 hrs) compare each sensor's operating characteristics with set sensitivity and recalibrate the dual alarm limits, if necessary.
- (vii) Central processing unit (CPU)
- Central processing unit (housed in the fire alarm panel) utilising the microprocessor shall form the central monitoring unit for all the functions of the fire alarm system.
 - CPU shall have provision for communicating / interfacing with various components of the microprocessor based fire alarm system viz., fire alarm panels, VDU, printer, etc.
 - The system software shall be specifically designed for fire detection and alarm system application which includes alarm processing, control status monitoring and various other functions to meet all the requirements of the system specified.
 - The capacity of the processor shall be adequately designed to include all input / output signals and various functional requirements of the system.
 - The processor offered shall be minimum 16-bit processor.
 - The processor shall be designed such that for graphic display, time for display on VDU screen on operator's request shall be less than 3 seconds.

TEST

The Contractor shall conduct all the type, routine and functional tests for all equipment supplied under this contract and for the system as installed. Tests shall be conducted as required by the relevant standards as well as by the PURCHASER/ END USER. Copies of all test certificates shall be furnished.

III. UPS SYSTEM

This specification covers the requirements of Uninterruptible Power Supply (UPS) for SCADA & critical AC load systems or any other critical systems, which have stringent requirements, imposed on voltage and frequency regulation, harmonic content and transient recovery.

APPLICABLE STANDARD

The design, manufacture and testing of equipment shall be carried out as per the latest Indian Standards/International standards.

Wherever the Indian Standards do not exist, the equipment/components shall be designed, assembled and tested in accordance with the latest editions of the Standards of the International Standard Institutions, Institution of Electrical & Electronic Engineers, USA (IEEE), National Electrical Manufacturers Association, USA (NEMA) and/or International Electro-Technical Commission (IEC).

PARTICULAR	APPLICABLE STANDARD
Basic climatic & mechanical durability tests for components for electronic and electrical equipment	IS 9000
Environmental tests for electronic & electrical equipment	IS 9000
Transformer and inductors (Power, Audio, Pulse & switching) for electronic equipment	IS 6297
Printed wiring boards	IS 7405
Environmental requirements for semiconductor devices and integrated circuits	IS 6553
Terminals for electronic equipment	IS 4007
HRC Catridge fuses	IS 9224, BS 88, IEC 60269-1
Indicating Instruments	IS 1248, BS 89, IEC 60051
Degree of protection	IS 13947, IEC60 947-1
Semiconductor converters	IEC 60146
Semiconductor rectifier equipment code	IS 6619
Thyristor converters	IS 5082
Emergency std by power systems	IEEE 446
Sealed lead acid cells	IEC 60896-2
Vented type Ni-Cd batteries	BS : 10918, IEC 60623
Stationary cells of batteries lead acid type- Tabular plate	BS : 1651, IEC 60896-1
IEEE recommended practice for sizing Ni-Cd batteries for stationary application.	IEEE 1115
1100V cables	IS 1554

Surge withstand capability test in accordance with	IEC 60255-5, ANSI C37-90-1
Harmonic levels	IEEE-519

SYSTEM REQUIREMENT

The UPS system shall be true on-line static type and the components of UPS shall isolate power line transients, frequency and voltage variations. The UPS shall provide no-break power supply to the critical loads under normal conditions, during outages in the input power and during failure / mal operation of the main components of the UPS by switching the alternate supply. Static UPS systems shall be as described below.

Parallel redundant operation with bypass to regulated supply

UPS system shall be working in Parallel Redundant configuration having two sets of 100% rectifiers, batteries and inverters and shall share the load. Under normal conditions, when AC mains power is available, both the rectifiers shall operate independently and supply DC power for float / boost charging the batteries and simultaneously to inverters. In case of failure in any one rectifier, the respective battery shall feed the load on the bus without any interruption. Each rectifier shall be designed for feeding inverter load and float / boost charging of the battery to its rated capacity within 10 hours. Each rectifier shall be equipped with automatic 'On Line' as well as manual charging facility.

Normally both inverters will be synchronized with each other and with bypass (Solid State Voltage Stabilizer) supply. The two inverters shall operate in parallel and share the load equally. When a disturbance / fault occurs in any one of the inverters, the faulty unit shall automatically get disconnected and the entire load shall be fed from the other inverter. In case, both inverters develop a fault, the complete load shall be transferred to stabilized bypass (Solid State Voltage Stabilizer) supply through static switches and retransfer of load from bypass to inverter supply shall be automatic.

Both the inverters shall be paralleled and redundant cable shall be provided to feed the redundant ACDB.

A manually operated make before break changeover switch in a segregated compartment shall be provided to bypass the UPS power circuits (inverters and static switches) for maintenance and repair purposes.

DESIGN REQUIREMENT

All UPS components, ie., inverter, static switch, by-pass switch, isolation transformer, associated controls shall be mounted in floor mounted, sheet steel panel. The panels shall be designed for continuous operation for the ambient conditions defined in Data sheet. The battery shall be separately installed in a battery room. In case fans are required for cooling, 100% stand-by shall be provided to ensure rated output of the UPS.

The UPS system shall be provided with necessary meters, mimic diagram, local indication / alarm conditions.

Suitable ACDB for feeding various loads shall be provided.

Battery:

The battery backup time, type of batteries shall be as specified in Data Sheet. The Contractor shall choose the required voltage and number of the battery. The AH capacity of battery shall be chosen by Contractor, based on the battery back up time / duty cycle, and minimum ambient temp. specified in Data Sheet and the guaranteed DC/AC efficiency of the UPS system offered. Contractor shall furnish calculation for sizing of the battery based on the requirements specified in Data Sheet.

Rectifier:

The rectifier shall essentially be a three phase 6 pulse design with input isolation transformer. For Redundant UPS design the two rectifier input isolation transformers shall have vector grouping and connections to ensure 12 pulse operation seen from the source side. The rectifier shall be provided with soft start feature. The rectifier shall have features for temperature compensation charging of the batteries.

The rectifier shall be capable of supplying the inverter full load, in addition to charging the fully discharged batteries in 8 to 10 hours or as recommended by battery manufacturer and then maintain the battery on trickle charge mode. The rectifiers shall automatically share the load during parallel operation in case of common battery, as specified in Data Sheet.

Inverters:

The inverter shall be of PWM (Pulse Width Modulation) type. The inverter system shall be complete with necessary filters to limit the harmonic distortions to the load. The system shall have features to prevent deep discharge of battery.

Static Switch:

The static switch shall comprise thyristors connected in anti-parallel configuration, enabling loads on each branch circuit to be connected to the inverter of the other branch circuit or to the stand-by regulated AC supply.

The current rating of the static switch shall be not less than the continuous full load rating of the branch circuit and short time rating of 1000% for 20 milliseconds.

Automatic initiation of the transfer from a faulty branch circuit to either a healthy branch circuit or the stand-by regulated source shall be accomplished during following conditions.

- a) Inverter failure.
- b) Loss of inverter AC output.
- c) Load over current (in case of non-redundant UPS with static bypass to regulated supply)

Regulated Stand-by AC Supply:

Regulated stand-by AC supply shall be derived from stand-by source through a 3 ph servo-controlled voltage stabiliser (SCVS) and a 3 ph Delta-Vee connected adequately rated isolation transformer.

The voltage regulation and transient response shall be as specified in Data Sheet.

Circuit Protection:

The following devices shall be provided to protect the UPS system:

- a) AC input circuit breaker to Rectifier unit.
- b) AC input circuit breaker to supply stand-by transformer / voltage stabilizer.
- c) DC circuit breaker for battery output.
- d) Fast acting semiconductor fuses

Meters:

Meters shall be suitable for semi flush mounting with flanges projecting in vertical panels.

Meters shall have circular 2400C scale, 110 mm square, moving coil (taut band) type, conforming to IS: 1248 with accuracy class 1.0 or better.

DC ammeters shall be provided with external shunts.

Control & Monitoring

Discrete LED indicators integrated in mimic diagram or multi line alpha numeric text display unit shall be provided for continuous monitoring of the UPS operation. The UPS control system shall be fully compatible for remote operation via communication link. Contractor to consider suitable communication protocol. Contractor to indicate details of links provided in the system. The control system shall operate on Windows or eqvt. platform. The following operating conditions shall be annunciated.

Alarm Indication

- a) System fault
- b) Rectifier charger failure
- c) Inverter failure
- d) Battery undervoltage
- e) Thyristor over temperature
- f) Fuse failure
- g) Over load
- h) Static transfer to stand-by
- i) Transfer inhibited
- j) Over load shutdown
- k) Emergency shutdown
- l) Battery circuit breaker / switch open
- m) AC Main failure
- n) AC stand-by source mains failure
- o) Manual bypass ON
- p) Fan failure
- q) Asynchronous condition
- r) Control power failure
- s) DC ground fault.

Status Indication on Mimic

- a) Mains on
- b) Rectifier on
- c) Battery on load
- d) Inverter on
- e) AC Stand-by source on
- f) Inverter on –load
- g) Manual by-pass on
- h) Load on static by pass.
- i) Invertor faulty

HARMONICS

Necessary input and output filters shall be provided or the Rectifier and Inverter design shall be such that the harmonics injected back to the source and to the load shall be within limits specified in IEEE-519 at the point of coupling of the UPS to the system. The fault level of the system at the point of common coupling shall be as specified in data sheet.

SYSTEM EARTHING

The Contractor shall clearly bring out the earthing philosophy to be adopted for the UPS electronics, protective earthing (PE) and neutral earthing. Necessary earthing system inclusive of protective earthing, neutral earthing, clean earthing etc shall be provided by the Contractor.

TEST ON BATTERY

Routine Tests:

All tests as prescribed in the relevant IS standard shall be conducted on sample cells as per standards on typical and identical with the cells forming the complete battery offered. The following tests shall be conducted as minimum on all batteries as routine tests.

- a) Verification of constructional requirements
- b) Verification of marking
- c) Verification of dimensions
- d) Test for capacity
- e) Test for voltage during discharge

- f) Ampere-hour and watt-hour efficiency tests
- g) Tests for retention of charge
- h) Endurance test
- i) Battery impedance test
- j) Hear run test

Type Tests:

Type test certificate for ageing test conducted on similar battery type and design shall be furnished by the Contractor for review and approval.

Acceptance Tests:

The CONTRACTOR shall be responsible for all site/commissioning tests. All necessary testing equipment required for testing and commissioning shall be arranged by the CONTRACTOR. The following tests shall be conducted at site on completion of installation and commissioning and immediately prior to putting the battery in service.

- a) Verification of marking
- b) Verification of dimensions
- c) Test for capacity
- d) Test for voltage during discharge
- e) Battery impedance test to be conducted before and after the capacity test

Contractor shall furnish detailed commissioning check lists along with procedures and formats for recording of the test results for all equipment for PURCHASER/ END USER's review/approval.

The Contractor shall maintain all tests, calibration records in PURCHASER/ END USER's approved formats, and these shall be countersigned by authorized quality control personnel of the Contractor supervising these works.

All meters and other reference devices used for testing shall have valid Calibration Certificate traceable to reputed national laboratories/institutes. Inspection by PURCHASER/ END USER/Engineer will not be carried out unless the CONTRACTOR confirms that such calibrated equipment is ready for proceeding with the tests.

The Contractor shall completely assemble, mount & wire all the associated equipment including bought out items and test each cubicle as per relevant standards specified in Data Sheet.

Copies of the test certificates for all bought out items shall be submitted for the PURCHASER/ END USER's approval before despatch of the equipment. Bound copies of complete test results as specified in the distribution schedule shall be furnished with the equipment. These shall include complete reports and results of the routine tests as also certified copies of type tests carried out on equipment of identical design.

System tests shall be performed on the completely assembled UPS system. System tests shall include frequency regulations. Voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such synchronisation with range of adjustments, transfer of static switches for conditions of loss of square wave, overload and under voltage conditions.

DATA SHEET FOR UPS

SR. NO	PARTICULAR	REQUIREMENT
1.0	<u>GENERAL</u>	
1.1	Application	For supply to SCADA & any other critical AC load and any other critical load of Distribution Substation (DSS) + Switching Station (SS)
1.2	Power rating at load PF 0.8 lagging	CONTRACTOR to furnish with supporting calculations
1.3	Quantity (nos.)	As per Design Criteria
1.4	Method of energy storage	Battery back -up
1.5	Type	Parallel Redundant with static by pass to regulated supply
1.6	Installation	Indoor, Natural ventilated
1.7	Ambient Temperature ($^{\circ}\text{C}$)	50 Degrees.
1.8	Relative Humidity	Upto 95% Non-condensing
2.0	<u>ENCLOSURE</u>	
2.1	Sheet steel thickness	2mm, CRCA for doors and 1.6mm CRCA for side covers

2.2	Degree of protection as per IS13947	IP – 42 if located in Non-air conditioned area /IP-31 if located in air-conditioned area.
2.3	Painting	
	- Exterior	
	- Interior	Glossy white
2.4	Cable Entry	Bottom / Top
2.5	Acoustic Noise level	60 – 65 dBA upto 40 kVA 60 – 70 dBA above 40 kVA Measured at a distance of 1m
2.6	Space heater, 240V, 1 Ph	Required
3.0	<u>UPS SYSTEM</u>	
3.1	Input	
3.1.1	Supply voltage	415 V, 3 PH, 3 W, 50 Hz AC Non-Effectively earthed / effectively earthed.
3.1.2	Allowable Variation	
	(a) Voltage	$\pm 10\%$
	(b) Frequency	$\pm 5\%$
	(c) Combined voltage + frequency	10%
3.2	Output	
3.2.1	Output voltage	415 V, 3 PH, TP2N
3.2.2	AC voltage accuracy (steady state) over entire load, load PF & DC voltage range.	$\pm 2\%$ for balanced load
3.2.3	Transient voltage regulation	$\pm 8\%$ at 100% load step
3.2.4	Transient recovery	Return to steady state condition within 50 ms after disturbance.
3.2.5	Voltage wave from	Sinusoidal
3.2.6	Range of adjustment of AC output voltage	$\pm 5\%$ at rated load

3.2.7	AC Harmonic content (THD-Voltage)		5% Total, 3% for any single harmonic
3.2.8	Phase displacement for three phase output		$120^0 \pm 1^0$ for balance load $120^0 \pm 3^0$ for 20% unbalanced load.
3.2.9	Nominal frequency		50 Hz
3.2.10	Frequency regulation (Without static by-pass source)		± 0.1 Hz
3.2.11	Frequency regulation (With static by-pass source)		2 Hz
3.3	AC standby supply		
3.3.1	Servo controlled voltage stabilizer (SCVS)		Required / Not required
	(a)	Rating	To match UPS continuous rating
	(b)	Overload capacity	10 times rated current for 100mS
	(c)	Input voltage phase & frequency	$415V \pm 10\%$ 3 ph 3 wire 50 HZ
	(d)	Percentage voltage regulation	$\pm 2\%$
	(e)	Spike busters / surge suppressors and input filters	Required.
3.3.2	Isolation transformer		
	(a)	Rating	To be decided by CONTRACTOR
	(b)	Input voltage phase & frequency	415V, 3ph, wire 50 Hz
3.4	Maintenance by pass switch		Required.
4.0	<u>BATTERY</u>		
4.1	No. of 100% capacity batteries		CONTRACTOR to furnish supporting calculations
4.2	Type of battery cell		SMF type Lead acid
4.3	DC link voltage		To be chosen by CONTRACTOR
4.5	Battery backup time		- 60 Minutes

4.6	Mounting Arrangement	Open Type : Single tier / Multi Tier
5.0	<u>RECTIFIER</u>	
5.1	Rectifier unit	Three phase 6 pulse / 12 pulse
5.2	Parallel Operation	Required
5.3	Recharge time on battery boost charge	As per Battery manufacturers recommendation
6.0	<u>INVERTER</u>	
6.1	Overload Capacity	125% for 10 Min.
		150% for 1Min
		300% for 4 milli seconds
6.2	Synchronising	
	- Between inverters	Required
	- Between inverters and standby supply	Required
6.3	Parallel Operation	Required
6.4	Synchronising Range	50 ± 2 Hz(adjustable)
7.0	<u>STATIC SWITCH</u>	
7.1	Maximum transfer time	5ms (1/4 cycle)
7.2	Short time current rating	1000% for 20 milli seconds
8.0	<u>CIRCUIT BREAKER & LOAD BREAK SWITCHES</u>	
8.1	Type	ACB/MCCB / LOAD BREAK SWITCH
9.0	<u>AC DISTRIBUTION BOARD</u>	
9.1	Type	Integral or separate
9.2	Construction	Modular, single / double front
9.3	Busbars	Aluminium
9.4	Incoming	ACB/MCCB (TP2N)

9.5	Outgoing	MCB/MCCB (TP2N)
9.6	Cable entry facility	Top / Bottom

IV. ADVANCE METERING INFRASTRUCTURE (AMI)

SCOPE

The specification covers complete design, engineering, manufacture, inspection and testing at VENDOR's/SUB-VENDOR's works, delivery to site, erection, testing, commissioning and performance demonstration of Advance Metering Infrastructure (AMI) including Head End System (HES) & accessories.

This specification also covers the minimum functionalities and performance for Advance Metering Infrastructure (AMI) system.

Smart meters including Single Phase direct connected meters, Three Phase direct connected meter, Three Phase CT operated meters, and Transformer operated PT – CT shall in the scope of plot owner/ consumer and shall be as per DHBVN requirements. Supply of Smart Meters are not the part of this tender.

FUNCTIONAL REQUIREMENTS - ADV METERING INFRASTRUCTURE (AMI)

The functional requirements describe the minimum functionalities and performance for AMI system. The main objective of AMI is to enable two way communications between smart energy meter and Head End System (HES) to enable remote reading, monitoring and control of electrical energy meters (consumer, feeder, DT meters etc.) to serve as repository of record for all raw, validated and edited data. The sanitized data may be subscribed by other utility function for higher order analysis and billing and collection engine etc.

BASIC FUNCTIONS OF AMI

The AMI system shall help utility to manage their resource and business process efficiently. AMI system shall support the following minimum functionalities:

- a) Remote Meter data reading at configurable intervals (push / pull).
- b) Time of day (TOD) / Time of Use (TOU) metering.
- c) Pre-paid functionality.

- d) Net Metering / Billing.
- e) Alarm / Event detection, notification and reporting.
- f) Remote Load Limiter and connection/ disconnection at defined/on demand conditions.
- g) Remote firmware upgrade.
- h) Integration with other existing systems like IVRS, Billing and collection software, GIS mapping, consumer indexing, new connections and disconnection, analysis software, Outage Management System etc.
- i) Import of legacy data from existing modules / MDAS. The extent and modalities of integration with the existing system, if any, shall be worked out by the VENDOR.
- j) Security features to prevent unauthorized access to the AMI including Smart meter and meter data etc. and to ensure authentication of all AMI elements by third party.
- k) This is only an indicative but not exhaustive list. The system should be capable to support the other functionalities as per the requirement of DHBVN/ CLIENT.

The System should accurately maintain system time synchronization across all devices to ensure accuracy of data. The system should support the interfacing with the future Smart Grid functionalities like outage management system, distribution automation including self-healing system, distribution transformer monitoring units, Electric vehicle, distributed energy resources etc. The communication network shall preferably be able to support multiple applications.

The Contractor shall submit an approach paper during execution/detailing describing overall architecture and operational philosophy of the proposed AMI solution and methodology for achieving different functionalities, specified in this document and also highlight additional features, if any.

GENERAL AMI SYSTEM REQUIREMENT

Smart Meter (Single phase direct connected, Three phase direct connected, and CT operated three phase meters) for consumers / system shall be based on Radio Frequency (RF) mesh in license free frequency band / Power Line Carrier Communication (PLCC) or GPRS/3G/4G communication technology or combination of these technologies as per the site requirement and to ensure the performance level given in this document. The smart meter data using RF mesh/PLCC shall be collected by Data Concentrator Units (DCUs)/Access point and transported to HES through WAN while the data from smart meters using GPRS/3G/4G technologies shall be transported directly to HES through WAN. The AMI Implementing Agency (AIA) shall be responsible for proper data exchange

among Smart meter, DCU, Meter Data Management System (MDMS), HES and other operational / requisite software as part of fully functional AMI system.

AIA shall adhere with the appropriate security algorithm for encryption and decryption. For smooth functioning of the entire system, it is essential that the details of such algorithm including the mechanism of security key generation be kept in a secured escrow account which shall be used by the DHBVN/ CLIENT only in case of termination of the contract for reasons whatsoever.

AIA shall design appropriate architecture for providing end to end metering solution. AIA is free to decide upon the best solution out of all the available options. However, the entire responsibility of fully functional AMI system shall rest with one agency i.e. AIA in order to meet the performance levels as given in this document. The communication provider may adopt Radio Frequency (RF) mesh in license free frequency band / Power Line Carrier Communication (PLCC) or GPRS/3G/4G communication technology or RF based canopy system or a combination of these technologies as per the site requirement adopting best available technology in the proposed area of implementation.

The following core components of AMI system shall be provided:

- a) Communication infrastructure.
- b) Head End System (HES)
- c) Meter Data Management System (MDMS)
- d) Web application with updated on-line data of consumers etc.
- e) Mobile app: AIA shall provide a mobile app through which consumer shall be able to log in through Android / iOS / Window based mobile app to see information related to his/her energy consumption. App shall also provide platform for implementation of peak load management functionality by providing existing tariff and incentives rates, participation options etc. This mobile app shall be part of complete system and therefore no additional cost shall be payable for up gradation / maintenance separately.

SMART METERS (SINGLE &THREE PHASE)

Single Phase and Three Phase smart meters shall be in the owner/ consumer scope and shall be as per DHBVN requirement. The Smart meter installation shall be done by DHBVN.

After meter installation, customer identification no., meter ID, its hardware and software configuration, name plate details, make, type i.e. single phase or three phase, etc. shall be updated in DCU / HES / MDMS. The information would also be updated on the portal/app for providing information to consumers.

COMMUNICATION INFRASTRUCTURE

The communication infrastructure should either be based on RF mesh network / PLCC or cellular network or a combination of these. The communication network shall be based on applicable standards from ITU / IEC / IEEE / CEN / CENELEC / ETSI for NAN and WAN network. Communication network shall provide reliable medium for two-way communication between various nodes (smart meter) and Head End Station (HES). RF based network should use license free frequency band available in India. The engagement of network service provider would be in the scope of AIA to meet the performance level as given in the document.

Smart Meter shall communicate with HES by using communication module supplied by the VENDOR. The communication module used in smart meters shall work satisfactorily on communication infrastructure developed by AIA. The communication module should be inside the meter either in-built or pluggable type. In case of GPRS based smart meter, meter shall communicate with the HES in a secure manner. Provision of limited access to utility to change only the SIM card in case of GPRS based meter shall be given. Smart Meter shall accommodate SIM card from any service provider. In case of Plug in type communication module, the meter should log communication module removal event with snapshot of all capture parameters applicable for tampers. The communication module option can be decided by DHBVN/CLIENT at the time of actual implementation.

The general requirements to be considered by AIA are as follows.

- a) The AIA shall design a reliable, interference free and robust communication network keeping in view the site conditions. It shall be flexible in terms of providing communication in variable terrain and urban density.
- b) The AIA shall design the network architecture keeping in view the existing and planned infrastructure. During designing, suitable consideration shall be kept for future expansion as per requirement. Before designing the communication network, the AIA shall do the site survey and would provide the most efficient communication infrastructure.

- c) The entire infrastructure and associated civil works required for installation & commissioning of equipment / devices like DCUs, repeaters, routers and access points, etc. shall be in the scope of AIA. The operational testing of all the network elements has to be demonstrated by the AMI to the satisfaction of the DHBVN/CLIENT.
- d) The network solution offered by the VENDOR should have disaster recovery mechanism in place. The redundancy mechanism of HES and MDMS and their disaster recovery plan shall also be described by the VENDOR in the approach paper to be submitted along with the BID
- e) The quality of installation of the various equipment and power supply wiring to all field equipment shall be as per standards / regulations / prevailing practices of the DHBVN/CLIENT. The supply of electricity needed for operation and maintenance of entire AMI system shall arranged by the AMI from the DHBVN/CLIENT.
- f) Suitable network management system (NMS) shall be provided to monitor the performance of the communication network round the clock. The NMS shall provide viewing of all the networking elements deployed at site and enable configuration and parameterization of the networking devices and the nodes.

NETWORK SECURITY

The Network shall have adequate cyber security measures not limited to the measures as described below. The network security would be extended to all the interfaces also.

Secure Access Controls

The system shall include mechanisms for defining and controlling user access to the operating system environment and applications. Best practices from enterprise security including password strength, password aging, password history, reuse prevention etc. must be followed for access control.

Authorization Controls

A least-privilege concept such that users are only allowed to use or access functions for which they have been given authorization shall be available.

Logging

Logs must be maintained for all attempts to log on (both successful and unsuccessful), any privilege change requests (both successful and unsuccessful), user actions affecting security (such as password changes), attempts to perform actions not authorized by the

authorization controls, all configuration changes etc. Additionally, the access to such logs must be controlled in accordance to the least-privilege concept mentioned above, so that entries may not be deleted, accidentally or maliciously.

Hardening

All unnecessary packages must be removed and/or disabled from the system. Additionally, all unused operating system services and unused networking ports must be disabled or blocked. Only secure maintenance access shall be permitted and all known insecure protocols shall be disabled.

Malicious Software Prevention

Implementation of anti-virus software and other malicious software prevention tools shall be supported for all applications, servers, data bases etc.

Network Security

The network architecture of the HES + MDAS must be secure with support for firewalls and encryption. The system shall also allow host-based firewalls to be configured, as an additional layer of security if the network firewall were to fail.

COMMUNICATION NETWORK ELEMENTS (DCU OR ROUTER BASED)

Data Concentrator Unit (DCU) Based Communication Network

The Data Concentrator Unit shall be a gateway for communication of data between the Smart Meters and the HES. The Data Concentrator Unit shall receive information from the Smart Meter on a scheduled / need basis and stores the data, which can be accessed by HES for onward transfer to MDMS.

The DCU shall provide the central link between Smart Meters and HES, enabling continuous / periodic meter read and control. DCU shall exchange data from smart meters on RF / PLCC communication and with HES on WAN.

For the communication system having DCU based RF network, following requirement shall be met.

a) Hardware And Power Supply Of DCU

Enclosure / box of DCU shall be minimum IP55 or better compliant unless otherwise specified in Data Sheet. A suitable mounting arrangement required for DCU installation shall also be provided.

- (i) A suitable and optimum power supply shall be provided keeping in view that even in case of outage in one or two phases, DCU can be powered. DCU should be capable of withstanding surges and voltage spikes as per applicable standard. Power supply shall be terminated on suitable sized MCB to facilitate isolation during on-site maintenance.
- (ii) DCU shall have battery with backup for the time period specified in Data Sheet for normal meter reading, to push tamper event, carry out on demand reading and the network health status / connectivity continuity and check. DCU should have the suitable feature to send power outage and restoration message to the HES. The battery shall have a guaranteed life as specified in Data Sheet.
- (iii) DCU shall have built-in Real Time Clock (RTC) with separate battery backup. The battery shall have a guaranteed life of 10 years. It shall have self-diagnostic feature for RTC, memory, battery, communication module, etc. Alternatively, Software driven RTC may also be used as per agreement between AIA and DHBVN/CLIENT.

b) Configuration, Functionality and Interface Of DCU

DCU shall have following configuration functionalities:

- i. It shall be able to configure the communication with underlying nodes/meters.
- ii. It shall pull data from the field devices and push the data at configured intervals to the HES. It shall also facilitate reverse communication from MDMS to HES and meter. The data acquisition (Push / Pull) frequency shall be programmable. DCU shall be capable to prioritize control commands.
- iii. DCU shall ensure a secure communication to HES and shall have internal memory for storing interval data for at least 5 days.
- iv. DCU shall support on demand read and ping of individual/group of meters.
- v. It shall support IPv4 / IPv6 network addressing.
- vi. DCU shall push events like tamper, power off etc. to HES immediately on occurrence/receipt from field devices/meters.

General Requirement of Router Based RF Mesh Network

The general requirements for the Router based RF network are specified below.

- a) The communication network shall have dynamic and self-healing capability. If one of the communication element like router or access point fails then nodes connecting to that element shall switch to best available element for communication of data to HES.
- b) It shall support IPv4 / IPv6 network addressing.
- c) Each node shall keep a track of best available nearby nodes.
- d) The communication network equipment shall use license free frequency spectrum as defined by Government of India.
- e) All the communication network equipment shall be certified by WIRELESS PLANNING & COORDINATION (WPC) Wing of the Ministry of Communications, Government of India for operation in license free frequency band.
- f) Suitable network management system (NMS) shall be available to monitor the performance of the communication network round the clock. The NMS shall provide viewing of all the networking elements deployed at site and enable configuration, parameterization of the networking devices and the nodes.
- g) It shall support remote firmware upgrading.
- h) It shall be secure enough to avoid all cyber threats like DDoS, spoofing, malwares etc.
- i) The communication network shall ensure secure communication of data to HES.
- j) The equipment shall be weatherproof, dustproof and constructed for outdoor installation (minimum rating: IP-55 unless otherwise specified in Data Sheet). A suitable mounting provision shall be made for the equipment.
- k) Enclosure: Provision for security sealing shall be provided and in case the gasket of the cover is used for protection against moisture, dust and insects, the gasket shall be made of weather and aging resistant material.
- l) The list of standards followed in all the devices / equipment used in communication network shall be furnished for approval.
- m) Routers / Access Points shall have suitable power supply arrangements. Provision of battery backup for the time period specified in Data Sheet shall be there to continue operation in case of power supply failure. The life expectancy of battery shall be as specified in Data Sheet
- i. It shall be weatherproof, dustproof and constructed for outdoor installation (minimum rating: IP-55 unless otherwise specified in data sheet). A suitable mounting provision shall be made for the equipment.
- ii. Enclosure: Provision for security sealing shall be provided and in case the gasket of the cover is used for protection against moisture, dust and insects, the gasket shall be made of weather and aging resistant material.

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- iii. The list of standards followed in all the devices/equipment used in communication network shall be furnished for approval.
 - a) DCU Communication
 - i. The communication architecture shall be as defined under applicable standard.
 - ii. The DCU shall ensure the appropriate backhaul for secure transfer of data to HES. In case of GPRS/3G/4G backhaul, it shall support SIM card from any service provider. It shall have Wide Area Network (WAN) connectivity to the HES through suitable means.
 - iii. DCU shall be able to communicate with meters either on RF mesh (license free band) or PLCC.
 - iv. DCU shall periodically monitor meter reads / downstream commands and shall retry and reconnect in case of failed events / reads.
 - v. It shall push events like tamper, power off etc. to HES immediately on occurrence/receipt from field devices/meters. DCU shall be able to acquire and send data to HES for full capacity (designed for no. of meters/field devices as indicated in Data Sheet) to ensure the performance level.
 - vi. After Power Interruption, on restoration of power supply, DCU shall establish communication with underlying devices as well as upstream application automatically.
 - vii. DCU shall be able to communicate with the nearest meters depending on topographical features. For further communication among the meters, distance of the other meters with the DCU shall not be a constraint as communication of the nearest meters shall be established with other meters through appropriate mesh formation / other formation.
 - viii. Remote Firmware Upgrade: The DCU shall support remote firmware upgrades as well as remote configuration from the control centre. Configuration of programmable parameters of smart meters shall be done through HES.
 - ix. All meters falling under one DCU shall be commissioned and checked for proper communication in presence of DHBVN/CLIENT.
 - x. DCU shall keep the records of minimum of the following events:
 - No of packet failures.
 - Retry attempts.
 - Missed periodic readings.
 - iv. Failure to connect.
 - Tamper events.

Router Based RF Mesh Network

For the communication system having router based RF mesh network, different nodes (smart meters) shall interconnect with each other using RF mesh network and they shall communicate with nearby routers to transfer the data to access points. In such

communication network, if any routers/repeaters/access points fail, then nodes connected on that device shall automatically reconfigure the mesh with available nearby nodes.

General Requirement of Router Based RF Mesh Network

The general requirements for the Router based RF network are specified below.

- a) The communication network shall have dynamic and self-healing capability. If one of the communication element like router or access point fails then nodes connecting to that element shall switch to best available element for communication of data to HES.
- b) It shall support IPv4 / IPv6 network addressing.
- c) Each node shall keep a track of best available nearby nodes.
- d) The communication network equipment shall use license free frequency spectrum as defined by Government of India.
- e) All the communication network equipment shall be certified by WIRELESS PLANNING & COORDINATION (WPC) Wing of the Ministry of Communications, Government of India for operation in license free frequency band.
- f) Suitable network management system (NMS) shall be available to monitor the performance of the communication network round the clock. The NMS shall provide viewing of all the networking elements deployed at site and enable configuration, parameterization of the networking devices and the nodes.
- g) It shall support remote firmware upgrading.
- h) It shall be secure enough to avoid all cyber threats like DDoS, spoofing, malwares etc.
- i) The communication network shall ensure secure communication of data to HES.
- j) The equipment shall be weatherproof, dustproof and constructed for outdoor installation (minimum rating: IP-55 unless otherwise specified in Data Sheet). A suitable mounting provision shall be made for the equipment.
- k) Enclosure: Provision for security sealing shall be provided and in case the gasket of the cover is used for protection against moisture, dust and insects, the gasket shall be made of weather and aging resistant material.
- l) The list of standards followed in all the devices / equipment used in communication network shall be furnished for approval.
- m) Routers / Access Points shall have suitable power supply arrangements. Provision of battery backup for the time period specified in Data Sheet shall be there to continue operation in case of power supply failure. The life expectancy of battery shall be as specified in Data Sheet.

CONFIGURATION, FUNCTIONALITY AND INTERFACE

Access points shall have following configuration functionalities.

- a) It shall be able to configure the communication with underlying nodes/end points.
- b) It shall support on demand read and ping of individual/group of meters.
- c) It shall push events like tamper, power off etc. to HES immediately on occurrence/receipt from field devices / meters.
- d) It shall have Wide Area Network (WAN) connectivity to the HES through suitable means.
- e) It shall communicate with routers/nodes/end points on RF mesh (license free band).
- f) It shall periodically monitor meter reads/downstream commands and shall retry and reconnect in case of failed events/reads.
- g) After power Interruption, on restoration of power supply, it shall establish communication with underlying devices as well as upstream application (HES) automatically.
- h) Access point shall facilitate recording of
 - No of packet failures.
 - Retry attempts
 - Missed periodic reading
 - Failure to connect
 - Tamper events
- i) It shall be capable to handle interval data of suitable nos. of any type of smart meter (1ph / 3ph). Access point shall be able to acquire and send data to HES for full capacity (No. of meters/field devices it is designed for) within a suitable time period to achieve the performance level. Full capacity of access point is required to be indicated in the offer.
- j) Access point shall support remote firmware upgrades as well as remote configuration from the control center.

TESTING OF THE DCU /ACCESS POINT

DCU/Access Point shall be tested for the following as per applicable standards:

- a) Radio interference measurement
- b) Surge test
- c) Fast transient burst test
- d) Test of immunity to electrostatic discharges
- e) Test of immunity to electromagnetic HF field
- f) Resistance to heat and fire

The CONTRACTOR shall provide test certificate for DCU / Access Point for approval of IP-55 protection or that specified in Data Sheet.

HEAD END SYSTEM (HES)

The main objective of HES is to acquire meter data automatically avoiding any human intervention and monitor parameters acquired from meters.

The AIA shall provide the HES suitable to support the collection and storage of data as per performance level for a defined no. of smart meters with facility of future expansion as per the requirement of the DHBVN/CLIENT. The no of smart meters/future expansion shall be as specified in Data Sheet.

HES shall perform all the requisite functions as per the defined functionalities of AMI and it is the responsibility of the AIA to supply the requisite software and hardware to achieve the defined functionalities of AMI. HES shall ensure data integrity checks, for example, checksum, time check, pulse, overflow, etc. on all metered data.

HES shall be developed on open platform based on distributed architecture for scalability without degradation of the performance using additional hardware. HES shall support storage of raw meter data, alarms and alerts for minimum 3 days. Adequate data base and security features for storage of data at HES needs to be ensured.

The suggested functions of HES (not limited to) shall be :

- a) Acquisition of meter data on demand and at user selectable periodicity.
- b) Two way communication with meter/ DCU.
- c) Signals for connect and disconnect of switches present in end points like meter.
- d) Audit trail and Event & Alarm Logging.
- e) Encryption of data for secure communication.
- f) Maintain time sync with DCU / meter.
- g) Store raw data for defined duration.
- h) Handling of Control signals / event messages on priority.
- i) Setting of Smart meter configurable parameters.
- j) Communication device status and history.
- k) Network information in case more than one technology is deployed in field between the two devices.

- l) Critical and non-critical reporting functionality. The suggestive critical events may be alarms and event log for meter events like tamper/power failures etc., if data is not received from DCU/Meter, if relay does not operate for connect / disconnect or there is communication link failure with DCU/Meter or network failure while non critical events may be retry attempts on communication failure, periodic reading missing and failure to connect etc.

Configuration

HES shall facilitate programming of following meter parameters as per requirements of DHBVN / CLIENT some of which are listed below:

- a) Load profile capture period.
- b) Demand integration period.
- c) Setting of parameters for time of day (TOD/TOU) billing.
- d) Prepaid function.
- e) Net metering.
- f) Billing date.
- g) Clock setting / time synchronization.
- h) Load curtailment limit.
- i) Event setting for connect/disconnect.
- j) Number of auto reconnection attempt.
- k) Time interval between auto reconnection attempts.
- l) Lock out period for relay.
- m) Remote firmware upgrade.
- n) Password setting.
- o) Push schedule.
- p) Setting threshold limits for monitored parameters.
- q) Provision for adding more programming features in future.

Integration

HES shall preferably interface with MDMS on standard interfaces and the data exchange models and interfaces shall comply with CIM / XML / IEC as specified in Data sheet or any other open standard. The solution shall be Service Oriented Architecture (SOA) enabled.

METER DATA MANAGEMENT SYSTEM (MDMS)

The Meter Data Management System shall support storage, archiving, retrieval & analysis of meter data and various other MIS along with validation and verification algorithms. It shall act as a central data repository. MDMS shall have capability to import raw or validated data in defined formats and export the processed and validated data to various other systems sources and services in the agreed format. It shall provide validated data for upstream systems such as billing, consumer Information system, customer care, analytics, reporting, Network planning and analysis, load analysis/forecasting, Peak Load Management, Outage management etc.

MDMS should also support the future requirement of DHBVN/CLIENT and should support the integration of other smart grid functionalities like Distribution Transformer Health Monitoring system, self-healing system etc. as and when implemented by the DHBVN/CLIENT.

The AIA shall specify and deliver an initial system that supports the collection and storage of data for meeting the performance level for the defined no of consumers/ smart meters. The Number shall be as indicated in Data Sheet with facility of future expansion.

The MDMS shall have the ability to selectively choose which data to be maintained and which to be purged or archived as per requirement of DHBVN/CLIENT (user selectable).

Functional Requirements:

- a) Asset Management
 - i. The MDMS shall maintain information and relationships between the current installed meter location (apartment, shop, industry/ address etc.), Consumer information (Name etc.), Consumer account no, Meter ID, Type of Meter (type of consumer, 1 phase / 3phase, with or without relay, etc.), Meter configuration (Demand integration period, Load profile capture period etc.), GIS supplied information (longitude, latitude, connection with feeder/ transformer/ pole etc.) etc.
 - ii. The software should support tracking the status of meters and communication equipment from the date when they are installed in the field. The history of in-service asset location is maintained throughout the device life with start and end dates associated with each in-service location reference.
 - iii. Ability to report and log any damage / deterioration in the meter attributable to Consumer /DHBVN/CLIENT.
- b) AMI Installation Support

The MDMS shall also support device lifecycle management from device registration, installation, provisioning, operations and maintenance to decommissioning etc. The MDMS shall generate exceptions for meter or modules not delivering the correct meter data after installation.

- i. The MDMS shall provide a reconciliation report that identifies the meters that have been installed but not communicating for a designated (configurable) period. MDMS shall generate reports on the number of meters installed in comparison to the number of meters successfully communicating.
- c) Meter Data
 - i. The MDMS shall accept input, process, store and analyze Meter data from HES and meter data collected through hand held meter reading instruments and manual meter reads. In case of manual reads, provision should be there to insert associated notes like assessed energy etc.
 - ii. The MDMS should accept input, process, store, and analyze nonbilling meter data such voltage and power quality data (like under/over voltage etc) as they are available from AMI Head End Systems. The MDMS should also support schedule and on-demand meter reads and pinging of meter energized states by authorized users and by other utility systems.
 - iii. The MDMS shall provide storage of all collected Meter Data, events and alarm. It shall have capacity of storing data via archiving as per requirement of DHBVN/CLIENT.
 - iv. Correctly track and resolve energy usage across meter changes with no loss of individual meter data.
 - v. Provide complete history and audit trail for all data collected from meters including commands sent to meters and other devices for 30 days (configurable period) or as per DHBVN/ CLIENT requirements
 - vi. Execute on-demand read processes.
 - vii. Handle special metering configurations like net metering/multiple meters at same premises.
 - viii. The MDMS shall have the ability to manage at a minimum 15 minute interval data or as per DHBVN/ CLIENT requirements.
 - ix. Data Integrity- AIA shall ensure data integrity checks on all metered data received from data collection systems.
- d) Data Validation, Estimation And Editing (Vee)
 - i. The validation and estimation of metered data shall be based on standard estimation

methods. The MDMS should also support and maintain following data:

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- Registered Read Data including register reads, daily billing cycle as well as derived billing determinants like TOU.
 - Interval Data channels with variable intervals and variable units of measure
 - Calculated Data that is derived or computed such as billing determinants and aggregated loads.
 - Event data storage of all collected event and alarm data from meters, network equipment and MDMS itself
- ii. MDMS shall flag, alarm and trigger an estimating process including but not limited to when the following anomalies occur in the cumulative ("CUM") register reads:
- CUM Decrements within a billing cycle (except net-metering).
 - CUM reads increments more than configurable threshold.
 - Future or old read dates.
 - Number of digits exceeds number of meter dials.
 - Any other requirement of DHBVN/CLIENT
- iii. MDMS shall detect, flag, alarm and trigger an estimating process including but not limited to when the following anomalies occur in Time of Use (TOU) register reads.
- Register Decrements (except net-metering).
 - Resets (to zero) (except net-metering)
 - CUM reads increments more than configurable threshold.
 - Future or old read dates.
 - Erratic compared to CUM read (sum of TOU reads minus CUM read)
 - Any other requirement of DHBVN/CLIENT
- iv. MDMS shall detect, flag, alarm and trigger an estimating process including but not limited to when the following anomalies occur in Demand register reads.
- Do not reset on cycle.
 - Do not reset coincident with customer move-out or move-in.
 - Reset off cycle inappropriately.
 - Too high.

- Any other requirement of DHBVN/CLIENT
- v. All data shall be transferred to billing system after meter data validation and estimation including transformer / feeder station wise energy audit.
- vi. MDMS shall estimate usage for non-metered service points such as street lights, farm lights, traffic signals, etc.
- vii. The MDMS shall maintain both the original received raw data in a nonmanipulated state, in addition to VEE (Validating, Editing and Estimating) data.
- viii. Notwithstanding the latency of data collection via the AMI system, once the MDMS receives meter read data, the VEE process occurs in real-time and the post-VEE data is then immediately available to DISCOM/CLIENT or external systems.
- ix. The MDMS shall be able to automatically flag data changes from manual edits, VEE rules and data source corrections and electronically generate audit trail with timestamps and user-ids.
- e) Billing Determinants Calculations
 - i. The MDMS shall allow configuring multiple TOU/TOD options (e.g. the number and duration of TOU rate periods) by customer type, tariffs and day type (weekend, weekdays, and holidays) and by season.
 - ii. The MDMS shall support the processing of interval data into billing determinants to include the following at a minimum:
 - Total Consumption
 - Consumption in different time blocks for ToU billing.
 - Maximum Demand (in kW and kVA).
 - Number of tamper counts.
 - Average power factor
 - Any other requirement of DHBVN/CLIENT
 - iii. MDMS shall process interval data and frame it into the appropriate TOU periods for consumption and demand; for example, roll up 15/30 minute data intervals in to hourly data.
 - iv. MDMS shall have the ability to properly account for special metering situations such as check metering, sub metering, prepaid metering and net metering when calculating billing determinants and sending them to billing and other systems.

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- v. MDMS shall have the ability to properly account for special situations including, but not limited to, curtailment requests, demand response scenarios when calculating billing determinants and sending them to billing software.
 - f) Exception Management
 - i. Ability to capture and log data exceptions, problems and failures and to generate management reports, provide trend analysis, automate generation of service requests and track corrective actions.
 - ii. Ability to group, prioritize, filter and send system generated alarms and events to predetermined email addresses, cellular text messages to phone numbers/SMS/customer care etc.
 - iii. Exception Generation - MDMS shall generate exceptions based on configurable business rules including but not limited to the following:
 - Meter tamper alerts.
 - Communication module health alerts for Meter/DCU.
 - If the consumption is less/more than pre-defined average consumption.
 - Negative Consumption (not for net-metering).
 - Power outage indications received from the Smart meter.
 - Any other requirement of DHBVN/CLIENT
 - g) Service Orders
 - i. The MDMS shall generate service orders based on configurable rules for various events and alarms such as stop meter, tampers, problem in communication networks, AMI host server, etc.
 - ii. MDMS shall send service orders via SMS, email, etc. with the email addresses / phone numbers being configurable. MDMS shall receive feedback on action taken on the service order and track the status of service orders.
 - h) Customer Service Support
 - i. The solution shall provide customers with access to current and historical consumption and interval data, outage flags, voltage and power quality indications. The data shall be displayed in graphical and tabular form depending on user choice. The Customer may also access data through customer portal. The solution shall integrate via a user friendly graphical interface.
 - ii. MDMS shall support email/SMS notification of configured alarms and events to selected users.

- iii. The MDMS shall support the web portal or shall have the ability to interface with the 3RD party portal/DISCOM/CLIENT portal to provide the consumer near real time online views of both usage and cost and helping consumers to understand electricity usage and cost information, alerts and notifications and energy savings tips with different levels of detail. The portal should support the view for past electricity usage, last week's, yesterdays, current days or other period etc. as per selection. The portal should provide user friendly access to consumer for their data via colorful graphs and charts and can download the data into a spreadsheet.
- iv. Shall support mobile app through which consumer shall be able to log in through Android/iOS/Window based mobile app to see information related to his energy consumption. App shall also provide platform for implementation of peak load management functionality by providing existing tariff and incentives rates, participation options etc.
- i) Analysis

The MDMS shall have analysis capability based on configurable business rules including but not limited to the following:

 - i. Display consumption/load profiles by configurable period (15/30 min, hour, day, month, year etc.) day type (weekday, weekend, holiday, festival wise etc.) and by tariff, customer type, or any user specified collection of meters.
 - ii. Generate peak and off-peak load patterns by aggregating all loads of DT/Feeder/consumer group.
 - iii. Perform DT/feeder wise energy audit.
 - iv. Perform load analysis for different groups and categories of consumers.
 - v. Ability to provide the data to load forecasting, load research or demand response applications and perform error management like: Missed reads and intermittent meter reads before taking into forecasting, load research or demand response.
 - vi. Ability to configure the system to effectively visualize consumption trends, identify unusual patterns, and visualize load analysis to understand which assets are being over utilized.
 - vii. Analyzing data to identify new patterns of usage, Setting fraud alert / transformer overload alerts / demand – supply gap alert etc.
 - viii. Ability to receive and store outage and restoration event data from smart meters and outage systems and to log all such events for analysis.
 - ix. Any other requirement of DHBVN/CLIENT.
- j) Reporting

The solution shall include a list of the standard reports that are provided with the MDMS including but not limited to following.

- i. Daily data collection report.
- ii. Usage exceptions.
- iii. VEE validation failures.
- iv. Missing interval Read date and times (on hourly, daily, weekly and monthly basis).
- v. Physical meter events (install, remove, connect, disconnect) and meter reset report.
- vi. Meter flags.
- vii. Meter inventory.
- viii. Defective meters.
- ix. AMI performance measurements
- x. Threshold Exception

The solution shall support users modifying standard reports to better meet specific reporting requirements.

- i. The MDMS shall enable the DHBVN/CLIENT to deliver reports in standard digital format such as PDF, Excel, etc.
- ii. Ability for GUI (Graphical User Interface) to set up or change report delivery to configurable email addresses, network file directories, ftp sites or printer systems without modifying source program code and without any proprietary language skills.
- iii. All queries shall be generated through user driven drop down menu in GUI. The Contractor shall provide example queries to support internal report generation needs.
- iv. Ability to provide daily and weekly interface exception reports between MDMS and other subsystems e.g. billing, outage, etc.
- v. In case more than one communication technology (example PLC and RF between Smart Meter and DCU) deployed in the field, the MDMS shall generate report on the performance and availability of data being delivered per AMI technology.
- vi. Any other requirement of DHBVN/CLIENT.

k) Revenue Protection Support

- i. Ability to analyze meter tampering flags, power outages, usage trends and usage profiles to identify potential energy diversion situations and produce daily reports, monthly reports and service order requests for investigation.
- ii. The business rules for revenue protection alerts shall be configurable via a user-friendly interface.

iii. The MDMS shall filter out revenue protection alerts that may be caused by field activities if the field activity information is provided to the MDMS.

iv. The MDMS shall support the analytics/investigation (i.e. view current and historical usage patterns) to valid suspected revenue protection issues.

l) Support for Enterprise Apps

Contractor shall describe how its MDMS shall support other Enterprise Apps for Smart Grid like Demand Response programs involving Demand Response (DR) systems as part of Peak Load management (PLM). The solution shall support the following analysis:

- i. Totaling the actual consumption during the DR event.
- ii. Totaling the actual consumption of different groups that participated in the DR event.
- iii. Comparing the actual to baseline consumption for the groups in above.
- iv. The MDMS shall support the tracking, monitoring and managing of Smart Meter and events and monitors customer response to facilitate payment of customer incentives.

m) OMS / Other Smart Grid Functionality Support

MDMS shall support Smart Grid OMS system as per the requirement of the DHBVN/CLIENT. MDMS shall support the interfacing with OMS software for providing AMI meter data needed for fault location identification and other requisite services like updating the data after attending the fault etc.

MDMS should also support the interfacing of other smart grid functionalities like Distribution Transformer Health Monitoring system, self-healing system, electric vehicle etc. as and when implemented by the DHBVN/CLIENT.

n) Additional Features

i. Net-Metering

MDMS shall flag, alarm and trigger an estimating process including but not limited to the following when anomalies occur:

- CUM decrements of forward energy within a billing cycle.
- Register decrements for Time of Use (ToU) of forward energy.
- Power generated (exported) by any net-metering consumer more than the installed capacity of solar PV rooftop system.
- Energy exported in any given day by any net-metering consumer more than the programmable threshold value.
- Any other requirement of DHBVN/CLIENT.

ii. Prepaid Functionality

The prepaid functionality can either be availed at smart meter level or through MDMS. In case of MDMS, following shall apply:

- The MDMS should support pre-payment metering and capability to interface with pre-payment application.
- The prepayment should support the system that payment and connection parameters are stored centrally and the details are being updated to consumer portal/ app.
- The system should periodically monitor the energy consumption of prepaid consumer and decrease the available credit based on consumption.
- The system should send connect/disconnect command on the basis of available credit as per notified rules and regulations.
- The system should send low-credit notifications to the consumer when their balance approaches a threshold.
- Any other requirement of DHBVN/CLIENT.

1.1.1.1 User Interface:

The AIA shall provide user interface for the following:

a) DHBVN/CLIENT

- i. Compare total energy costs on one rate schedule v/s. one or many
- ii. alternative rates.
- iii. Enable the user to see how different options within a rate affect costs.
- iv. Enable the user to see how adjusting load or consumption levels or shifting them to different time periods influences costs.
- v. Compare multiple facilities against each other based on costs, average spend, cost per area and cost by weather.
- vi. Display meter data at a user defined configurable cycle through a GUI that allows authorized users to view energy usage patterns and the data behind them for selected customers.
- vii. Allow authorized users to view metered data, initiate and view reports, modify configurations, and initiate and update service requests via a GUI.
- viii. Display via a GUI the energy usage profile for a single meter or group of meters. The load profile shall illustrate energy consumption and peak demand in user defined intervals for a user-specified time period.
- ix. Display via a GUI the energy usage profile for a single meter or group of meters according to Time of Use (ToU) tariff.

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- x. Access to a minimum of 5 years of historical energy usage and meter reads through the GUI
 - xi. GUI to clearly and visually distinguish between metered, estimated, allocated and substituted data.
 - xii. GUI to provide role-based access, based on user identity and user role. Shall have following types of users:
 - xiii. Administrator.
 - xiv. Operator
 - xv. Field staff
 - xvi. Viewer/Guest
 - xvii. Configure the look, feel, and functionality of the MDMS in accordance with business needs, business processes and business conventions. (e.g. GUI, content, look and feel of screens, validation rules, exception handling, etc.).
 - xviii. Ability for DISCOM/CLIENT through user interface to set up alarm and event notifications that can be directed to a combination of configurable email addresses, cellular text messages or phone numbers.
 - xix. User interface for utility to update the credit amount of prepaid consumers to MDMS. Such type of user interface before login shall require password and login ID. for authentication. User interface after getting information like consumer ID., mobile number and recharge amount etc. shall update the same to MDMS. The details of payment information shall also update to consumer through SMS, email etc.
- b) Consumer
- i. User interface for all authorized consumers shall have ability for at least the following functionality:
 - View metered data, initiate and view reports.
 - View data according to Time of Use (ToU) tariff
 - Can make request for connection/disconnection.
 - User can update mobile number/email.
 - Can initiate service requests for maximum demand updating, meter checking etc. vi. In case of net-metering consumers, user can view data for both import and export.
 - In case of prepaid consumers, consumers can view recharge history and present balance.

- Prepaid consumers shall be provided facility to recharge their account by logging on user interface. User interface shall require consumer ID, mobile number and password for secure login. This user interface shall be integrated with the present online payment gateway of DHBVN/CLIENT.

Integration With Other Systems

- (a) MDMS shall preferably interface with other systems on standard interfaces and the data exchange models and interfaces shall comply with applicable standards. CIM / XML / IEC or IS as specified in Data sheet / Indian Companion Specification/ any other open standard. MDMS solution shall be Service Oriented Architecture (SOA) enabled.
- (b) MDMS integration with other systems shall include but not limited to the following:
 - HES for data exchange from other AMI solutions.
 - Utility Administration.
 - Existing other Data Collection Systems.
 - IVR system, CRM, Consumer Portal.
 - Billing and collection system
 - GIS Systems integration with CIS and with MDMS system.
 - Support of interface with HHU or manual reading system etc.
- (c) AIA should provide suitable number of HHUs to read and update the data in MDMS in case of any communication failure between meter and HES/MDMS.

PERFORMANCE LEVELS

The performance levels shall apply to the complete AMI system.

AMI system includes the communications links provided by Network Provider /third parties such as telecommunications companies and AIA has to ensure the desired performance level.

The performance levels are average performance levels over the period of a year and exclude force majeure events. The following are the required performance levels:

- (a) Performance levels for collection of daily meter readings (as per applicable standards).

- (b) Following are the performance levels required for the daily collection of the previous day's interval energy data and total accumulated energy.
 - (i) All interval data from 95% of meters within 8 hours after midnight
 - (ii) All interval data from 99.9% of meters within 24 hours after midnight.
- (c) Performance levels for remote reads of individual meters if data is not received on daily basis.

The performance level of an individual read applies to the collection of seven days of interval energy data and the current total accumulated energy from a particular AMI meter whose data is not being received on daily basis. The performance level required shall be as follows:

- (i) Action performed at 90% of meters within 1 Hour;
 - (ii) Action performed at 99% of meters within 2 hours
 - (iii) Action performed at 99.9% of meters within 6 hours.
- (d) Performance level for remote load control commands for selected consumers. The performance level required for individual meters shall be:
- (i) Action performed at 95% of meters within 5 minutes;
 - (ii) Action performed at 99% of meters within 10 Minutes.
- (e) Performance level for remote connect/disconnect for selected consumers. The performance level required for selected individual meters shall be:
- (i) Action performed at 90% of meters within 10 minutes;
 - (ii) Action performed at 99% of meters within 1 hour
 - (iii) Action performed 99.9% of meters within 2 hours
- (f) Performance levels for Meter loss of supply and outage detection
- (i) Alarms to be received within 5 minutes for 90% of meters
- (g) Performance levels for remotely altering settings in meter/ firmware upgrade. The performance level required for individual meters shall be:
- (i) Action performed at 99% of meters within 24 hours
 - (ii) Action performed at 99.9% of meters within 36 hours
- (h) Performance levels to remotely read events logs

Performance level required for reading the full event log that pertains to an individual meter shall be:

- (i) Action performed at 90% of meters within 30 minutes
- (ii) Action performed at 99% of meters within 1 hour
- (iii) Action performed at 99.9% of meters within 6 hours.
- (i) To read the event logs pertaining to all meters
- (i) The data pertaining to 99.5% of meters with in 1 day
- (j) Performance levels for updating of data on consumer portal/ app

The performance level of updating of individual consumer data on portal/ app after receiving the data in MDMS shall be:

- (i) Action performed for 90% of consumers within 1 hour after receiving the data in MDMS
- (ii) Action performed at 99.5% of meters within 6 hours after receiving the data in MDMS.

The performance level for generation of bills would be as per requirement of DHBVN/CLIENT. The performance levels regarding meter discovery time line after installation, on demand reading of meter data for operational purposes, outage restoration enquiry response time etc. would also be declared by the Contractor.

Additionally, the Disaster Management timelines in terms of Recovery Time Objective (RTO) and Recovery Point Objective (RPO) of HES have to be defined by the Contractor.

PERFORMANCE REQUIREMENT FOR USER INTERFACE

The user interface performance testing shall be done as per following criteria:

SR. NO.	USER INTERFACE REQUIREMENTS	RESPONSE TIME
1	Any real time display and application display on workstation console along with data values shall appear on screen.	Within 2 sec
2	Manual data entry of the new value appears on screen.	Within 2 sec
3	Display Update rate	2 sec for 4 displays together

4	Response time for display of Alarm and event after receipt in system	Within 1 sec of receipt in system
5	Requests for printing of displays (to be acknowledged with an indication of request is being processed).	Within 2 sec
6	Requests for generation of reports (to be acknowledged with an indication of request is being processed).	Within 2 sec

TECHNICAL OBSOLESCENCE:

The systems including communication technologies, which are at a risk of technical obsolescence over the next 10 years and over the operating life of the system should be identified and reported. This may also include end-of-sale and end-of support policies governing the proposed technologies. The compatibility between the various elements of the system need to be considered and mitigation options, not be limited to periodic update from OEM/System supplier, shall be indicated in detail.

V. LIGHTING AND SMALL POWER SYSTEM

GENERAL REQUIREMENT

The Lighting system includes the following items.

- (a) Lighting fixtures complete with Lamps and accessories (lumen per watt shall be indicated)
- (b) Lighting system equipment (ISI make)
- (c) Light control switches, receptacle units with control Switch units, lighting wires, conduits and other similar items necessary to complete lighting system.
- (d) Lighting fixture supports, street lighting poles and flood light towers for internal roads.
- (e) Main Lighting distribution board, lighting panels.
- (f) Multi core cables for street, boundary and flood lighting.
- (g) PVC Conduits.

1.1.1.2 Load balancing of lighting system shall be made.

DESIGN

The lighting system design shall comply with the acceptable norms and the best engineering practices. The lighting layout shall be designed to provide uniform illumination with minimum glare. The layout design shall meet all the statutory requirement, local rules etc.

The value of the ratio of spacing (S) to mounting height (H) shall be commensurate with the type of fittings selected and uniformity of illumination.

APPLICABLE CODES & STANDARDS

All standards and codes of practice referred to below shall be the latest edition including all official amendments and revisions.

- 3 pin plugs & sockets : IS 1293
- General safety requirements : IS 1913
- for luminaires
- Luminaires for street lighting : IS 10322(Paart-5,S 3)
- Fitting for rigid steel : IS 2667
- conduits for electrical wiring
- Code of practice for interior : IS 3646 & IS 6665
- illumination
- Switches for domestic & : IS 3854
- similar purposes
- Electric ceiling type fans : IS 374
- & regulator
- Code of practice for electrical : IS 732
- wiring installation (system
- voltage not exceeding 650
- Volts)
- General lighting LED and
- LED Modules : IS 16101
- Self-ballast LED lamps for general

- lighting services : IS 16102 (Part-1 & 2)
- LED modules for general lighting : IS 16103(Part-1 & 2)
- Safety of lamp control gear : IS 15885 (Part-2/sec-13)
- DC or AC supplied electronic control gear for LED modules: IS 16104
- Method of measurement of lumen maintenance of solid state light (LED) sources : IS 16105
- Method of electrical and photometric measurements of solid state light (LED) products : IS 16106
- Luminaries performance : IS 16107 (Part 1 &2)
- Photo biological safety of lamps and lamp system: IS 16108

LIGHTING DESIGN

Following factors shall be considered while arriving at the utilisation factor to determine the number of fixtures for each area/buildings in the plant.

(a) Maintenance Factor

- Air-conditioned clean interiors like control rooms/houses 0.8
- Industrial areas with normal interiors 0.7

(b) Reflection factor for wall/ceiling

- White and very light colors : 0.7
- Light colors : 0.5
- Middle tints : 0.3
- Dark colors : 0.1

(c) Utilization factor considering the room index at applicable surface reflection factors. The working plane shall be considered at 1.5 m from the floor level.

The illumination levels for various areas shall be considered as follows:

Area

Illumination level (Lux)

Control Room	500
Office Room	500
Switchboard Room	200
Cable Galleries	150
Corridor/ Staircase	150
Pump House/WTP	150
Outdoor plant area and Road	As per IS 1944 code (Part 1 & 2)

LED luminaires shall be used primarily for internal and external lighting. All other internal areas shall be lit with LED luminaires.

Luminaires shall be installed to permit ease of maintenance. The Contractor shall provide all equipment necessary to carry out maintenance on the lighting installation and demonstrate its operation to the satisfaction of the Engineer.

Earth leakage Circuit Breaker (ELCBs) shall be provided at the incomer of Lighting panels.

Type of Luminaire at various areas as below (Minimum requirement):

AREA	TYPE OF LIGHT FITTINGS
Control rooms	40 W LED 40W with mirror optic decorative recessed type with adjustable reflector
Switchgear Room	Surface/Suspended Mounted Luminaire with 40W LED
Electrical rooms having PDB, MCC	40W LED Batten type fitting
Staircases of Substations	20W LED Rail mounted fitting
Flood lighting/Periphery lighting	Weather proof flood LED light fittings

Flood Light Luminaries:

- (a) Flood light luminaries shall be of weather proof construction with high pressure die cast aluminum with cooling fins and graphite grey polyester powder coating, resistant to corrosive and saline environments with a separate internal high purity (99.85%) polished, anodised aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary gaskets to prevent ingress of dust.
- (b) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.
- (c) For focussing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg. in vertical direction.
- (d) Deleted.
- (e) The luminaries shall be provided with cable gland on the canopy in down ward direction for cable connection.
- (f) It shall be possible to adjust the lamp position to achieve wide beam, medium beam or narrow beam.
- (g) It shall be possible to replace the lamp from the canopy without opening the front glass.
- (h) The flood light shall be supplied with knife switch enabling safe lamp replacement from rear side.
- (i) Retained steel screws with special anticorrosion and anti-gripping treatment shall be provided. Igniter box shall be thermally isolated from the housing.
- (j) Gasket made of silicone platinic material shall be provided.
- (k) The floodlights shall contain an internal baffle to improve efficiency and to reduce glare.
- (l) Access for re-lamping shall be from the rear of the floodlights with a provision of power cut-off switch to discontinue the lamp current when the rear door is opened.
- (m) Precision aiming arrangement by way of external telescope shall be provided in the luminaire.

VI. STREET / FLOOD LIGHTING SYSTEM WITHIN SUBSTATIONS & SMART GROUP STREET LIGHTING CONTROL & MONITOR SYSTEM

The illuminance level for road lighting in India is governed by IS 1944 (Part 1 & 2): 1970/ Code of practice for lighting of public thoroughfare.

The layout for street lighting system will be planned in such a way that uniformity ratio as required by IS: 1944 is maintained.

All the Poles shall be designed to withstand the maximum wind speed as per IS 875. The top loading .i.e. area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BSEN 403:2000, pr EN-40-3-3.

All pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations .i.e. from inside and outside.

The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

Aesthetic appearance - All the grooves and carvings of the pole unit shall be free from any kind of distortion for a pleasing aesthetic appearance.

The poles and bracket shall be hot dip galvanized as per IS 2629/ IS 2633/ IS 4759 standard with average coating thickness of 75 micron. The galvanizing shall be done in single dipping.

Top Mountings -The galvanized mounting bracket shall be supplied along with the Poles for Installation of the luminaries.

The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

Electrical connections - Four way connectors shall be provided along with Slide lock suitable for connecting 1.1 kV grade, 4 core Al cable. It shall also in house 1 no. 6 amps SP MCB, 2.5 sqmm connectors for looping with 2.5 Sqmm Copper wires for connecting to the luminaire through 1.1 kV grade, 3 core X 2.5 mm² PVC insulated copper conductor flexible un-armoured Cable from the terminal block to the fixture within the pole. All the cables laid through the pipe shall be without any joint.

Two nos. earth boss shall be provided at the bottom of the pole (diagonally opposite) suitable for connecting 25X6 mm GI earth strip or 6SWG GI wire for earthing of the poles.

Two nos. 50 mm NB HDPE Sleeves of suitable length shall be provided through the foundation upto the Junction Box for entry of power cable.

The CONTRACTOR shall carry out all the relevant tests and inspection in the presence of the PURCHASER or Third Party Agency, as may be selected by the PURCHASER, before the dispatch of the poles at no extra cost to the PURCHASER.

The CONTRACTOR shall inform the PURCHASER at least FIFTEEN (15) days in advance, about the manufacturing programme so that arrangement can be made for inspection. PURCHASER reserves the right to waive the inspection at any stage.

All the material/equipment/accessories shall be supplied with manufacturer's test certificates.

CONTRACTOR shall submit the Proposed Product Catalogue, Detail Data sheet, spare parts list and drawing of Pole & Bracket along with the BID for each product quoted.

CONTRACTOR shall arrange for all the tools and equipments.

M20 concrete foundations shall be provided for all the poles. Approx dimension of the foundation for evaluation purpose is 600X600X1700 mm. However, CONTRACTORs shall design as per the stability requirement and Soil bearing Capacity of each location. The Poles shall be bolted on a pre-cast foundation with minimum four foundation bolts for greater rigidity.

LUMINAIRE DESCRIPTION

LED luminaires shall be used for internal & outdoor lighting. Luminaires shall be installed to permit ease of maintenance. The Contractor shall provide all equipment necessary to carry out maintenance on the lighting installation and demonstrate its operation to the satisfaction of the Engineer.

The Luminaires shall have a sturdy and corrosion resistant high pressure Die cast Aluminium housing with weatherproof gasket for lamp and control gear accessories. The Housing shall be Epoxy coated, without any cracks or thorough holes, made in a single

piece of die-cast LM6 aluminium alloy. The luminaries shall be totally enclosed, dust tight and water proof.

Heat sink used should be aluminium extrusion having high conductivity. The dimensions of luminaries shall be optimum and adequate to permit sufficient heat dissipation, through the body itself, so as to prevent abnormal temperature rise inside the lantern and consequential damage to the cover and gasket materials, LEDs, lenses and electronic drivers. Heat sink must be thermally connected to MCPCB/ LED light source.

The Luminaries Housing shall be suitable for termination of Cable with Double Compression Cable Glands.

Housing protection: IP-66. If the LEDs and LED Driver are in different compartments, then the two compartments must be individually IP-66. For achieving IP-66, proper gaskets should be provided. Test certificate of NABL accredited laboratory is to be submitted for the luminaire model/rating offered.

Luminaires should conform to the photometric Distribution / requirements of Cut-Off / Semi Cut – off light distribution and optics as classified in IS 1944.

Suitable number of LED lamps shall be used in the luminaries. The manufacturer shall submit the proof of procurement of LEDs from OEMs at the time of testing.

The Luminaries shall be provided with high tensile heat resistant toughened glass or UV resistant polycarbonate cover fixed with stainless Steel screws.

An extruded silicon loop gasket shall be provided in the lantern body to ensure a weather proof seal between the cover and the metal housing to exclude the entry of dust, water, insects, etc. Luminaries should conform to degree of protection of IP 66 or above. Felt gasket will not be accepted.

Year of Manufacture, Batch No., Serial Number or Identification No. Luminaries Manufacturer's Name / Logo, Wattage and Frequency should be embossed on the housing.

LED luminaries, should conform to the various National / International standards for safety & performance. Manufacturer should provide test reports as per LM 79 & LM80. Lumen maintenance report as per LM 80 guidelines shall be submitted for the LEDs used along with the BID.

Luminaries should conform to the IS standards for Safety & Performance and test certificates as per IS 16107 should be provided by the manufacturer. In case of luminaries are imported, the CONTRACTOR shall conform to test parameters as per UL or equivalent standards.

The electrical component of the LED and LED driver must be suitably enclosed in sealed unit to function in environment conditions mentioned earlier.

All the connecting wires inside the Luminaries shall be low smoke halogen free, fire retardant cable.

Adequate protection against Overloading, Short Circuit, Over Voltage, over temperature, Under Voltage, String Open shall be provided within the Luminaries.

Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.

The equipment should be compliant to IEC 60598-1, IEC 62031 and IEC/ PAS 62612 depending on the type of luminary.

All the material used in the luminaries shall not contain any toxic material/ metal like mercury; shall be halogen free and fire retardant confirming to relevant standards.

The Manufacturer shall have all the relevant testing facilities certified by an accredited laboratory and shall be offered for inspection to the PURCHASER for verification of the required parameters and tests.

The control gear shall comply to the provisions of IEC 61347-2-13, IEC 62031 and IEC 62384 as appropriate.

MCB + RCCB (DP For single phase and 4P for three phases MCB DB) shall be provided at the incomer of Lighting panels and SP MCB for outgoing feeders.

PORTABLE EMERGENCY LIGHT LUMINAIRE

Emergency light of Installite luminaire shall be indoor type for providing emergency light during failure of normal AC supply.

The luminaire shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for 3-4 hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two meter length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.

The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal A.C. supply the luminaire shall pick-up automatically and on restoration of A.C. supply the luminaire shall switch off automatically.

VENTILATION FANS

Variable speed ventilation ceiling fans shall be provided in offices, control rooms, control areas and switchgear rooms. One fan shall be provided for each 10 m² or part thereof of the area concerned. Where fitted ceiling fans shall be connected to the local lighting circuit.

Ceiling fans shall be suitable for operation on 240 V, 1 phase, 50 Hz supply and shall be complete with standard mounting accessories such as suspension rods, top and bottom caps etc. The fans shall be supplied with appropriate speed regulators.

SMALL POWER OUTLETS

Switched single phase three pin 6 A and 16A receptacles shall be provided throughout. In offices and control rooms they shall be the decorative type and industrial type in all other areas.

Receptacle units of 6/16 A rating with switches shall be supplied. The units shall be suitable for mounting flush on GS sheet boxes. The receptacle shall be suitable for 240V, 1-Phase, (or 415 V, 3-Phase), 50 Hz AC supply.

Unless required to be provided in greater numbers to power specific Plant items the number of such outlets shall be as follows:

- 6 A type: one outlet per 5 m or part thereof of perimeter in offices;
- 6 A type: one outlet per 20 m or part thereof of perimeter in all other areas;
- 16 A type: one outlet per 20 m or part thereof of perimeter in offices;
- 16 A type: one outlet per 20 m or part thereof of perimeter in all other areas.

32 A switched three phase and neutral receptacles shall be provided in plant areas where appropriate i.e. adjacent to areas where flooding is likely (to permit the use of portable sump pumps) or where other portable equipment is likely to be used in the operation of the treatment plant. The Contractor shall install ten such outlets at various locations throughout the treatment plant. The location of outlets shall be approved by the Engineer. The spacing of 6 A and 16 A outlets shall be arranged to suit the intended location of equipment, desks etc. Receptacles for outside areas shall have a degree of protection of IP 65.

TESTS AND TEST REPORTS

Type tests, acceptance tests and routine tests for the lighting fixtures, accessories and receptacles covered by this specification shall be carried out as per the relevant standard.

Manufacturer's type and routine test certificates shall be submitted for tests conducted as per relevant standards for the fixtures, accessories and receptacles.

The following routine tests shall be conducted as per the relevant Indian Standards.

Each fixture shall be tested at 1500 Volts (rms), 50 Hz, AC for one minute and no flash over or breakdown shall occur between current carrying parts and ground.

Insulation resistance of each fixture shall be tested at 500 V DC and the insulation resistance so measured shall not be less than 2 mega-ohms between all current carrying parts and ground.

All luminaires provided with glass covers shall be subjected to thermal shock-proof test. A test shall be conducted to ensure that the cover glass will withstand sudden variation in surface temperature due to rainfall or splashing water when the lighting fixture is lit. The cover glass shall be heated in an oven to attain a steady temperature of 100°C and then plunged into cold water. No crack should develop.

Contractor shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards.

LIGHTING SYSTEM INSTALLATION

The Contractor shall supply, install, test and commission the complete system of lighting and receptacles in accordance with the approved lighting drawings and documents and in

accordance with relevant Indian Standards, codes of practice, Indian Electricity rules and safety codes in the locality where the equipment/system is to be installed. Nothing in this specification shall be construed to relieve the Contractor of this responsibility.

Installation of Lighting Panel, Lighting fixtures & Receptacles. The scope of installation work shall include mounting of lighting panel, lighting fixtures and receptacles at locations as per the approved drawings. All work associated with installation such as providing and fixing of wooden blocks, ball sockets, hooks, etc., as required, drilling holes in walls, ceilings, etc., or any civil work including scaffolding, provision of ladders, etc., together with supply of hardware shall form part of the Contractor's work. All work items necessary for completing earthing connections shall be included in the scope of work.

WIRING

The work shall comprise wiring in heavy gauge (minimum 16 SWG) GI conduits, fixed and supported at intervals of 300 mm on walls, ceiling etc.; installation of light control switches and receptacles housed in GS boxes; earthing with 16 SWG copper wire run along the conduit and clamped to it at every 300 mm; and termination of cables/wires at lighting panels, light control switches, receptacles, lighting fixtures etc., as required. The minimum size of conduit shall be 20 mm. Space factor (ratio of total wire area to internal conduit area) shall be 40 %.

Supply of all the items of work detailed above including 650 V grade, 2.5/4 sq. mm stranded copper conductor PVC insulated cables; 6 / 16A switches; GS conduits and accessories (such as junction boxes, tees, elbows, etc); 16 SWG GS boxes complete with gasket, knockouts for conduit entries, earthing terminal with bolts, nuts and washers; 16 SWG aluminium earthing wire; flexible conduit etc. shall be included in the Contractor's scope. All work necessary for fixing boxes, conduits etc., together with supply of necessary accessories hardware, shall also be included in the Contractor's work.

All light control switches and receptacle units (connected on the same phase) at one location (such as room entrance), shall be housed in one common GS sheet steel box.

Receptacle and lighting fixtures shall be fed from different circuits and wiring for the same shall be done in different conduits. The maximum load on any lighting circuit shall not exceed 800 Watts.

Wires belonging to different phases shall not be run in the same conduit. However, more than one circuit on the same phase can be run in the same conduit. For every phase wire, a separate neutral wire shall be run. Neutral wire for different phases shall not be looped.

Size of wire chosen shall be such as to limit the voltage drop to within 3 %. Minimum area of conductor shall be 2.5 sq mm stranded copper for lighting and 4 sq mm for 6A / 16A receptacle circuits respectively, and copper current density shall not exceed 1.2 A/sq mm. Generally, not more than 8 to 10 lighting points shall be wired in one circuit. For calculating connected loads of various circuits, a multiplying factor of 1.25 shall be assumed on the rated lamp wattage for sodium vapour and fluorescent lamp fixtures to take into account the losses in the ballast. A loading of 100 watts and 500 watts shall be assumed for each, single phase 6 amps and 16 amps receptacles respectively.

Estimation for point wiring (Electrical)

Wiring of all lighting fixtures, fans and receptacles and earthing wiring shall be on point wiring basis. Insulated green coloured earthing wire shall also be run in conduits. Indian TNS type of distribution (as per IS 3043) shall be followed. Neutral of the circuits shall not be looped.

Mains Wiring upto Switchboards

- a) Mains wiring consist of wiring from lighting panel to first point of switch board (where provided) of the circuit. Where no switchboard is provided (switching is directly from MCB on the lighting panel), no “mains wiring” is applicable.
- b) Mains wiring work shall consist of supply, installation and testing commissioning of wiring with 4 sq mm copper PVC wires and their terminations including supply of 19/25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, coupler, junction boxes, 16 SWG green copper wire for earthing, etc.) from lighting panel to first point of the circuit (switches for control are excluded).
- c) The mains wiring shall be classified into the following lengths:

Short point	– from 0 to 5m
Medium Point	– 5 to 10m
Long Point	– 10 to 20m
Extra long point	– more than 20m

Point wiring for Lighting and Fans

- a) Primary point (GI) shall consist of supply, installation and testing commissioning of lighting system / fan system including supply of 19/25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 2.5 sq. mm. copper PVC wires and their termination etc.
- b) The point wiring for lighting and fans shall be classified into the following lengths:
 - a. Short point – from 0 to 5m
 - b. Medium Point – 5 to 10m
 - c. Long Point – 10 to 20m
 - d. Extra-long point – more than 20m

Point wiring for Receptacles (6A)

- a) Primary point (GI) shall consist of supply, installation and testing commissioning of 6A receptacle including supply of 19/ 25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 2.5 sq. mm. copper PVC wires and their termination etc.
- b) The point wiring for 5A receptacles shall be classified into the following lengths:
 - a. Short point – from 0 to 5m
 - b. Medium Point – 5 to 10m
 - c. Long Point – 10 to 20m
 - d. Extra long point – more than 20m

Point wiring for Receptacles (16A)

- a) Primary point (GI) shall consist of supply, installation and testing commissioning of 16A receptacle including supply of 19/ 25 mm (16G) GI conduits with all accessories (e.g. bends, reducers, couplers, switches for control, junction boxes, 16 SWG green copper wire for earthing, etc.) with 4.0 sq. mm. copper PVC wires and their termination etc.
- b) The point wiring for 15A receptacles shall be classified into the following lengths:
 - a. Short point – from 0 to 5m
 - b. Medium Point – 5 to 10m
 - c. Long Point – 10 to 20m
 - d. Extra long point – more than 20m

DRAWINGS AND DATA

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified in Bid Document.

SMART GROUP STREET LIGHTING CONTROL & MONITOR SYSTEM (GCMS)

Energy Efficient smart lighting system is considered for Outdoor Street Lighting system. In order to arrive at Energy Efficient Street lighting, LED based smart street lighting system shall be employed.

DESIGN CRITERIA

- a) The illuminance level for road lighting in India is governed by IS 1944 (Part 1& 2): 1970 Code of Practice for lighting of public thoroughfare. The layout for street lighting system will be planned in such a way that uniformity ratio as required by IS: 1944 for Group A1, A2 & B1 type of roads are maintained.
- b) Road classification and lux level requirement as per IS1944 is given in below table:

- c) The following criteria shall be followed for designing the GCMS system for the identified roads;

- Only Group ON-OFF shall be provided for the cycle lane, footpath of all roads.
 - Group ON-OFF shall be provided for the carriage way of 45 / 36 / 32/ 24-meter roads.
 - Group ON-OFF shall be provided for the carriage way of 18-meter roads.
- d) Maintenance factor shall be considered as 0.8 for the lighting calculation.
- e) The road designs consist of five typical cross sections of 45m, 36m, 24m and 18m ROW. The road designs have been developed to accommodate all forms of traffic ranging from heavy vehicles to light motor vehicles and from cycle tracks to pedestrian walkways. The Carriageway on either side of the central median have been designed for an average lighting level of 30 lux and Uniformities of 0.4 (Emin/Eavg) and 0.33 (Emin/Emax). Similarly, the secondary carriageway, pedestrian pathway and cycle tracks have been designed for a lighting level of 15 lux of 0.4 (Emin/Eavg) and 0.33 (Emin/Emax) uniformities.
- f) The layout for street lighting system will be planned in such a way that uniformity ratio as required by IS: 1944 for Group A2 & B1 type of roads is maintained.
- g) The Contractor should submit the design reports for the same in latest version of Dialux.

GENERAL REQUIREMENTS FOR LED LIGHTING

1.1.1.3 Applicable Standard:

S. No.	Brief Title	IS/IEC Code
1.	Testing procedure of photometric testing for LED Luminaires	LM 79
2.	Testing procedure on the lifespan of LED Luminaires	LM 80
3.	National Lighting Code	NLC 2010
4.	Method of Measurement of Lumen Maintenance of Solid State Light (LED) Sources	IS:16105 – based on IES-LM-80-2008
5.	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products	IS:16106 – based on IES-LM-79-2008
6.	Limits of Harmonic Current Emissions	IS 14700-3-2

S. No.	Brief Title	IS/IEC Code
7.	DC or AC supplied electronic control gear for LED modules - Performance requirements	IEC 62384
8.	Lamp control gear: Particular requirements for DC or AC supplied electronic control gear for LED modules	IEC 61347-2-13
9.	Environmental Testing: Tests – Test Db: Damp heat, Cyclic (12h+12h cycle)	IEC 60068-2-38
10.	Electro Magnetic compatibility (EMC)- Limits for Harmonic current emission— (equipment input current ≤ 16 A per phase)	IEC 61000-3-2
11.	Equipment for general lighting purposes - EMC Immunity requirements	IEC 61547
12.	LED Modules for General Lighting-Safety Specifications	IEC 62031
13.	Degrees of Protection provided by enclosures (IP Code)	IEC 60529
14.	Particular Requirements - Fixed general purpose Luminaires/ Specification for Luminaires	IEC 60598-2-1/ IS10322
15.	General Lighting - LEDs and LED modules – Terms and Definitions/ General lighting – Light emitting diode (LED) products and related equipment –Terms and definitions	IS:16101 / IEC TS 62504
16.	LED Modules for General Lighting - Safety Requirements	IS:16103(Part1)
17.	LED Modules for General Lighting - Performance Requirements	IS:16103(Part2)
18.	Safety of Lamp Control Gear - Particular Requirements of D.C. or A.C. Supplied Electronic Control gear for Led Modules	IS:15885(Part2/ Sec13)
19.	Luminaire Performance – Particular Requirements – LED Luminaire	IS 16107-2-1

Luminaire Description:

- a) The Luminaires shall work on single phase three wire system (phase, neutral & earth).
- b) The luminaire light output (lumen) shall be constant and shall be able to withstand allowable supply source voltage variations/ fluctuations, spikes and harmonics.
- c) The Luminaries shall have a sturdy and corrosion resistant high pressure Die cast Aluminium alloy housing with weatherproof gasket, with separate Driver compartment and control gear accessories. The housing shall be Epoxy coated, without any cracks or thorough holes, made in a single piece of die-cast LM6 Aluminium alloy/ ADC 12. The luminaries shall be totally enclosed, dust tight and water proof with minimum ingress protection of IP 66 and above.
- d) It should be easily replaceable in the field condition.
- e) Heat sink used should be Aluminium extrusion/ Aluminium pressure die casting having high conductivity. The dimensions of luminaries shall be optimum and adequate to permit sufficient heat dissipation, through the body itself, so as to prevent abnormal temperature rise inside the lantern and consequential damage to the cover and gasket materials, LEDs, lenses and electronic drivers. Heat sink must be thermally connected to MCPCB/ LED light source.
- f) The Luminaries Housing shall be suitable for termination of 3C X 1 sqmm copper conductor PVC insulated flexible Cable with Double Compression Weather proof Cable Glands if required.
- g) The optical system shall consist of Poly Carbonate lenses on individual high-power LEDs designed & tested to achieve typical street lighting distribution from the LED Luminaire. These lenses provided for individual LEDs are to be fixed on lens plate in order to have consistent light distribution from luminaries. Luminaries should conform to the Photometric Distribution / requirements of Cut-Off / Semi Cut – off light distribution and optics as classified in IS 1944 and NLC 2010.
- h) Suitable number of LEDs shall be used in the luminaries. The manufacturer shall submit the proof of procurement of LEDs from OEMs at the time of testing along with the test reports.
- i) The Luminaries shall be provided with distortion free, clear, high tensile, heat resistant, toughened glass of minimum 0.8mm thickness or UV resistant polycarbonate cover with required degree of protection. It is preferred that CONTRACTOR offer Cover with

Integrated individual lenses for LEDs fixed to housing providing required degree of protection. All hardware shall be corrosion free/ stainless Steel.

- j) An extruded/ moulded silicon loop gasket shall be provided in the lantern body to ensure a weather proof seal between the cover and the metal housing to exclude the entry of dust, water, insects, etc. Luminaries should conform to degree of protection of IP 66 or above. Felt gasket will not be accepted.
- k) Luminaire shall be enclosed in an aesthetically designed housing with corrosion resistant polyester powder Coating after phosphor-chromate treatment.
- l) All Luminaires shall conform to RoHS and BIS requirements and Certifications. All the test reports from Third Party NABL accredited laboratory shall be submitted as required. Drivers used in the luminaires should be having individual BIS CRS number. BIS certificate shall be submitted along with the BID as a compliance.
- m) Name of the Client, Year of Manufacture, Batch No., Serial Number or Identification No. Luminaire Manufacturer's Name / Logo, Wattage and Frequency shall be provided by Screen printing and Sticker in the external and internal of Housing of Luminaire respectively.
- n) LED luminaries, should conform to the various National / International standards for safety & performance. Manufacturer should provide test reports as per LM 79 & LM80. The test reports shall be certified from UL/ILAC/ Third Party NABL accredited Laboratory (TPL) and shall be submitted for approval.
- o) Luminaries should conform to the National / International standards for Safety & Performance and test certificates as per relevant standards shall be provided by the manufacturer. In case of luminaries are imported, the CONTRACTOR shall conform to test parameters as per UL or equivalent standards. However, Luminaire should be registered under BIS CRS for IS 10322 part 5 Sec 3 which covers all safety and protection criteria since it has been made compulsory by BIS. CONTRACTOR shall submit the BIS registration number of Luminaires including the Driver or both if separately registered proposed for the project for approval.
- p) The electrical component of the LED and LED driver must be suitably enclosed in separate sealed unit to function in environment conditions mentioned above.
- q) All the connecting wires inside the Luminaries shall be Low Smoke Halogen Free, fire retardant cable or as per IS 10322 part 5 Sec 3 whichever is stringent.

- r) Adequate protection against Overloading, Short Circuit, Over Voltage, Over temperature, Under Voltage, String Open, Surge Protection shall be provided within the Luminaries. Drivers shall have inbuilt protection system to operate safely, automatically isolate during abnormal conditions & restart as soon as the system normalizes. Third party Test certificates from NABL accredited Lab shall be submitted during execution of project for all the above. Drivers shall be capable of withstanding the voltage stress of 440V. Test certificates shall be submitted to justify the same.
- s) Design of the thermal management shall be done in such a way that it shall not affect the properties of the diffuser.
- t) All the material used in the luminaries shall not contain any toxic material/ metal like mercury; shall be halogen free and fire retardant conforming to relevant standards.
- u) The Manufacturer shall have NABL accredited testing facilities or shall be associated for this project with any third party NABL accredited laboratory to avail its services for all type of tests including Routine tests, Acceptance tests and Type test. The luminaires shall be offered for inspection to the Client for verification of the required parameters and tests.
- v) The control gear shall comply with the provisions of IEC 61347-2-13:2014, IEC 62031:2018 and IEC 62384:2006 as appropriate or equivalent BIS standards IS 15885 Part-2 Section 13. BIS certificate shall be submitted for approval.
- w) The switching surges are expected in the power supply system. Appropriate surge protection shall be provided by the CONTRACTOR for all the Luminaires offered. Such protections can either be provided centrally at the Feeder Pillar or at each individual luminaire level or a combination of both, as may be decided by the CONTRACTOR. No claim for failure of Luminaires, on account of surges will be considered.
- x) Additionally, as per ANSI C 136.2-2014/ UL-1449, External Surge protection device (SPD) with Thermal Protection (TMOVs) of minimum 10 kV/ 10 kA to be separately installed with each fixture while an additional surge arrestor of 20kV/10kA shall be installed inside Feeder Pillar / field panel. The same shall be certified from independent lab and follow IEC 62305:2010 & IEC 61643-11-2011. No claim for failure of Luminaires, on account of voltage surges other than Lightning surges, will be considered.
- y) The Luminaires shall be suitable for operation within the input supply voltage range specified. The driver of the light should be able to sense and cut-off power to the light in case of phase-to-phase/ 440 V fault. No claim in this regard shall be considered.
- z) The lighting fixtures and driver/ control gear offered shall comply with the data sheet.

Testing Of Luminaire

- a) The Routine test on each of the offered Luminaries shall be carried out by the CONTRACTOR before dispatch. Following tests shall be carried out as Routine tests by the CONTRACTOR for the offered Luminaries;
- Visual and Dimensional check
 - Checking of documents of purchase of LED
 - Insulation resistance test
 - HV test
 - Reverse polarity
- b) The Acceptance test shall be carried out by Client Representative on a sample of the lot offered for Acceptance. The Lot shall be different from the lot from which the Type test samples have been drawn. The cost of the testing shall be borne by the CONTRACTOR. Following tests shall be carried out as Acceptance tests by the CONTRACTOR for the offered Luminaries;
- Visual and Dimensional check
 - Checking of documents of purchase of LED
 - Insulation resistance test
 - HV test
 - Over voltage protection
 - Surge protection
 - Reverse polarity
 - Test for IP 66 protection
- c) Following Type tests reports shall be provided by the CONTRACTOR for the offered Luminaries from Third Party NABL Accredited Laboratory;
- Resistance to humidity, Dust and Moisture
 - Insulation resistance test/ electrical strength
 - HV test
 - Over voltage protection

- Surge protection
- Reverse polarity
- Temperature rise Test
- Colour Rendering Index measurement test
- Heat resistant test
- Fire retardant Test (Including Wiring)
- Test for IP 66 protection
- Test report confirming to Impact resistance
- Endurance Test
- Life Test
- Photometric Measurements Test Report (IES LM 79)
- LED Lumen Maintenance Test Report (IES LM 80) (As provided by LED manufacturer)
- Vibration test as per ANSI
- Drop Test

TECHNICAL SPECIFICATION OF STREETLIGHT FEEDER PILLAR- SWITCHING POINT

All Feeder Pillars (FP) shall be Outdoor type, Wall/ Column/ Steel Support mounting, Weatherproof, double door, single front, non-compartmentalized enclosure with locking facilities.

Outdoor type Smart Intelligent street light control Panel having suitable loading capacity of minimum 20KW, made of 2mm thick CRCA Sheet duly powder coated to avoid any corrosion, having degree of protection IP 65, 300mm high Galvanize M.S. angle iron Stand for floor mounting, suitable for bottom side cable entry, Pad locking facility etc. as per technical specification & System requirement, equipped with the following items (but not limited to) complete in all respects. 4G / RJ45 LAN enabled gateway controller having controlling facility to control three nos. of 1Ph / 3Ph contactor separately via separate Relay output for phase wise control, Modbus RTU (RS 485) interfacing facility, door open / close status and spare digital inputs for connection of further components, integrated relay output, Setup and operation with CCMS software, Type of protection: IP65, 12/24V

DC battery (minimum 4 hours backup) with battery charger. 63A,4Pole, with thermo-magnetic release & extended rotary handle, 10KA MCCB as incomer. AC/DC Operated ,4Pole, AC3 type, 63A Power contactor (in case of DC operated contactor battery & Battery charger etc. shall be an integral part of the Panel). High electrolytic grade Aluminum Busbar set for 100A capacity with heat shrinkable sleeve on suitable Insulators.

Multifunction meter, CT/PT, Indication Lights for phases and operation status, completely wired up with FRLS wire etc. One set of Power terminals for incoming supply and 6nos. set of power terminal for outgoing supply suitable for 415 Volts AC 3-Phase 4 wire supply.. 25x6 mm Al/GI Earthing Strips. 3 x 6nos TPN 20Amp Curve 10kA MCB for outgoing.

Application Software with 5-year cloud license along with all other items required for system requirement shall be an integral part of the Panel board.

The OFP (Outdoor Feeder Pillar) shall be made of either Galvanised sheet steel enclosure or Powder coated with minimum seven tank process (certification confirming the same shall be submitted) CRCA panel enclosure. All the feeder pillars shall be Outdoor type with permanent rain canopy and shall be dust, damp and vermin proof. All feeder pillars shall conform impact resistance of IK10 and shall be minimum IP55 certified. Third Party Type test report for Impact and Ingress protection shall be provided for approval.

The GI feeder Pillar shall be fabricated from 2 mm CRCA sheet and shall be Hot Dipped Galvanized as per relevant latest standards after entire fabrication. The enclosure shall be powder coated with Epoxy paint as per desired colour of Client. The gland plate shall be 3mm thick.

The fabricated enclosure shall not have any welds or bolt heads apparent from outside. All fabrication work like cutting, drilling, punching, shearing & welding etc. related to the enclosure shall be complete before proceeding to 7 tank process. The fabricated body shall be thoroughly cleaned and treated by chemical agents as required to produce a smooth surface free of scales, grease and rust.

Sheet metal components shall be pre-treated using the seven-tank phosphating process consisting of de-greasing, acid pickling, de-rusting, phosphating and passivation including repeated rinsing in between each process. On completion of passivation of the components they shall be preheated and then epoxy powder coated with selected shade for exterior as well as interior and Glossy White shade for the gland plates (Inside the panel) and component mounting plate.

All interiors and exteriors of the enclosure shall be finished and painted to prevent rusting and corrosion. The paint should be carefully selected to withstand tropical heat, rain and environmental effects. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling. Thickness of all painting shall be average 80 microns DFT. The final colour of Feeder pillar shall be as per Client requirements.

The gasket shall be of neoprene rubber suitable to withstand all weathers for long tenure of service. All hardware shall be made of non-corrosive material either HD Galvanized or stainless steel. Door shall be with concealed type hinges & captive screws.

Both the doors shall have an Inspection/ View Window for monitoring the energy meter reading without opening the door. The window on the external door shall be provided with a metal flip cover with small canopy which can be moved up and down for viewing the meter.

Both the doors shall have panel type lock with keys in duplicate as per the requirements.

All the feeder pillars shall be of uniform height and shall be mounted with the bottom of the panel at minimum 800mm above the Finished Ground or Floor level as the case may be.

A danger notice board written in English, Hindi and local language shall be made of 2mm thick GI plate and shall be provided on the front door of the feeder pillar.

CONTRACTOR shall provide minimum 10 mm thick MS fabricated Cage covering entire feeder pillar with 7 lever locking arrangement.

The details of max load in KW, Rating of Incomer, no of phase, voltage, frequency, controller no., Meter No., road name, Pillar no. name of the agency and year of erection shall be labelled using radium sticker/radium paint.

The feeder pillar shall have cable entry at the bottom suitable for terminating double compression glands for 2 Runs of 3.5 C x 50sqmm Aluminium conductor, XLPE insulated armoured cable at the incoming terminal and minimum 4 Runs of 4 core 16 sqmm Aluminium conductor, XLPE insulated armoured cable at the outgoing terminal.

All MCBs/ RCBOs/RCCBs shall be comply with the relevant IS and IEC standards. It shall be current limiting type and shall provide a cut off in, < 10 ms for prospective currents during faults. It shall be provided with fixed thermal overload, short circuit and earth fault release as appropriate. The breaking capacity of the MCB shall be 10kA for 1 sec.

The Outgoing and Incoming breakers shall be discriminated based on Current. Two nos.

Pipe Earthing electrode shall be provided for each Feeder pillar and connected with 25X6 mm GI earth strip. The pipe electrode shall be as per the latest version of IS 3043- 2018.

HDPE/ DWC pipe of suitable size (minimum 40 mm ID) for conveniently accommodating the above incoming and outgoing cables shall be laid upto the feeder pillar for carrying the buried cables upto the feeder pillar for termination. The GI strip for earthing shall be laid with proper dressing.

The feeder pillar shall be mounted on prefabricated Galvanised Steel Support structure duly fastened with a concrete foundation with M20 concrete suitable to sustain the local geological conditions, seismic conditions and max wind speed requirements.

All the material/equipment/accessories must confirm to the relevant IS with its latest amendments. All the material/equipment/accessories shall be supplied with manufacturer's test certificates.

Insulation resistance between live parts and earth terminal shall be 2 MΩ minimum. All power equipment shall be able to withstand high voltage (HV) test at 2.5 kV for 1 minute between live parts (current carrying parts) and earth terminal without breakdown of insulation.

Following documents needs to be submitted for approval before Manufacturing Clearance:

- General Arrangements drawing.
- Support and foundation drawings
- Wiring diagram.
- QAP (Quality assurance Plan).
- Datasheet for each component.
- Bill of material

Routine test shall be conducted as per relevant IS/IEC and shall be carried out at manufacturer place and same shall be witnessed by Client's representative. Following shall be minimum check:

- Visual inspection Check

- Bill of material.
- Electrical Continuity check.
- Functional Check.
- HV insulation check.
- Functional/ Operational check

TECHNICAL SPECIFICATIONS OF SMART GROUP LIGHTING CONTROL & MONITORING SYSTEM FOR STREET LIGHTING

Scope of Work:

This includes supply, Erection, testing and Commissioning of Smart Street Light control & monitoring system of LED Street Light luminaries with Group Level ON / OFF control using latest LPRF technology with necessary hardware and software to centrally monitor and control the system. The system shall be scalable type in order to expand the same in future with the same type of controller and Software.

QUALITY CONTROL & TESTING INFRASTRUCTURE

The manufacturer should possess the all in-house testing facilities & equipment's carry out electrical, photometric & environment related measurements and tests as per BIS standards and shall provide calibration reports of the same.

WARRANTY:

Tests Reports to be submitted by Contarctor Along with the Sample of Street Light Fixture as per Approved Make & Tender Specifications.

- i. IS10322 Luminaire General Safety Report from NABL Lab / Accredited Lab
- ii. IP and IK test certificates from NABL Lab / Accredited Lab
- iii. The bidder shall submit the LM-80 test report of the LEDs used in offered lighting fixtures for 9000 hrs. of testing along with TM21 projection report which shall have LED life of more than 50000 hrs. tested at 105 Deg C at maximum rated current of LED Chip.

iv. LM-79 confirming to the applicable for LED Luminaries Performance with the bid.
The test report must clearly indicate model, Cat. No. and wattage of fixture.

v. IS16108 / EN62471 – Photo biological Safety report of LEDs used in the luminaries

TECHNICAL SPECIFICATIONS: LUMINAIRE

INGRESS PROTECTION: -

Ingress protection should be IP 66. The fixture should have double-wall construction with silicone gasket designed for IP66 without using any glue to prevent breakdown of the water and dust proof seal for both the LED & the driver compartments.

GLARE: The Lens used in the luminaries shall be full cut off type such that the glare from individual LED is restricted and shall not cause inconvenience to the public. Individual or Group of LEDs shall have Lens and product without Lens are not acceptable.

SURGE PROTECTION: Internal Surge protection of 4KV with an External surge protection of 10KV should be put in the Luminaries to ensure protection against surge arising from power line.

TEMPERATURE RISE: -The fixture body temperature shall not exceed 40 Deg C from ambient even after continuous operation for 24 hrs.

The fixture shall work on single phase or three wire system (phase, neutral & earth). The maximum tolerance in wattage of fixture will be within the wattage range mentioned in the item schedule.

GROUP CONTROL MONITORING AND CONTROL SYSTEM:

This section covers the design, construction and testing of Smart Group Street Lighting Control & Monitor System (GCMS) with programmable timer unit, contactors, relays, internal wiring with remote operation and housing. All components of the lighting control system shall be housed in the IP54 electrical enclosure.

The Lighting Automation System shall feature a web-based solution for remote management of lighting. The system shall control and monitor Group streetlights and lighting distribution boards remotely via wireless communications such as GPRS as one of the primary communications networks to the server.

The system shall control and monitor Group of street lights and lighting distribution boards remotely via wireless communications such as GPRS as one of the primary communications networks to the server.

The system shall be modular and easily scalable to include larger areas without any major upgrade on server and software. The centralized solution shall provide Group level on/off control, simplified maintenance and a remotely operated system. Programming shall be enabled remotely and can be changed at any time. The ON / OFF times shall be optimized for the different daylight hours every day for energy optimization. That is, it would be optimized to follow the sunrise and sunset times every day. Electrical cabinet monitoring configurations shall be enabled remotely and can be changed at any time. Power supply voltage input to electrical cabinets shall be available On-Demand. All alarm/fault detection events shall be logged and available for report-out printing for analysis.

Intelligent Outdoor Lighting System

Intelligent outdoor lighting system offers end to end solution for Smart Group Street Lighting System. Solution should include street light control unit hardware, GCMS Gateway with Smart Feeder panel and Web based application for remote monitoring & control. The system is based on GPRS/Ethernet and LPRF technology, which establishes communication to server and enable data logging, monitoring and control.

Features of proposed system:

- Group level control at Feeder Panel
- Phase Wise Turn ON / OFF Lights as per predefined schedule
- Control of Light as per Astronomical Time clock
for Sun Set and Sun Rise times
- 24 x 7 Online monitoring
- Failure reporting
- Reports and Measurements of base load



RF based lighting control system for Street Lights

RF-based two-way communications between lamp Ballasts (drivers) and segment gateway controllers based on industry standards which saves direct investment in external communication arrangement. Schedule switching in street lights yields long lamp life and energy savings up to 50% also leading to reduced maintenance & operating cost. Condition Management via Smart Street Network in which parameters are control with specially designed & easy to use interface

System Components

- Smart Feeder panel with Gateway - GPRS / LAN Enabled
- Software (Smart Street Network)

General function of the system:

Control	Monitor	Protection/Alarm
Lamps ON/OFF	Input Power of each Phase	Input High Input Voltage, Current
	Supply Voltage, Current, Power factor, Energy Consumption	Input Power factor, Phase Failure
	Lamp Voltage, Current, Status	Input Under voltage
	Lamp Operating hours	

GCMS PRODUCT SPECIFICATION

1) PRODUCT: GCMS CONTROLLER

A. Technical Specifications -

- Processor: 32bit
- Real Time Clock: Battery Backed RTC Network Fault Tolerance
- GSM Characteristics: GPRS based
- Storage Memory: 256MB X NAND Flash
- Power: Universal AC input 100-260 VAC, 50/60HZ
- Ports: Optional - Ethernet: 10/100 Base-T
- Installation: Pole Mount or Wall Mount or Panel Mount

- Capable of interface with three-phase power supply with battery charger

B. General Specifications –

- Mains Connection: Single Phase Two Wire or Three Phase Four Wires
- Input Sense & Output Drive: 6 - AC Input 3 - Drive Output
- Communication Wired: RS232 / RS485 for Energy meter Interface
- Locator: GPS as an option
- Indications: Active Indication LED for Communication of Energy meter, GPRS, GPS, RF
- Memory: Inbuilt Micro SD card for data storage (Capacity up to 16GB)
- Enclosure Mounting Type: Panel Mount / Din rail Mount
- Capable of downloading configuration and stored data through a PC interface

C. Input Sense

- 230V AC 50 Hz sensing: Three line for input R-Y-B phase sensing Three line for output of R-Y-B contactor sensing
- Sensing: Door open/close sensing

D. Output Drive

- 230V AC 50 Hz output: Three lines for driving single pole R-Y-B contactor.

E. Environmental Specifications

- Operating Temperature: -10°C to +55°C
- Storage Temperature: 0°C to +55°C
- Humidity: less than 95% RH, Non-condensing.

GCMS System Details:

Smart Feeder Panel made up of single / double door CRCA Sheet Steel with Grey Powder

Coating / Painting of minimum 22 SWG and with IP54 Protection with

A) Switching Point Controller: This hardware consists of MCBs, Contactors and Fuses which protects system and operators in case of electrical malfunction, Switching point controller VA rating is designed for twice the lighting load requirement, SPC uses Class 1.0 Single or Three Phase energy meter, It should allow Manual override of the system with Isolator during maintenance and system faults. It should have single phase/ three phase energy meter, Street light Feeder pillar with GCMS Controller and Switching components, web-based application and cloud server. System capabilities including Scheduling, Group lamp Control, fault notifications and report generation in command CVS format.

B) Energy Meter: It compliance with the standard IS: 13779/1999 or IEC: 1036. CBIP Report-325 Complied. Voltage Rating should be 10- 60A, Class 1.0, Rated frequency 50Hz, Power factor 0.25 lag - Unity 0.5 lead, as per IS13779. The system monitors energy parameters and communicate it with GCMS unit to transmit it to server, Voltages each phase, Current each phase, PF each phase, Metering KWH cumulative, Metering KVAH, Number of operational light, Number of non-operational lights, Failure of contactor, Status of the incoming supply (power failure), High /low voltage, Overload on the phases.

C) GCMS Controller: Power supply - 230VAC, Communication through GSM/GPRS or Wi-Fi. It Should supports Phase wise on /off switching by Schedule or by built in astronomical clock for ON/OFF luminaires based on selection and Manual ON/OFF of lights of a particular switching point or networked switching points from Central Control Station. Battery Backed RTC in built in side GCMS Controller. Internal storage Memory 256MB X NAND Flash. Optional - Ethernet. Inbuilt Micro SD card for data storage (Capacity up to 16GB). Alert message in pre-defined abnormal system conditions through SMS (5 numbers) and web-based application through GSM/GPRS for: i) Phase-wise currents on crossing threshold values ii) Phase-wise voltages on crossing threshold values. iii) MCB trips, iv) Theft alerts, v) No output supply vi) Group failure of lights vii) No input/output supply. Serial Communication: RS485/RS232, GCMS Controller can be remotely configurable through server. Communication Protocol - Street Light Gateway supports RS485 MODBUS communication and HTTPS support for Wireless communication with server using SIM based GPRS Connection.

Local / Cloud managed Web based Application Software - It Enables comprehensive display of live and historical data with remote configurations features. Configuration and Control – Allows user to communicate with individual and networked switching points and Group of

Street lights remotely. Fault Alarms/Alerts – Switching point failures, Group Luminaires failure, excess voltage/current drawn, no mains power, and GPS Location change and contactor failure. Allows user to trace switching points, Allows user to generate various reports, possible to configure switching points through web application. Remote configuration includes new ON/OFF timings, RTC time, Real time data of each switching point, Energy meter parameters, Web application enables user safety with multiple user privileges and differentiates admin/general users, System is fail proof with password protection, Web application provides comprehensive dashboard with real time status of switching point, real time faults of various switching points, power consumption, cumulative data, Google map integration for lamps connected to Feeder panel on map along with its real time status with basic energy parameters of gateway controller etc., Web based software offers SMS and Email alerts for various faults. Also, provides daily/ weekly/ monthly reports through email, Minimal interval of data update – 15 mins and programmable up to 1 min (Recommended >5 mins). It also enables user to identify each SPC with unique/Asset ID with additional information like individual SPC's real time status and basic electrical parameters.

Server Cloud: The server/Cloud platform shall be of dedicated Windows / Linux server with minimum of 16GB RAM with sufficient bandwidth. Software shall be installed in server i. java language ii. MySQL server, the server/Cloud platform should support sufficient storage, Server/Cloud platform provider shall have capable to perform auto backup and restore facilities, Server/Cloud platform provider shall have regular maintenance of the server and immediately address in case of server down, Server/Cloud platform shall have minimum uptime of 99%, Server/Cloud should able to handle minimum of 1000 concurrent connections. It shall support GDPR guidelines prevailing at the time of commissioning and installation.

In case of CLOUD server, the CLOUD registration shall be done in the name of Client/ Owner. Only Administrative rights shall be provided to the CONTRACTOR during the contract period. The CLOUD services shall be intact upon renewal every year after the contract period. The CLOUD shall not be OEM specific and shall be independent of OEM so that after the completion of contract period there should be no dependence on OEM for cloud services. Ministry of Electronics and Information Technology (MEITY) empaneled companies for providing Cloud services shall only be considered.

CABLE AND CABLE TERMINATION

All the LV Power cables shall be 1100V grade, multi-stranded, Al / Copper conductor, XLPE insulated, extruded inner & outer PVC sheath compound type ST2 and galvanised

steel strip armoured cables.

All cables shall conform to IS 7098 – Part I, 1988 (Reaffirmed- 2015) and all armouring shall confirm to IS: 3975, 1999 (Reaffirmed- 2014).

For all LT power and control cables, double compression glands with aluminium lugs for Aluminium cables and tinned Copper lugs for Copper cables shall be used in indoor and outdoor application.

The termination shall be inclusive of miscellaneous items such as clamps, cleats, cable tags, cable markers etc.

In general cable installation works shall be carried out in accordance with IS 1255 – 1983 (Reaffirmed- 2016), latest version. At road crossings, the depth of the Pipe shall be minimum 1m else proper concrete encasing shall be provided.

For Underground cables, all cables shall be laid in minimum 63 mm ID HDPE/ DWC pipes laid by excavation. The top of the pipe shall be at least 750mm below the finished ground level. There should not be any joints between two pole distance. The roads shall be made good as before by following standard procedure for preparation of roads and with standard quality material.

Cable markers shall be provided in the vicinity or on the top of the corridor such that it should not obstruct the pedestrian/ parked or traffic vehicles. Cable markers shall project 150mm above ground and shall be spaced at an interval of 20metres, and at every change in direction. Top of cable marker/joint marker shall be sloped, to avoid accumulation of water/dust on marker. On finished surface like foot path etc. the marking shall be accomplished with a separate colour tiles/ paver block for highlighting the route of the cable.

Cable tags shall be provided on all cables both at feeder pillar end as well as on each pole JB (just before entering the equipment enclosure).

Cable Glands

- a) Double compression type cable glands with rubber hoods shall be used for the termination of all the power and control cables. Cable glands shall be brass casting, machine finished and Nickel-plated to avoid corrosion and oxidation. Rubber components used in cable gland shall be of neoprene.

- b) For single core cables, gland shall be with brass ring.
- c) Cable glands shall be with metric threads.
- d) Cable glands shall be conical (& not flange type).

Cable Lugs

- a) Cable lugs shall be of tinned Copper, solder less crimping type for Cu cables & Al lugs for the Al cables.
- b) The current rating of the lugs shall be same as that of the respective cable conductors.
- c) Ring type cable terminations shall be used.
- d) Insulated lugs are not acceptable for any cable terminations.
- e) Bi-metal strip/ Bi-metallic lug shall be used whenever two different metals are to be connected together.
- f) Double hole extended neck (long barrel neck) type lugs shall be used in case of cables above 185 sq. mm.
- g) Fork terminals shall be used for luminaries & decorative switch/ socket. Pin terminals may be acceptable during execution only in case other terminals/ lugs cannot be accommodated.
- h) Reducer / wire pin terminals shall be avoided for MCB terminations. MCB terminations shall be with 'long palm terminals.
- i) All terminations in Feeder Pillars / enclosure for earthing & neutral busbars / terminals shall be with ring type terminals.
- j) All earthing terminations shall be with ring type lugs only.
- k) All control & interlock cable terminations shall be with ring type lugs.
- l) Anticorrosion/ anti-oxidation compounds shall be used for crimping lugs [This shall especially be ensured for Al cable terminations & any bimetallic terminations (Cu cable termination using tinned Copper lugs)].

If termination is done with crimping tool employing crimping die then forming dies shall be used to make the sector shaped conductor into a round conductor before crimping the lugs on the conductor. The lug must not be crimped directly on the sector conductor. Before crimping the lug, the conductor shall be thoroughly cleaned and special jelly applied over it to prevent further oxidation.

LED LUMINAIRE DATASHEET

Sr. No.	Parameters	Requirements / Value
1.	Type	LED Luminaries complete with all accessories including driver, internal wiring and protections
2.	LED chip make	Nichia, Philip Lumiled, Osram, CREE
3.	Rated Voltage	230-240V
4.	Operating Voltage Range	Single phase 140-280 volt AC. But luminaries shall be tested for 100V to 300 V AC
5.	Frequency	50 Hz +/- 3%
6.	Power Factor	> 0.95
7.	LED wattage	>1Watt & <3 Watt
8.	LED chip Efficacy	>135 Lm/Watt system lumen output at 25 degree C, supported by LM80 report, to be submitted.
9.	LED Drive current	>=350 mA<750 mA
10.	LED Beam Angle	CONTRACTOR to decide
11.	Colour Temperature	≥5500K and within ± of tolerance limit as per relevant standards
12.	Rated Minimum LED Life (L70)	50000 Burning Hours (With only 30% Lumen Degradation or 70% Lumen maintenance)
13.	System efficacy	≥ 120 Lm/Watt

14.	Total Lumen Output	CONTRACTOR to offer
15.	Colour Rendering Index of Luminaires	>70
16.	System Power Efficiency	≥ 90%
17.	Driver Type	Constant Current based Electronic Driver
18.	Driver Efficiency	> 90% for luminaire wattage > 75W and > 85% for luminaire wattage ≤ 75 W
19.	Driver Life	Same as LED Luminaire Life.
20.	Maximum temperature rise for Driver	<30 Deg C at 45 Deg C ambient
21.	Operating Temperature Range	-10 Deg C to + 50 Deg C
22.	Luminaries body temperature after 12 hours of continuous operation	≤ 30 Deg C from ambient
23.	Junction temperature	< 85 Deg C - self certified by Manufacturer
24.	Heat Sink Temperature	≤ 75 Deg C from ambient
25.	Solder point temperature	< 78 Deg C
26.	Operating Humidity	10% to 95% RH
27.	Operating Hours	Dusk to Dawn (max 12 Hrs.)

28.	Total Harmonics Distortion (THD)	<10%
29.	Construction	High power LED must be mounted on Copper MCPCB for high thermal conductivity and fastest heat transfer from the LED junction
30.	IP Protection	IP66 or more; no water stagnation anywhere
31.	Luminary Housing	Pressure Die Cast Aluminum (grade 5000 or similar) housing with corrosion resistant polyester powder coating & safety as per IEC 60598:2014 and 2017 / IS 10322, 1982 (Reaffirmed 2005). Mounting bracket with aiming & locking facilities. Large surface area with fins to dissipate the heat to ambient air
32.	Heat Sink	Well-designed thermal management system with defined heat sink
33.	Clip / Fasteners	Corrosion free/ Stainless steel.
34.	Wire	The connecting wires used inside the luminaries shall be Low Smoke Halogen Free, fire retardant e-beam cable or as per IS 10322 part 5 sec which ever is stringent shall be provided in input side.
35.	Materials	As per relevant standard and specification whichever is stringent
36.	Optics	As specified in the Specifications.
37.	IK protection for Optic Cover	≥ IK07

Sr. No.	Parameters	Requirements / Value
38.	Photometric measurements	LM-79/IS16105, 2012.
39.	Minimum in-built Surge Protection: Min Surge protection required for luminaires	4 kV; 10kV/10 kA
40.	Min Surge protection at Feeder Pillar	20kV/10kA

DRIVER/ CONTROL GEAR Data Sheet

Sr. No.	Parameters	Requirements / Value
1.	Type	Constant Current based Electronic Drive (inbuilt in Luminaire housing)
2.	Driver Efficiency	> 90% for luminaire wattage > 75W and > 85% for luminaire wattage ≤ 75 W
3.	Driver Life	Minimum 50000 Hours or Same as LE Luminaire Life.
4.	Operating Voltage Range	100V to 300 V AC
5.	Frequency	50 Hz +/- 3%
6.	Power Factor	> 0.95

Sr. No.	Parameters	Requirements / Value
7.	Total Harmonic Distortion (THD)	<10%
8.	Protection Class	Class I
9.	Operating Temperature Range	-10 Deg C to + 50 Deg C
10.	Minimum in-built Surge Protection	4 kV
11.	IP Protection	IP65 or more
12.	Output Current Range	<750 mA
13.	Output Voltage Range	40 V DC – 215 V DC
14.	Output Power	< 150 W
15.	Short Circuit Protection	Yes; Constant current limit mode.
16.	Open Circuit Protection	Yes
17.	Over Voltage Protection	Yes; Auto Isolation
18.	Over Temperature Protection	Yes; Auto Shut Off.
19.	Under Voltage Protection	Yes
20.	EMI Compliant	Yes

VII. OCTAGONAL STREET LIGHT POLE

GENERAL REQUIREMENT

The Product should be designed for the specific climatic and environmental conditions of the region to ensure full durability and safety throughout its designed life.

All the Octagonal Poles shall be designed to withstand the maximum wind speed of 180 kmph as per IS 875. The top loading i.e. area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BS EN 40-3-3:2013.

The pole shall also be designed to withstand the Earthquake as per the provisions of the relevant BIS/other standards.

The pole shaft shall have octagonal cross section and shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding of the pole shaft. The welding of the pole shaft shall be done by Submerged Welding process.

All octagonal pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing minimum 4 foundation bolts. The base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside. The welding shall be done as per standard approved process.

The materials of the pole are as follows:

- a) Pole - Conforming to grade S355J0 as per BS EN 10025/ E350 as per IS 2062.
- b) Base Plate: - Fe 410 Conforming to IS 226/ IS 2062.
- c) Foundation Bolts: - 6.8 Gr. as per IS 1367/ EN8 grade as per BS970.
- d) Pole Sections: - The Octagonal Poles shall be in single piece with single longitudinal welding joint,
- e) Galvanization: - The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 and BSEN ISO 1461 standards with average coating thickness of 65 micron. The galvanizing shall be done in single dipping. The zinc Ingot raw material shall be 99.99% pure and procured from reliable sources with Quality Test Certificates.
- f) Paint:- Entire Pole and its accessories shall be given an extensive three stage treatment with Polyurethane (PU) based etch primer and two coat of approved Polyurethane (PU)

paint (Marine grade paint) to minimum average DFT of 70 microns for surfaces to make it absolutely rust and corrosion proof, as well as giving it a pleasing appearance. The color shall be of the choice of Client.

The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

The poles shall have integrated Junction box with openable door of adequate size (Not less than 500mm length) at the elevation of 750 mm from the base plate. The door shall be hinged type with mechanical interlock, dust proof, weather proof and vandal resistant and shall ensure safety of inside connections and components. The door shall be flush with the exterior surface and shall have suitable locking arrangement. The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

The door of the Junction Box shall permit clear access to the components inside viz., termination strips, connectors, MCBs, cables etc. There shall also be suitable arrangement for the purpose of earthing.

Electrical connections - Four way connectors shall be provided along with Slide lock suitable for connecting 1.1 kV grade, 4 core X16 sqmm Al cable. It shall also house 1 no. 6 amps DP MCB, 2.5 sqmm connectors for looping with 2.5 Sqmm Copper wires for connecting to the luminaries through 0.75kV grade, 3 core X 2.5 mm² PVC insulated copper conductor flexible un-armoured Cable from the terminal block to the fixture within the pole. All the cables laid through the pipe shall be without any joint.

Two nos. Earth Boss shall be provided at the bottom of the pole or on base plate (diagonally opposite) suitable for connecting 25X6 mm GI/ CU earth strip earthing of the poles. Similar Earth Boss suitable for connecting 4 sqmm copper wire shall be provided on the control plate inside the Junction Box for earthing of the electrical components.

Two nos. 50 mm DWC HDPE sleeves of suitable length shall be provided through the foundation up to foundation top.

Earthing of each pole shall be carried out with one earth electrode for a set of 5 poles. The earth electrode shall be GI pipe electrode as recommended in the latest version of IS 3043. The earth electrode shall be connected with 8SWG wire laid in DWC pipe along with lighting cable to the two distinct earth boss on the pole.

Aesthetic appearance - All the grooves and carvings of the pole unit shall be free from any kind of distortion for a pleasing aesthetic appearance.

Top Mountings -The galvanized decorative mounting bracket as selected by the GSCL shall be supplied along with the Poles for Installation of the luminaries.

The Poles shall be bolted on a pre-cast foundation with a set of foundation bolts for greater rigidity.

The CONTRACTOR shall carry out all the relevant tests and inspection in the presence of the Client or Third Party Agency, as may be selected by the Client, before the dispatch of the poles at no extra cost.

The CONTRACTOR shall inform the Client at least FIFTEEN (15) days in advance, about the manufacturing program so that arrangement can be made for inspection. Client reserves the right to waive the inspection at any stage.

All the material/equipment/accessories shall be supplied with manufacturer's test certificates.

CONTRACTOR shall submit the Proposed Product Catalogue, Detail Data sheet, spare parts list and drawing of Pole & Bracket during the execution stage for approval.

CONTRACTOR shall arrange for all the tools and equipment's including spares.

M20 concrete foundations shall be provided for all the poles. Approx. dimension of the foundation for evaluation purpose is 600X600X1700 mm. However, CONTRACTORs shall design as per the stability requirement and Soil bearing Capacity of each location. The Poles shall be bolted on a pre-cast foundation with minimum four foundation bolts for greater rigidity.

Galvanized Poles Dimensions – These are the minimum dimensions to be followed. However, CONTRACTOR may offer as per their design for a particular Height.

List of Certificates to be submitted by Contractor for Poles:

- a) Galvanizing test certificate.
- b) Steel grade certificate from steel mill.
- c) Stability test certificate after installation of pole.

d) Wind Tunnel Test Certificate from reputed laboratory or organization.

MINIMUM REQUIREMENTS OF THE GI POLES:

HEIGHT	TOP DIA (A/F)	BOTTOM DIA (A/F)	SHEET THICKNESS	BASE PLATE DIMENSIONS (LxBxT)	FOUNDATION BOLT			
					BOLT SIZE (NO. x DIA)	PITCH CIRCLE DIA (PCD)	BOLT LENGTH (MM)	PROJECTED BOLT LENGTH
(mtr)	(m)	(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
5	70	130	3	200 x 200 x 12	4 x 16 Dia	200	600	80
6	70	130	3	220 x 220 x 12	4 x 20 Dia	205	600	100
7	70	130	3	220 x 220 x 12	4 x 20 Dia	205	750	100
8	70	135	3	225 x 225 x 16	4 x 20 Dia	210	750	100
9	70	155	3	260 x 260 x 16	4 x 24 Dia	250	750	125
10	70	175	4	275 x 275 x 16	4 x 24 Dia	270	750	125
11	90	210	4	300 x 300 x 20	4 x 24 Dia	300	750	125

HEIGHT	TOP DIA (A/F)	BOTTOM DIA (A/F)	SHEET THICKNESS	BASE PLATE DIMENSIONS (LxBxT)	FOUNDATION BOLT			
					BOLT SIZE (NO. x DIA)	PITCH CIRCLE DIA (PCD)	BOLT LENGTH (MM)	PROJECTED BOLT LENGTH
(mtr)	(m)	(m)	(mm)	(mm)	(mm)	(mm)	(mm)	(mm)
12	90	240	4	320 x 320 x 20	4 x 24 Dia	325	850	125
14	90	240	4	As per manufacturer Recommendations				

VIII. EARTHING & LIGHTNING PROTECTION SYSTEM

SCOPE

This specification covers supply, design, installation, commissioning & testing of items required for earthing system including grounding conductors, rods, fittings, accessories and hardware to permanently and effectively ground the neutral points of transformers, electrical apparatus, computer equipment, electrical equipment frames, conduit, cable trays and all non-current-carrying metal parts, including structural steel and fences.

APPLICABLE CODES & STANDARDS

The earthing and lightning protection system shall conform to the Indian Electricity rules, and the latest applicable standards indicated below:

Code of Practice for Earthing	:	IS:3043
Code of Practice for the Protection of	:	IS:2309
Building and allied structure against lightning		
Hot dip galvanizing	:	IS:2629, 2633, 4759
Structural steel	:	IS:2062& 808
Welding	:	IS:816

GROUNDING SYSTEM

General Requirements:

The design of the equipment shall meet the following requirements.

- a) It should provide means to dissipate the current into the earth during normal and fault conditions without exceeding the operating and substation equipment limits and connections.
- b) The ground grid shall provide least resistance path for grounded neutral circuits.
- c) The ground grid shall provide means of discharging current carrying parts which are to be handled by personnel.
- d) Grounding consists of all conductors, ground rods, connectors and all other necessary items to make a complete grounding system.
- e) The Contractor shall finalize the layout of the grounding system as required for the final equipment dimensions and locations.
- f) The ground grid shall be designed so as to provide a maximum ground resistance of 1.0 ohm or less.
- g) Ground grid shall be installed at a minimum depth of 600 mm from ground level.
- h) Earthing of transformers will be done separately through plate electrodes & further connected to the main collector network using connectors/ risers.
- i) Where the ground conductor crosses the cable/ pipe trenches, the conductor shall be suitably lowered so as to cross cable trench at least 150 mm below its bottom surface.
- j) Risers shall be brought out above the ground level for further extension and connection to equipment.
- k) All conductors in the ground grid shall be welded together at every crossing and at every point where from risers emanate. Continuous lap welding shall be done instead of tack welding.
- l) The risers from the grid shall be laid to avoid contact with reinforcement to guard against false grounding during resistance tests.

- m) All non carrying current metal parts of electrical equipment and apparatus shall be earthed with two separate diametrically/ diagonally opposite connectors. The apparatus shall include:
- n) Bodies of electrical machinery, transformers etc.
- o) Frames of panels and cubicles.
- p) Metallic structures of switchgear, casing of cable boxes.
- q) Shielding of cables and electrical wiring conduits.

Design Criteria:

- a) Fault Current & Duration: The earthing system will be designed for fault current of 21kA for 1 sec.
- b) Conductor Material:

The earthing system conductors and accessories shall be as follows:

(a)	Conductors above ground level and in trenches	:	Galvanised steel
(b)	Conductors buried in ground or embedded in concrete	:	Mild Steel
(c)	Electrodes for treated earth pit	:	Maintenance free earth electrode
(c)	Electrodes for non-treated earth pit	:	32mm dia rod Mild Steel
(c)	Electrodes for treated electronic earth pit	:	Copper Plate

- c) Soil Resistivity

The Contractor shall undertake the soil resistivity measurements at site and select suitable type of conductors. However for bidding purpose soil resistivity shall be considered as 100 ohm-meter (APPROX.). If any major changes in soil resistivity after actual measurement during detailed engineering, shall be adjusted accordingly.

- d) Size of Conductors

The earthing conductor sizes shall be calculated as per IS: 3043. The calculated size shall be suitably (depending on the resistivity of soil) increased to account for the loss of material due to corrosion in soil.

e) Maintenance free Earthing Electrode System/ Chemical Earthing

In maintenance free earthing copper bonded earthing rod electrode shall be of 17.2 mm in diameter and 3 mtr length. The rod shall be placed in a 150 mm dia an augured hole in the ground and then surrounded by ground enhancement material in either a dry form or pre mixed in slurry. Once set, ground enhancement material becomes hard and as such holds positively to the rod as well as surrounding ground.

Earth rod offered shall have passed the test required of BS7430/ ANSI/ UL467 and confirm to the adhesion of the copper coating to the steel core (Design feature that prevents the ingress of moisture and subsequently the integrity of the rod.

Minimum 0.25 mm thickness of copper shall be deposited over the steel core as per BS 7430/ UL 467. Average life of the ground rod shall be 30 years in most soil.

Ground enhancement material shall be as per IEEE-80 clause 14.5d with a resistivity of less than 0.12 ohm-meter. The ground enhancement material shall be permanent and not leach any chemicals in to the ground. The pH value of the ground enhancement material shall be 6.9 to 7.2 of 100 gm/ lit @ 20 deg.C.

The electrode shall be surrounded by atleast 10 kgs (5kg x 2bags) of Ground Enhancing material like TEREK+ or equivalent so as to provide maximum contact between the electrode and the backfill. The product shall be tested for resistivity by Govt Lab like CPRI for atleast 5-years. Chemicals used should be certifid to be environmental friendly& pH neutral.

Inspection chamber shall be of 400 x 500 mm with concrete base CI manhole cover with frame painted with bitumastic paint. 2 Nos. of 50 x 6 mm cross section & 300 mm long copper strip to be clamped with copper claded rod electrode have sufficient nos (But not less than 4 Nos.) of 10 mm GI nuts & bolts for connection to the equipment / interconnection to the other pits to form equi-potential bonding.

f) Plate Electrodes

GI/Copper plate electrodes shall be used as per IS-3043. Minimum 10% of test pits shall be provided. Electrodes installed in the test pits shall have disconnecting facilities. Necessary number of treated earth pits shall be provided for all transformers.

g) Earthing of Electrical Equipment

All electrical equipment shall have double earthing. A ring earthing system shall be provided within the plant to which electrical equipment shall be connected at least at two places. The earth point on the machine shall be connected to the plant earthing system through GI wire.

The size of the earthing leads shall be decided based on the type of equipment and structure to be earthed and shall be provided generally as per IS: 3043 and also with a view to minimise the number of sizes.

An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a copper flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument plate type earth. If due to the physical size of a control panel more than one instrument earth bar is required the additional bar shall be connected again with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radials from the same plate type earth point.

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated. Connection between instrument earth bar and instrument plate type earth pit shall be insulated copper wire such that earth pit resistance is less than 1 Ohm at panel.

Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

a) Fabricated Steel a) Thickness less than 2 mm, But not less than 1.2 mm b) Thickness less than 5 mm, but not less than 2 mm c) Thickness 5 mm and over	340 gms/sq.m 460 gms/sq. M 610 gm / sq.m
b) Fasteners Upto nominal size M10 Over M10	270 gms/sq.m 300 gms/sq.m

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

EARTHING SYSTEM LAYOUT

The Contractor shall submit the earthing drawing/ layouts to electrical Inspector for his approval. Necessary modification wherever required shall be carried out by the Contractor and got approved by the Inspector at no extra cost to the Employer. After installation the resistance of the ground grid shall be tested in presence of Employer/Consultant as per the CEA guidelines 2010. After the test, report shall be submitted to Electrical Inspector for approval. The submission of Earthing layout, drawings and obtaining Electrical Inspectorates final clearances & approval shall be within the responsibility of the Contractor. If the resistance is observed to be not less than 1 ohm, the Contractor shall derive additional earth pits such that resistance is less than 1 ohm.

General:

Metallic frames of all current carrying equipment, supporting structures adjacent to current carrying conductors, structures and neutral points of various systems shall be connected to a single earthing system. Two earthing leads shall be used if rated voltage of equipment is above 250 V. If the rated voltage is 250 V or below, one earth lead shall be provided. Metallic structures adjacent to electrical equipment shall be earthed by one earthing lead.

Earthing conductors in outdoor areas shall be installed at a minimum depth of 600 mm.

All cable trays in the plant buildings as well as inside the trenches shall be connected to earth grid at an interval of about 10 m.

Earthing Conductors Inside Building

Main earthing conductors shall be buried in earth around the building. Minimum two taps—off from this earthing loop shall be taken inside the building and connected to the earthing grid embedded in the floor slab with approximately 50 mm concrete cover.

Each RCC/ Steel column of the building shall be interconnected to the floor earthing grid in the ground floor. However, it shall not be considered for the grounding design.

Cable trays, steel pipes/ conduits, steel columns, etc. shall not be used as earth continuity conductors.

Instrumentation system and computer system shall be provided with a dedicated earthing system suitable for the equipment.

Earthing grids of all the buildings, outdoor yards shall be interconnected to form a single grid for the plant.

Earthing grid design shall be done in such a manner that the grid resistance is less than one ohm.

Earthing System Installation

- a) The spacing between two electrodes shall be at least equivalent to twice the length of the electrode.
- b) Earthing conductor running exposed on column, walls, etc., shall be supported by suitable cleating, at intervals of 750 mm.
- c) The earthing conductor crossing the road/ track shall be laid in hume pipe or laid at a greater depth to avoid damage.
- d) When earth conductor passes through floors, walls, etc., suitable pipe sleeves shall be provided and the same shall be sealed after installation.
- e) The connection between earthing pads/ terminal to the earth grid shall be made short and direct and shall be free from kinks & splices.
- f) Metallic conduits and pipes shall not be used as earth continuity conductor.
- g) Flexible earth conductors shall be provided at expansion joints for earthing the gates, operating handles, etc.
- h) Equipment bolted connection after being checked and tested shall be painted with anti-corrosive paint/ compound.
- i) Connection between the equipment earth lead and the grid conductor shall be welded. For rust protection, the welds shall be treated with zinc chromate primer and coated with zinc rich paint.
- j) The cable sheaths, screens armour shall be earthed at both ends for multi-core cables. For single core cables the same shall be done at one end (switchgear end) only.

- k) All bimetallic connections shall be treated with suitable compound to prevent moisture ingress.
- l) The fence around the electrical equipment shall be connected to the main grounding system at diagonally opposite corners.

LIGHTNING PROTECTION SYSTEM

Conductors For Lightning Protection System

The size of conductors for lightning protection system shall be decided based on mechanical strength. Lightning protection system shall consist of vertical air termination rods, horizontal roof conductors, down comers, and pipe electrodes.

Design Criterion

The lightning design shall be as per IS: 2309. It is designed to cover the complete building with horizontal conductors and any portion having height more than a meter from the horizontal conductor shall be given with air termination.

Need For Protection

The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than 1×10^{-5} shall be provided with lightning protection.

Lightning Protection System Layout

The lightning systems design and installation shall generally comply with IS: 2309 code of practice for the protection of building and allied structure against lightning.

Each down conductor shall be connected to a rod electrode, which in turn shall be connected to the station earthing system through test links.

Lightning Protection System Installation

Conductors of lightning protection system shall not be connected with conductors of safety earthing system above ground level.

The down conductors shall be welded to steel structures at 1000 mm interval or cleated to wall at 750 mm interval. Wherever welded, the weld locations shall be treated to provide rust protection.

Each down conductor shall be provided with a test link at a height of about 1000mm above ground level.

All the metallic structures within a vicinity of 2000 mm shall be connected to the lightning protection conductors.

IX. SAFETY REQUIREMENTS

Refer CPWD General Specification for Electrical Works Part IV-Substation (2023).

X. EV CHARGERS

SCOPE

This scope of work covers Engineering, Manufacture, Testing & Inspection in accordance with agreed QAP and Standards at Manufacturer's/ Vendors' works, Packing, Forwarding and Delivery/ Supply from Manufacturer's Works to Erection site, Unloading, Handling, Assembly, Erection, Testing & Installation, Commissioning, Performance demonstration at site and Operation & Maintenance as stipulated in tender document of systems listed below for Electric Vehicle Supply Equipment (EVSE).

APPLICABLE STANDARDS

The Electrical works shall also conform to following standards as amended up to date wherever relevant and applicable;

- CPWD General Specification for Electrical Works Part I - Internal (2023).
- CPWD General Specification for Electrical Works Part II - External (2023).

Sr. No.	Standard Reference	Standard Description
1	URDPFI-2014	Amendments in Urban & Regional Development Plans Formulation and Implementation Guidelines for Electric Vehicle Charging Infrastructure.
2	MMBL-2016	Amendments in Model Building Bye-Laws for Electric Vehicle Charging Infrastructure.
3	IEC-61851-1	Electric Vehicle Conductive Charging System- General Requirements.

Sr. No.	Standard Reference	Standard Description
4	IEC-61851-21-1	Electric Vehicle on-board charger EMC requirements for conductive connection to AC/DC Supply.
5	IEC-61851-23	DC Electric Vehicle Charging Station.
6	AIS 138 (Part-1)	Electric Vehicle Conductive AC Charging System
7	AIS 138 (Part-2)	Electric Vehicle Conductive DC Charging System.
8	IEC-61140	Protection against Electric Shock.
9	IEC-62196-2	Plugs, Socket Outlets, Vehicle Connectors, Vehicle Inlets- Conductive Charging of Electric Vehicles.
10	IEC-60309-1	Plugs, Socket Outlets and Couplers for Industrial purpose.
11	IS-17017-23	Indian Standard for AC and DC Charging.
12	IS-17017-24	Digital Communication between a DC Electric Vehicle Supply Equipment and an Electric Vehicle for control of DC Charging.
13	IS-17017-2-3	Electric Vehicle Conductive Charging System Plugs, Socket Outlets, Vehicle Connectors and Vehicle Inlets.

TECHNICAL SPECIFICATIONS OF EV CHARGERS

Technical Specification of DC Fast Charger with Single Charging Gun (30kW)-

Sr. No	Particular	Specification
A	AC Input	
1	Input Voltage (VAC)	400VAC, 3 Ph 4W + PE
2	Input Voltage Range (VAC)	340-480
3	Frequency (Hz)	45-55
4	Power Factor	0.99
5	Current THD	Less than or equal to 5%
B	DC Input	
1	Output Voltage (VDC)	200 to 750
2	Output Current max (A)	Minimum 40A for 500 V DC – 750 V DC, 60A for 200 V DC – 500 V DC
3	Regulation Accuracy	Less than or equal to 0.5%
4	Precision of Current	Less than or equal to 1%
5	The Output Voltage Range (VDC)	200 – 750
6	Output Power max (kW)	30
C	Environmental and Others	
1	Ingress Protection Grade	IP54 or better

Sr. No	Particular	Specification
2	Operating Temperature (Deg C)	-10 to +50
3	Storage Temperature (Deg C)	-40 to +70
4	Altitude (m)	Up to 2000 meter
5	Protection Function	Output Short Circuit, Over Temperature, Input Under Voltage, Input Over Voltage, Communication Failure
6	Cooling	Natural Ventilation
7	Display	LCD: 7-inch Touch screen or as per OEM satisfying display parameter requirement.
8	Status indicator	Yes (Power, Status, Charging, Fault)
9	User Recognition	RFID Card
10	DC Plugs	CCS II
11	Gun	Single Gun
12	Metering & Billing	Compatibility/ Provision for Grid responsive metering QR code OTP/ RFID Card/ APP Server based online payment
13	Charging Operation	RFID Card/ Scan Code/ APP based authentication
14	Compliance	Charging Device: IS 17017-23 EV-EVSE Communication: IS 17017-24 (CAN) IS-15118 (PLC) Charge Point Plug/ Socket: IS 17017-2-3
15	Charging Communication Protocol	OCPP 1.6 or higher
16	Network Interface	Compatibility for Ethernet (standard), WLAN, 3G for backend communication

Technical Specification of DC Fast Charger with Double Charging Gun (60KW)-

Sr. No	Particular	Specification
A	AC Input	
1	Input Voltage (VAC)	400VAC, 3 Ph 4W + PE
2	Input Voltage Range (VAC)	340-480
3	Frequency (Hz)	45-55
4	Power Factor	0.99
5	Current THD	Less than or equal to 5%
B	DC Input	
1	Output Voltage (VDC)	750

Sr. No	Particular	Specification
2	Output Current max (A)	80A (per Gun)
3	Regulation Accuracy	Less than or equal to 0.5%
4	Precision of Current	Less than or equal to 1%
5	The Output Voltage Range (VDC)	300 – 750
6	Output Power max (kW)	60 (Combined Gun 1 & Gun 2)
C	Environmental and Others	
1	Ingress Protection Grade	IP54 or better
2	Operating Temperature (Deg C)	-10 to +50
3	Storage Temperature (Deg C)	-40 to +70
4	Altitude (m)	Up to 2000 meter
5	Protection Function	Output Short Circuit, Over Temperature, Input Under Voltage, Input Over Voltage, Communication Failure, Overcurrent, Ground Fault, Plug out protection
6	Cooling	Natural Ventilation
7	Display	LCD: 7-inch Touch screen or as per OEM satisfying display parameter requirement.
8	Status indicator	Yes (Power, Status, Charging, Fault)
9	User Recognition	RFID Card
10	DC Plugs	CCS II Combo
11	Gun	Dual Gun
12	Metering & Billing	Compatibility/ Provision for Grid responsive metering QR code OTP/ RFID Card/ APP Server based online payment
13	Charging Operation	RFID Card/ Scan Code/ APP based authentication
14	Compliance	Charging Device: IS 17017-23 EV-EVSE Communication: IS 17017-24 (CAN) IS-15118 (PLC) Charge Point Plug/ Socket: IS 17017-2-3
15	Charging Communication Protocol	OCPP 1.6 or higher
16	Network Interface	Compatibility for Ethernet (standard), WLAN, 3G for backend communication

Technical Specification of Type-2 AC Chargers (7.4KW)-

Sr. No	Particular	Specification
1	Input Voltage (VAC)	230VAC, 1 Ph, 32A
2	Vehicle Serviced Simultaneously	1
3	No. of Plugs	1
4	Plug Type	Type-2 AC
5	Plug Output Current, kW	32A, 7.4 kW Max
6	Undervoltage Limited	<205V per phase
7	Overvoltage Limited	>270V per phase
8	Max. output current limited	32A
9	Residual current detection	30mA
10	Earth pin detection	Yes
11	Emergency shutdown button	Yes
12	Simultaneous charging	Yes
13	Status indicators	Yes (Power, status, charging, fault)
14	Protection	Over Voltage, Under Voltage, Overcurrent, DC residual current, short circuit, over temperature, ground fault, plug out protection
15	Plug output voltage	230V, AC, 1 PH
16	Plug Cable Length	Minimum 4 meter
17	Power & Energy monitoring	Yes
18	Voltage Frequency	50 Hz
19	User Interface	LCD Display
20	Enclosure	IP 54 or Better
21	Dimensions	As per OEM
22	Weight	As per OEM
23	Mounting	Wall Mount/ Pole Mount
24	Max Internal Temperature	+60 deg C
25	Ambient Temperature Rating	-10 Deg C to + 55 Dec C
26	Network Interface	Compatibility for Ethernet (standard), WLAN, 3G for backend communication
27	Charging Communication Protocol	OCPP 1.6 or higher
28	Altitude (m)	Up to 2000 meter
29	Compliance	Charging Device: IS 17017-23 EV-EVSE Communication: Bluetooth Low Energy Charge Point Plug/ Socket: IS 60309
30	Metering & Billing	Compatibility/ Provision for Grid responsive metering QR code OTP/ RFID Card/ APP Server based online payment
31	Charging Operation	RFID Card/ Scan Code/ APP based authentication

XI. RIGID, DOUBLE WALL CORRUGATED (DWC) HIGH DENSITY POLYTHYLENE (HDPE) PIPE

GENERAL REQUIREMENT

The conduit system is required for laying of Power, ICT and ELV cables along as well as across the green belt, grass pavers and roads for taking underground power, ICT and ELV cables through it.

The Conduit System for Electrical Installation with particular requirement of buried underground shall conform to IS 16205 Part 24.

Mechanical property: - The DWC conduit system shall have following Mechanical properties.

- i. The conduit shall withstand compression test as per IS 16205 Part 24.
- ii. The conduit system shall withstand Impact test for “Heavy” duty as per IS 16205 Part 24.

The DWC Duct shall consist of two layers, the outer layer will be corrugated and the inner layer shall be plain and smooth.

The inner wall of the conduit system shall be smooth to facilitate the free and safe drawing in / replacement of power and ICT cable.

Within the conduit system there shall be no sharp edge, burrs or surface projections which are likely to damage insulated conductors or cables or inflict impurity to the installer or user.

The protective properties of the joint between conduit and conduit fittings shall be not less than that declared for the conduit system.

The DWC Duct and fittings shall withstand the stresses likely to occur during transport, storage, recommended installation practice and application.

The DWC duct shall be supplied in continuous length in coil form or straight length, suitable for shipping and handling purpose.

The colour of the conduit shall be Green, Orange, Blue, Yellow, Brown, Violet, Grey and Red. Finalization of color of duct shall be under the discretion of Purchaser.

Duct shall be supplied in standard length of 6 mtr with $\pm 1\%$ tolerance.

DWC Duct ACCESSORIES

The following accessories are required for jointing the ducts and shall be supplied along with the ducts.

- i. Plastic Coupler
- ii. End Cap

The dimensions of accessories shall be suitable for joining the ducts.

The laying of DWC Pipe duct shall be carried out as per the standard procedure declared by Manufacturer and in the presence of Manufacturer representative.

Compression Strength:- The conduit system shall have adequate mechanical strength. Conduits when bent or compressed either during, or after, installation according to manufacturer's instructions, shall not crack and shall not be deformed to such an extent that introduction of the insulated conductors or cables becomes difficult or that the installed insulated conductors, or cables are likely to be damaged while being drawn in. Compliance may be checked with the application of force which shall be at least 750 N, when reaching the deflection of 5%. Conduits are subjected to a compression test as per IS.

Impact Strength:- The conduit system shall have adequate mechanical strength. Conduits when exposed to impact either during, or after, installation according to manufacturer's instructions, shall not crack and shall not be deformed to such an extent that introduction of the insulated conductors or cables becomes difficult or that the installed insulated conductors, or cables are likely to be damaged while being drawn in. Compliance may be checked by ensuring there shall be no crack allowing the ingress of light or water between the inside and outside after the test. Conduits are subjected to an Impact test as per IS.

Bending Strength:- The conduit system shall have adequate mechanical strength. Conduits when bend either during, or after, installation according to manufacturer's instructions, shall not crack and shall not be deformed to such an extent that introduction of the insulated conductors or cables becomes difficult or that the installed insulated conductors, or cables are likely to be damaged while being drawn in. During the test sample shall not flatten Compliance shall be checked by passing a ball having a diameter equal to 95% minimum inner diameter of the sample declared by the manufacturer,

through the sample whilst it is bent around the test apparatus. Conduits are subjected to a Bending test as per IS.

Resistance To Flame Propagation:- Non flame propagating ducts shall have adequate resistance to flame propagation. Samples of DWC HDPE Ducts shall be checked by applying a 1KW flame.

Anti-Rodent Properties:- Safety of ducts from the direct attack of subterranean organism anti rodent material is of utmost importance. These ducts shall be evaluated for their safety against rodents before laying them in the fields. The test against rodent may be conducted as per following procedures:

- i. The ducts are to be laid underground in fields. Therefore they should be exposed to 3-4 most predominant rodent species inhabiting these locations. The test rodent species may include the lesser bandicoot rat, *Bandicota bengalensis*, The Indian gerbils, *tatera indica*, the soft furred field rats, *Millardia meltada* and the house rats, *Rattus rattus*.
- ii. The test ducts should be exposed to these rodent species housed individually in iron mesh cages under laboratory conditions. Only freshly capture rodent are to be utilized for the study. The rodents are first acclimatized in laboratory cages for 7-10 days and then the tests be initiated. For each trial, 3-4 rodents of uniform body weight are to be used for the trial. Two different types of testes may be undertaken for all the ducts.
- iii. **Choice Tests:** In this trial the ducts of 15-30 cm length (one sample each of treated and untreated /control sample) are exposed to the test rodents along with food, thus the rodent had a choice between the food and the test duct. This test may be run for longer periods (30-45 days). Tap water should be provided ad libitum to the rodents.
- iv. **NO Choice Test:** The rodents are exposed to the test ducts only and no food is given to the rodents during the period of trial. The test ducts (one sample each of treated and untreated /control sample) are to the exposed to the test rodents. This trail may be run for 5-7 days depending upon the health status of starved test rodents.
- v. **Observation on tooth marks, rodent behaviour toward exposed ducts, relative extent of damage in treated and untreated samples should be computed for both types of ducts. Health status of test animals in choice and no choice test must also be monitored for the record any ill effect of exposure of treated / control ducts on these animals. Number of cases and the extent of rodent bites / scratch marks in control and anti-rodent treated ducts may indicate the relative deterrent/repellent properties of the test ducts.**

Resistance to External Influences on DWC HDPE Duct Accessories: - The DWC accessories shall be tested for external influences as per IS-12063 for ingress of dust and ingress of water.

LIST OF APPROVED MAKES:

The below list of approved makes shall be used with the prior approval of DHBVN/Engineer's In charge/Employer

S.No.	Item/equipment	List of Makes of various equipment's
1.	33kV & 11kV switchgears other equipments	ABB/SIEMENS/SCHNEIDER/ALSTOM/GE
2.	33kV substation	ABB / Siemens
3.	11kV Sub Station (SS) and 11/0.433 KV CSS	ABB / Siemens
4.	SCADA System	ABB / Schneider
5.	Squirrel cage Induction Motor (100 HP & above)	Kirloskar (KEC) / Jyoti / Siemens/ Crompton/ BHEL/ NGEF/ Bharat Bijlee/ GE
6.	Squirrel cage Induction Motor (Below 100 HP)	Kirloskar(KEC)/Jyoti/Siemens/Crompton/ BHEL/NGEF/GE/Bharat Bijlee/ GE/ Kirloskar (KBL)
7.	Electrical actuators	Auma/ Marsh/ Rotark/ Siemens/Emtork
8.	DG set (Alternator)	Crompton Greaves / Kirloskar Green/ Stamford / KEC/ Leroy somer
9.	DG set (Engine)	Cummins/ Kirloskar Green/ Caterpillar/ Penta Volvo /Ashok Leyland /Mahindra & Mahindra/ Perkins
10.	Battery Charger	AMARARAJA/EMERSON/BORRI
11.	LT PVC / XLPE insulated cable (3.5 Core x 35 sqmm and above)	CCI (Tropodour) / Asian cables/ Gloster/ Nicco/ Torrent / Polycab/Universal/ Havells/Finolex
12.	LT PVC / XLPE insulated cable (Up to 4 Core x 25 sqmm)	CCI (Tropodour) / Asian cables / Gloster/ Nicco / Torrent/ Polycab/ Universal/ Havells/Finolex/ KEI Incab / Vishal/ Gulmarg/ Indoasian

S.No.	Item/equipment	List of Makes of various equipment's
13.	HT PVC / XLPE insulated cable	CCI (Tropodour) / Asian cables/ Gloster/ Nicco / Polycab/ Universal /Havells/Torrent
14.	Cable Lugs & Glands	Dowells / Braco/ Jainson/ Siemens/ Comet
15.	Measuring Instruments, Ammeter, Voltmeter, etc.	Simco/ IMP/ Automatic/ GEC / MECO /AE/ Conserve/ Motwani / L&T/ Siemens /Industrial meters
16.	Selector Switches, Rotary Switches	Simco/ IMP/ Automatic/ GEC/ MECO/ AE/ Conserve / Motwani/ L&T/Siemens /Industrial meters
17.	Contactor / starters	Siemens/ Crompton/ C&S/ L&T/ ABB / GE / Schneider/Indo Asian
18.	Timers- electronic solid state	ABB, BHEL, GE, Jyoti, L&T, BCH, Siemens, Minilec, Legrand, GIC, C&S
19.	ACB/MCCB /MCB / ELCB/ RCCB/ SFU/ TPN/ Change over switch/ HRC fuses/ MCB Distribution Board	L&T/MDS/ABB/Crompton Greaves/GE/C&S/ Siemens/ Havells/ IndoAsian / Legrand/ Schneider/GEC/ Merlin Gerin/ Indokapp
20.	HPSV/ HPMV/ MH Street Lighting Fixture	Philips/ Crompton/ Bajaj/ Wipro/ Surya/ GE/ Havells/ Asian/ Mahindra
21.	LED street light/ flood light fittings	Philips/Crompton/ Bajaj/ Wipro/Surya/GE/ Havells /Asian/ Mahindra/Agile/Pharox
22.	Bulk head fitting	Philips /Crompton/ Lumex / Bajaj / Wipro/ Havells/ Surya
23.	LED lamps	Philips/ Osram/ Cree/ Edison / Nichiya/Syska
24.	HPSV / HPMV Lamp	Philips/ Crompton/ Bajaj/ Wipro/ Havells/Surya/GE
25.	Fluorescent fittings	Philips/ Crompton/ Bajaj/ Wipro/ Havells/ Surya/ GE, Anchor, Asian
26.	Fluorescent tubes	Philips/ Crompton/ Bajaj/ Wipro/ Havells/ Surya/ GE/ Anchor/ Osram
27.	CFL lamps	Philips/ Crompton /Bajaj /Wipro/ Asian/ Osram/ Havells
28.	PVC Insulated copper/ Aluminium wire/flat Cable	Polycab/ Finolex/ KEI/ Fort/ Gloster/ CCI/ Asian/ Gulmarg/ Anchor/ Nicco/ RR cable/ Havells/ L&T/ Jonson/Vishal
29.	Casing capping/ Conduit	Prestoplast/ Precision / Modi / Volex / Press Fit / BEC/ AKG/Finolex /Diamond
30.	Holder/ ceiling rose/ switches/ modular switches/ Plug/ sockets	Anchor/ Leader /Cona / Harison/ Indo Asian/ Legrand/ MK / Crabtree/ ABB/ Precision /Wipro/ Vinay
31.	Bell Buzzer	CONA/ MAX/ Anchor/ Leader/ SSK
32.	Exhaust Fan/ Ceiling fan/ Air	Crompton Greaves/ Usha/ Orient/ GEC/ Almonard/ Khaitan/ Havells/ Bajaj/ Philips / Polar/ Anchor

S.No.	Item/equipment	List of Makes of various equipment's
	circulator/ Pedestal fan/ Bracket fan	
33.	AC Units / Central ACs	Hitachi / LG/ Samsung/ Voltas/ Blue star/ Carrier / Godrej/ Videocon/ Mitsubhisi /LLoyed
34.	Capacitor Bank	ABB/CGL/Siemens/L&T/Asian/Powercap
35.	Air circulators	Crompton Greaves / Usha / GEC/ Alfa/ Unique/ Almonard/ Khetan/ Bajaj/ Havells
36.	Fan regulator	Anchor / Roma/ Rider/ Jainex / Cona/ Legrand/ Leader/ Crabtree/ MK / Anchor
37.	Electronic Energy meter	L&T/ Seimens/ Jaipur/ Mecco/ Enercon/ Udaipur/ Havells/ HPL/ IMP/ Secure/ Emco
38.	Electronic Ballast	Philips/ Crompton/ Bajaj/ Wipro / GE/ Surya/ Havells/ Anchor
39.	MS tubular pole	Unique/ Singh profile/National/ India pole/Bombay tube pole/Laxmi/ Ajay
40.	GI Octagonal Pole & High Mast	Philips/Crompton/ Bajaj/ Surya/ Wipro /Valmont/ Transrail
41.	FRP Box	Sintex/ United/ Indo Asian/National /Siemens
42.	Transformer (1000 KVA and above)	Bharat Bijlee/ Kirloskar/ Crompton/ EMCO/ Areva/ ABB/ BHEL/ IMP / Alstom / Siemens/ GEC/ Voltas
43.	Transformer (Upto 750 KVA)	Bharat Bijlee/ Kirloskar / Crompton/ EMCO/ Areva/ ABB/ BHEL/ IMP/ Alstom/ Aditya/ Vijay/ Siemens/ GEC/ Voltas/ NGEF/ Mahati/ Telwane/ Rakesh / Transfab/ Shrihans/ Urja / Nanda Transformer / Damsa Vidyut/ Volt-amp/ Saurabh/ Ramkrishna / Transdelta
44.	33/22/11 KV Horn Gap/ DO sets	Kiran / Pactil / S&S /Damsa
45.	33/22/11 KV GOAB switch	Kiran / Pactil / S&S /Damsa
46.	HV Lighting arresters	ELPRO / ABB / BHEL/ OBLUM
47.	Cable Termination & Straight Jointing kit	Raychem/ M-seal (3 M) / Xicon (CCI)/Densons / Mahindra & Mahindra
48.	RSJ pole	TATA/SAIL/Jindal/ Zenith / Khandelwal
49.	ACSR / AAA Conductor	Apar/ Sterlite/ Kanti cable/ Pratik conductors/ Bombay wire products/ Vekateshwar wires / Prem cables/ Lunkad
50.	33/ 22/ 11 KV Disc & pin insulator	BHEL/ S&S/ Jaishree/ Punjab/ Ceramic/ India Potteries /Bikanner ceramics
51.	HV indoor/ outdoor Circuit Breakers	Crompton / ABB/ Siemens/ Schneider/Alstom (Areva)/ Jyoti / BHEL/Andrew Yule

S.No.	Item/equipment	List of Makes of various equipment's
52.	LT Current Transformers	Pragati/ Kappa/ AE/ Jyoti / C&S/ L&T / MECO/ Gyro/Crompton/Schneider
53.	HT Current Transformers	AE/ Jyoti / Crompton/ ABB/ Siemens /Schneider/ Alstom Transdelta/Jain Electrical
54.	LT & HT Capacitors	Prabodhan/ Universal/ Crompton/ ABB/ BHEL/ L&T/ EPCOS/ Shreem/ Khatau Junker/Voltas/ Siemens/Schneider
55.	Metering Kiosk	ABB/ Huphen/ Transvolt/ Transdelta/ Jain Electrical
56.	Indication LED Lamp/ Push Buttons	L&T/ Siemens/ C&S/ Teknik / Rishab/ Asiatic/ Controls & Switchgear/ United Electric / Powergear / Puutron/ABB
57.	Relay	Alstom (Areva)/ Siemens/ ABB/Jyoti/ BHEL/L&T/ Easun Reyroll/ GE/ Enercon (Conserve)
58.	DC Battery	Exide/ Amco/ Okaya/ SF Sonic/ Amaron/ AmarRaja
59.	Battery charger	Usha Rectifier/ Hind Rectifier/ National Engineer Corporation / Suresh Electricals/Arti/ AE/ Suresh Electrical/Delta Electricals/Trinity Electricals/Panva
60.	On line UPS, Servo Stabilizer, Inverter	AEI/ BHEL/ Hind Rectifier/ L&T/ NGEF/Siemens/ Hi- rel/ Autometer/ Enertech/ Pyramid/ APC/Dubas/ Luminous/ Microtech/TATA Libert
61.	Bearing	SKF/FAG
62.	Electromagnetic Flow meter	ABB/ Siemens/ Endress & Houser/Krohne Marshal/ Electronet/ Nivocontrol/ Mikamachi
63.	HDPE pipes	Jain Irrigation, Kimplas, Timeplast, Duraline
64.	DI pipes	Jindal, KOBOTA, Electrosteel, Lanco
65.	CRANE & HOIST	Hercules, Electromech, Eddy Cranes, Consolidated Hoist, W H Brady
66.	Air Circuit Breakers	ABB/ Alstom/ BHEL/ CGL/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
67.	Alternators	AVK / SEGC/ Leyroy Sommers/ Stamford
68.	Annuciator (Facia Type)	Digicont/ Larsen & Toubro/ Procon
69.	Anti Vibration Spring Mounts / Pads	E&B Rubber Metal (EGAMA)/ Resistoflex
70.	Automatic Voltage Regulating Relay (AVR)	ABB/ Alstom
71.	Bimetalic Overload Relay	ABB/ Larsen & Toubro/ Siemens AG
72.	Buchholz Relay	Prayog / Equivalent

S.No.	Item/equipment	List of Makes of various equipment's
73.	Bus Ducts / Bus trunking	Ducati/ Larsen & Toubro/ Globe Electricals/ Schneider/ Audco/Zoloto
74.	Cables (Control & Instrumentation)	Delton/ Polycab/ Thermo Cables/ Universal/ RPG
75.	Capacitor Bank (11 kV)	ABB/ CGL/Asian/ Larsen & Toubro/ Powercap
76.	Capacitor Bank (415V)	ABB/ CGL/Asian/ Larsen & Toubro/ Powercap
77.	Change Over Switches	Control & Switchgear/ HPL/ Kirloskar
78.	Connector Upto 32 Amps Screw less type	LEGRAND/ Phoenix/Wago
79.	Contactors / Auxiliary Contactors	ABB/ Larsen & Toubro/ Schneider/ Siemens AG
80.	Control & Relay Panel	ABB/ Alstom / Areva/ Bharat Bijlee/ Siemens AG/ CGL
81.	CT & PT (33kV & 11kV)	ABB/ Alstom/ CGL/Kappa
82.	Distribution Boards (Lighting & Power)	Adlec/ Asiatic Switchgears/ Advance Panel & Swgr/ Hensel
83.	Distribution Boards (PCCs / MCCs)	ABB/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
84.	Engineering Plastics / FRP/GRP DB's & Panel Enclosures	Hensel/ Sumip/ Siemens AG/GE power
85.	Feeder Pillar (Non-Magnetic Stainless Steel)	ABB/ Amptech Electric
86.	Fusible Switches	ABB/ Alstom/ GE Power/ Larsen & Toubro/ Siemens AG
87.	Glands (Brass - Single & Double Compression)	Comet / Dowell/ HMI/ Electromac/lotus/Leader
88.	Isolator	ABB/ GR Power/ Siemens AG/ Elpro
89.	Lightning Arrestors	ABB/ Alstom/ CGL/ Lamco/ CAPE ELECTRIC
90.	Liquid Resistance Starters (LRS), Grid Rotor Resistance (GRR)	BCH/ Enterprising/ Poiner/ Resitech
91.	Load Break Switch	ABB/ Alstom/ Siemens AG/ Larsen & Toubro/ H.H.E (Elecon)
92.	Lugs (Copper)	Comet/ HMI/ Dowell/ Lotus
93.	Moulded Case Circuit Breaker (MCCB)	ABB/ Alstom/ Larsen & Toubro/ Legrand/ Schneider/ Siemens AG
94.	Neutral Grounding Resistance	Cutler Hammer/ National/ Pioneer Electricals/ Ohmark/ Resitech/ RSI

S.No.	Item/equipment	List of Makes of various equipment's
95.	Poles (FRP / GRP)	Bajaj/ Sumip
96.	Protection Relays (P.F. Correction)	ABB/ Alstom/ DUCATI/ Larsen & Toubro/SIGMA
97.	Rotary / Toggle Switches	ABB/ Alstom/ Larsen & Toubro/ Switron/ Siemens AG/ Kaycee
98.	Soft Starters (Standalone panels)	ABB/ CGL/ Schneider/ Siemens AG
99.	RMUs, Vacuum Circuit Breaker (Indoor & Outdoor) (GIS/AIS)	ABB/ Alstom / Areva/ Siemens AG
100.	Vacuum Contactors	ABB/ Alstom / Areva/ BHEL/CGL/ Siemens AG
101.	Variable Frequency Drives (Speed) (Standalone panels)	ABB/ Larsen & Toubro/ Siemens AG
102.	Fiber Optic Cables	Amp/ Krone/ Molex
103.	Nitrogen Injection Fire Protection System	CTR Manufacturing Industries Ltd / Tri- Parulex/ Tectonicus Services (India) Pvt. Ltd/ Nitin fire protection industries / Sakthi fire protection
104.	SCADA System	Honeywell / Siemens/ Allen Bradley
105.	GI Octagonal Pole & High Mast	Philips/Crompton/ Bajaj/ Surya/ Wipro /Valmont/ Transrail

LIST OF THE DOCUMENTS TO BE SUBMITTED AFTER THE AWARD OF CONTRACT

All the electrical equipments to be supplied must be of reputed makes and as approved by DHBVN/HVPLN/Employer. The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily since at least last 5 years continuously. Certificates from the end users, regarding their satisfactory Performances shall be submitted in this regard. Contractor to refer **APPENDIX-1** for List of the documents to be submitted by Contractor after the award of the contract.

APPENDIX-1

**(LIST OF DOCUMENTS & SUBMITTALS
TO BE DONE AFTER AWARD OF CONTRACT-POWER)**

1. LIST OF DRAWINGS TO BE SUBMITTED AFTER AWARD OF CONTRACT- POWER WORKS

All the electrical equipment to be supplied must be of reputed makes. The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily since at least last 5 years continuously. Certificates from the end users, regarding their satisfactory Performances shall be submitted in this regard.

Following drawings, calculations & schedules shall be submitted for approval before procurement, fabrication and Installation of equipment at site. The list is tentative and it is bidders responsible for complete system Design, Erection, testing, commissioning and operations to meet the DHBVN/ State Power guidelines and tender requirements in totality.

1.1 33/11KV DISTRIBUTION SUBSTATION (DSS)

S.N.	Drawings
1.0	Power Load calculations, Single Line Diagram of Complete Power network /Electrical System based on the design criteria.
2.0	Electrical Substation GA and sectional Layouts of 33kV GIS showing locations of various Equipment including, Transformer, cable trenches, Switchgear Panel, control & relay panels and other allied equipment's and associated systems as listed above.
3.0	Civil Drawings for the entire system including Cable trenches, foundations, buildings etc..
4.0	Substation HVAC System
a.	Providing Ventilation system for 33KV GIS Room & 11 kV Switch Gear Room, Control Room, Battery Room, Store Room, Lockers including Toilet and others etc.
b.	Providing Air Conditioning system for the Admin Rooms, Battery Room, SCADA & CRP Room and Office Rooms and others as applicable.
c.	Providing location for Fresh and Exhaust air Louvers wherever necessary.
5.0	33kV GIS
a.	General Arrangement and sectional drawings of overall layout of GIS, terminal arrangement, bay cross section of individual bays, LCP, PD monitoring system including all dimensional details, layout and maintenance requirements, details of supports required for piping and other accessories, cable entry details, Grounding requirements, etc.
b.	Foundation drawings for all equipment/accessories indicating the grouting details, static and dynamic loading data and any insert details for supporting structures and other equipment.

S.N.	Drawings
c.	Gas Section diagram, Guaranteed Technical Particulars.
d.	Schematic wiring diagrams & Block interlock diagrams indicating the control and interlock logic for all equipment/accessories.
e.	Equipment designation, make, type, rating, etc. of the various equipment mounted on the equipment.
f.	Type test certificates not older than Five years and submit certificates before award of contract.
g.	All Routine tests shall be conducted on each equipment.
h.	Descriptive and illustrative literature for the equipment.
6.0	33kV Relay & Control Panel
a)	Control and relay panel drawing showing plan, front elevation, foundation details, floor openings, terminal block location, etc.
b)	Schematic wiring diagrams.
c)	equipment designation, make, type, rating, etc. of the various equipment mounted on the panels.
d)	Interconnection and external connection wiring drawings - The drawings shall include all panel to panel interconnections and panel to field external connections to facilitate external cable connections.
e)	Type test certificates & Routine test certificates not older than five years and submit certificates before award of contract.
f)	All Routine tests shall be conducted on each equipment.
g)	Descriptive and illustrative literature for the Relays, Instruments, Meters, Annunciators, Control Switches, etc.
7.0	General arrangement for 33/11kV DSS (Distribution substation)
a)	G A drawing for 33kV substation showing 33kV GIS, 11KV AIS Indoor Panels, Battery/battery charger and DCDB, LV Panel, ACDB, 33/11kV Power transformer, Station transformer and cabling, earthing, lighting and lightning protection layouts.
8.0	33/11kV (Power transformer) and 11/0.433KV Station transformer
a.	General arrangement drawing shall indicate the overall dimensions, net weights, quantity of oil, crane requirements for assembly and dismantling of transformers, and the general constructional features.
b.	General arrangement drawing of the transformer showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, cable entries, earthing terminals, foundation/floor fixing details, jacking pads, crane lift for un tanking, size of lifting lugs and eyes, clearances between HV terminals, between LV terminals, between HV and LV terminals, between HV & LV

S.N.	Drawings
	terminals and ground etc.
c.	Valve schedule, Rating, diagram and terminal marking plates, complete with polarity and vector group.
d.	OLTC cabinets: schematic circuit diagram and actual detailed wiring diagram giving terminal numbers.
e.	Bushings Plan, elevation, terminal details, mounting details, make and type number, current and voltage rating, creepage distances and principal characteristics.
f.	Control wiring diagram for marshalling box.
g.	RTCC Panels GA & detailed Schematic drawings.
h.	NIFP System GA drawing with detailed P&ID Drawings.
i.	QAP
9.0	415V LV Panel/ ACDB/ Sub ACDB Panels/ Emergency/ UPS/ Lighting DB's
a.	Complete assembly drawings of the switchboard/distribution board showing plan, elevation and typical sectional views and location of cable boxes and control cable terminal blocks for external wiring connections.
b.	Foundation plan showing the location of channel sills, foundation, anchor bolts and anchors, floor plans and openings.
c.	Schematic power, Feeder operation logic and control wiring diagrams with control, interlocks, relays, instruments, space heaters, starters with Bi-metallic relay ratings and contactor ratings, busbar rating with material etc.
d.	Details of breakers, relays and other components as may be incorporated.
e.	Type test certificates not older than last five years and submit certificates before award of contract.
10.0	Battery & Battery charger with DC Distribution Board / UPS
a.	Dimensioned general arrangement drawings.
b.	Fully dimensioned general arrangement drawings of battery and battery charger with elevation, side view, sectional view and foundation details.
c.	Complete schematic and wiring diagrams.
11.0	Cabling system
a.	Design, Drawings and Calculation of Cable trench sizes, Details of Installation of Cables in Trenches, on cable trays, racks etc.,
b.	33kV, 11kV & 1.1kV Cable routing layout.

S.N.	Drawings
c.	Cable termination and mounting Kit Layout drawing.
d.	33 kV Cable Termination arrangement drawing.
12.0	Earthing & Lightning Protection system
a.	Detail calculations of Earthing network including step & touch calculations, main grid calculations.
b.	Earthing notes including detail write up and drawings of Earthing conductor layout, equipment & structural Earthing, joints, cable Earthing, instrument Earthing and special Earthing.
c.	Details such as material, sizes, etc. of the earth conductor and electrode pits.
d.	Earthing layout drawing showing routing of main grid inside and outside of Building with interconnection of equipment Earthing to the grid and earth pits.
e.	Lightning protection layout.
13.0	Lighting System for DSS Building and outdoor areas
a.	Detailed Room wise Lighting Layout with Type of fixture details and Circuit diagram showing phase wise load distribution and interconnection between switches, fixtures, Lighting panel, receptacles etc. & Detailed lux level calculations.
b.	Conduit layout showing room wise routing of wires from lighting panel to lighting fixtures, receptacles etc.
c.	Internal road Lighting and Area lighting layout with type of mounting details and fixture details.
14.0	SCADA
a.	SCADA Architecture drawings with details and interconnection with Smart Grid system.
b.	Functional design specifications.
c.	Factory acceptance test.
15.0	All Civil drawings related to Building & foundation of all the electrical items.
16.0	Drawing for the Fencing of the entire substation plot including necessary calculations.
17.0	Drawings for Firefighting, HVAC, Plumbing, SCADA System and Fire alarm system.
18.0	DG Sets
a)	General arrangement drawing shall indicate the overall dimensions, net weights and the general constructional features.

S.N.	Drawings
b)	General arrangement drawing of the DG Set showing plan, front elevation and side elevation complete with all accessories and fittings, detailed dimensions, cable entries, Earthing terminals, foundation/floor fixing details, etc.
c)	Control wiring diagram for Synchronizing Panel.
19.0	11kV HV Capacitor Bank/Panel/ HT Panels/ VCBs
a)	Design Calculations for Bus bar sizing, CT Sizing of all type etc. for each Switchboard along with a copy of relevant standard referred for the same.
b)	Guaranteed Technical Parameters.
c)	Equipment GA & Section drawings with dimensions, clearances, locations of components- CT, Terminals, etc. of each type of switchboard with component layouts like LV Compartment, etc. with general notes.
d)	Base frame and Foundation GA drawings with dimension and details.
e)	Electrical Control drawing for all panels with general notes like sizes, type, Material details and other details.
f)	Data sheet
g)	All the Type Test certificates to prove the compliance with the requirements and submit certificates before award of contract.
B.	Calculations
a.	Transformer Sizing Calculations.
b.	Fault level Calculations.
c.	Co-ordinated protection study with latest available version of ETAP software.
d.	HT & LT cable sizing.
e.	UPS & Battery Sizing Calculations.
f.	Switchyard Lightning Protection and Earthing Sizing Calculations.
g.	Room wise Lighting Calculation as per Lux level given in IS 3646 Part-I.
h.	Calculations related to Firefighting, HVAC, Plumbing, SCADA System and Fire alarm system.
C.	Schedules

S.N.	Drawings
a.	Cable Schedule
b.	Protection Relay Setting Schedule
c.	Interconnection schedule
d.	Junction Box Schedule

1.2 11/0.415KV COMPACT SUBSTATION (CSS) AND 33KV & 11KV RMU

S.N.	Drawings
1.0	11kV & 33kV RMU/ CSS/ HT Panels/ VCBs
a)	Design Calculations for Bus bar sizing, CT Sizing of all type etc. for each Switchboard along with a copy of relevant standard referred for the same.
b)	Equipment GA & Section drawings with dimensions, clearances, locations of components- CT, Terminals, etc. of each type of switchboard with component layouts like LV Compartment, etc with general notes.
c)	Base frame and Foundation GA drawings with dimension and details.
d)	Electrical Control drawing for all panels with general notes like sizes, type, Material details and other details.
e)	Data sheet
f)	All the Type Test certificates to prove the compliance with the requirements and submit certificates before award of contract.
B.	Calculations
a.	Transformer Sizing Calculations.
b.	Fault level Calculations.
c.	HT & LT cable sizing.
d.	Earthing Sizing Calculations.
C.	Schedules

S.N.	Drawings
a.	Cable Schedule
b.	Protection Relay Setting Schedule
c.	Interconnection schedule
d.	Junction Box Schedule

1.3 SMART STREET LIGHTING SYSTEM

S.N.	Drawings
1.0	Street Lighting Layout including 11/0.415kV Compact Substation & Street Light Feeder Pillars.
a)	Design Calculations for Bus bar sizing, CT Sizing of all type etc. for each Switchboard along with a copy of relevant standard referred for the same.
b)	Equipment GA & Section drawings with dimensions, clearances, locations of components- CT, Terminals, etc. of each type of switchboard with component layouts like LV Compartment, etc with general notes.
c)	Base frame and Foundation GA drawings with dimension and details.
d)	Electrical Control drawing for all panels with general notes like sizes, type, Material details and other details.
e)	Data sheet
f)	All the Type Test certificates to prove the compliance with the requirements and submit certificates before award of contract.
B.	Calculations
a.	Street lighting design calculations for each ROW of road including footpath & cycle track.
b.	Transformer Sizing Calculations.
c.	Fault level Calculations.
d.	HT & LT cable sizing.
e.	Earthing Sizing Calculations.
C.	Schedules
a.	Cable Schedule

b.	Feeder Pillar Schedule
c.	Interconnection schedule
d.	Junction Box Schedule

Whether specifically mentioned or not, all equipment/ system sizing calculations and layout shall be provided.