AURANGABAD MUNICIPAL CORPORATION

E-Tender Notice No. 2013 - 14

TENDER DOCUMENT FOR

Development of Underground Sewerage Collection System for Zone I to VI & Zone Salim Ali, Constructing, Erecting, Testing and Commissioning of Sewage Treatment Plant based on Modern technology at Nakshatrawadi(Kanchanwadi), Banewadi, Siddarth Garden, Zalta, Padegaon, CIDCO (Airport), Construction, Erection, Testing and Commissioning of Sewage pumping stations at Banewadi, Siddarth Garden, Padegaon, Golwadi, Zalta, Ward No. 98 & CIDCO (Airport), Providing, Lowering, Laying, Jointing and Testing Rising Main GRP/DI pipe line from Golwadi SPS to Nakshatrawadi (Kanchanwadi), STP and ward no 98 to STP for Aurangabad City.

Under

Urban Infrastructure Development Scheme for Small and Medium Towns (UIDSSMT)

Volume – II

SCOPE OF WORKS AND TECHNICAL SPECIFICATIONS

Aurangabad Municipal Corporation, Aurangabad

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NAME OF WORK: - Development of Underground Sewerage Collection System for Zone I to VI & Zone Salim Ali, Constructing, Erecting, Testing and Commissioning of Sewage Treatment Plant based on Modern technology at Nakshatrawadi (Kanchanwadi), Banewadi, Siddarth Garden, Zalta, Padegaon, CIDCO (Airport), Construction, Erection, Testing and Commissioning of Sewage pumping stations at Banewadi, Siddarth Garden, Padegaon, Golwadi, Zalta, Ward No. 98 & CIDCO (Airport), Providing, Lowering, Laying, Jointing and Testing Rising Main GRP/DI pipe line from Golwadi SPS to Nakshatrawadi (Kanchanwadi), STP and ward no 98 to STP for Aurangabad City .

VOLUME II-A

SCOPE OF WORK

VOLUME II - A

SCOPE OF WORK

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PREAMBLE

The “Volume IIA : Scope of Work” are to be read for the purpose of pricing in conjunction with "Volume-I : Conditions of Contract" of the Tender Documents containing instructions to Tenderer and General Conditions of Contract; “Volume IIB : Civil Specifications”, “Volume IIC : Mechanical Specifications”, “Volume IID : Electrical Specifications”, “Volume IIE : Operation and Maintenance”, Volume IIF : Quality Control and Quality Assurance” and “Volume-III : Commercial Bid” of this tender.

The prices quoted in the “Volume III: Commercial Bid” shall be all inclusive value for the work described including all costs and expenses which may be required in and for the execution of the work described together with all general risks, liabilities and obligations set forth or implied in the document on which the tender is based.

All works shall be carried out strictly as per detailed specifications whether actually specified or not. If not specified, work shall be carried out as per directions of Owner/Engineer-in-charge.

The total amount entered in the Volume III: Financial Bid document shall be written in ink and shall be entered both in figures and words.

Specifications of items of work are described in Section D for each item of Volume III: Commercial Bid shall read this in conjunction with other technical specifications and specific technical requirements and quote accordingly.

The tenderer can ask for clarifications, if any, by giving their queries in writing on or before pre bid meeting. Verbal queries shall not be considered.

Abbreviations used in the Volume IIA : Scope of Work have the meanings shown below:

mm	Millimetre	CI	Cast Iron
cm	Centimetre	GI	Galvanized Iron
m	Metre	GSW	Glazed Stone Ware
km	Kilometre	BBCC	Burnt Brick Cement Concrete
sq.m	Square Metre	RCC	Reinforced Cement Concrete
cum.	Cubic Metre	PCC	Plain Cement Concrete
M.T.	Metric Ton	wt	Weight
SWG	Standard Wire Gauge	kg	Kilogram
R.M.	Running Metre	I.D.	Internal Diameter
nos.	Numbers	C.M.	Cement Mortar
MS	Mild Steel	IS	Indian Standards
M.D	Metre Depth of Manhole	SS	Stainless Steel
OHT	Overhead tank	SW	Storm water
STP	Sewage Treatment Plant	PS	Intermediate/terminal Pumping Station
NP	Non Pressure	DWC	Double Wall Corrugated High Density Polyethylene Pipe

1. PROJECT INFORMATION

1.1. INTRODUCTION

Aurangabad is one of the fast growing cities in Asia. The existing sewerage scheme was designed for population of 2 lacs. The present population of Aurangabad City is 11.65 lacs. The projected population in year 2030 will be 17.32 lacs and for year 2045 will be 23.26 lacs.

Currently the city receives about 135 MLD water supply through many sources such as Jayakwadi, Harshul, Nahar E Ambari . The main source is Jayakwadi Dam, having two existing schemes. Currently there is deficit of between demand and supply. Therefore a water supply project parallel to the existing scheme is planned taking into population projection for next 30 years.

The existing sewerage system was insufficient to cater to the increase in population to 4 - 5 times. The expansion of the city demands a new sewerage system with proper collection network and efficient treatment. Presently only 6.5 MLD sewerage is treated and remaining waste water goes to the Kham River and Sukhana River as untreated.

Main Features of the PROPOSED Underground Sewerage Project

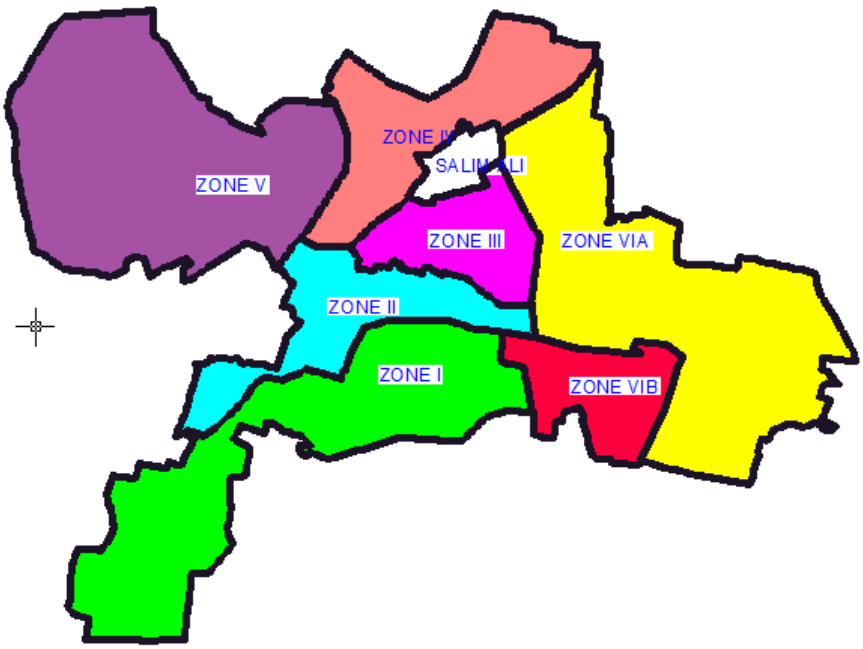
1. Population of Aurangabad City

Sr.No	Year	Population Souls	Status of year
1	2011	11,65,146	Design Year
2	2015	12,67,377	Base Year (0 year)
3	2030	17,32,298	Intermediate Year (15 years)
4	2045	23,25,994	Ultimate Year (30 years)

2. Sewerage Demand of Aurangabad City

Projected Sewerage Generation						
Year	**Incremental Increase**	**Water Supply at the rate of 135 lpcd at consumer end**	**Water Requirement in MLD**	**Projected Residential Sewage Generation in MLD - Considering 80% of the water demand and 5% as infiltration**	**Additional demand for the other area such as commercial, industrial and institutional demand**	**Total Sewage Demand (MLD)**
2011	1165146.00	135.00	157.30	**132.13**	37.73	**169.86**
2015	1267377.00	135.00	171.10	**143.72**	37.73	**181.45**
2030	1732298.00	135.00	233.87	**196.45**	37.73	**234.18**
2045	2325994.00	135.00	314.01	**263.77**	37.73	**301.50**

3. Sewerage Zone of Aurangabad City



4. Abstract of Main Sewers

Main Sewers in Kham Basin

1. **Main Sewer A:** Western part of Bibi Ka Maqbara to University to Padegaon

2. **Main Sewer B:** Part of Kham River flowing through Himayat Bagh Nallah – Siddharth Garden – Banewadi – Golwadi.
3. **Main Sewer C:** Majnu Hill – City Chowk - Barudgar Nala- Saraswat Bank-Nageshwarwadi – Varad Ganesh – Siddharth Garden.
4. **Main Sewer D:** Nallah flowing through MGM – Jafar gate - Dalalwadi - S.B. Colony-Nageshwarwadi – Varad Ganesh – Siddharth Garden.
5. **Main Sewer E:** Forest Office – Padampura - Kham River.
6. **Main Sewer F:** Nallah flowing through St.Francis High School - Tilaknagar – Vedant Nagar – MIT College
7. **Main Sewer K:** High court – Gajanan Maharaj Mandir - Jawahar Colony Police Station – Shahnoorwadi – MIT college – Nath Seeds- Golwadi

Two sewers in Sukhana basin:-

1. **Main Sewer L**: - Nallah is flowing through N-2 CIDCO to Sukhana River.
2. **Main Sewer M: -** Jadhav wadi - Chikalthana Gaothan – Chikalthana MIDC – Sukhana River.

Sewer Name	Location		Diameter (mm)														Total Length (m)
	Start point	End Point	400	450	500	600	700	800	900	1000	1100	1400	1500	1600	1800	2000	
A	Bibi-ka-maqbara	Padegaon STP	1552		912		334										2798
B	Himayat Bagh	Golwadi TPS			3655	827	44	954	711				562	2646	2214	396	12009
C	Majnu Hill	Siddarth Garden STP	2252			1177	1053	661		1435	1591	320	521				9010
D	MGM Hospital	Siddarth Garden STP			335		462	455	609	868	993						3722
E	Forest Office	Kham River	1061		228	81	2069	847									4286
F	Saint Francis High School	MIT College	459	195	168	584	346	857	866			5353					8828
K	High Court	Golwadi TPS	871			1491	551		1490								4403

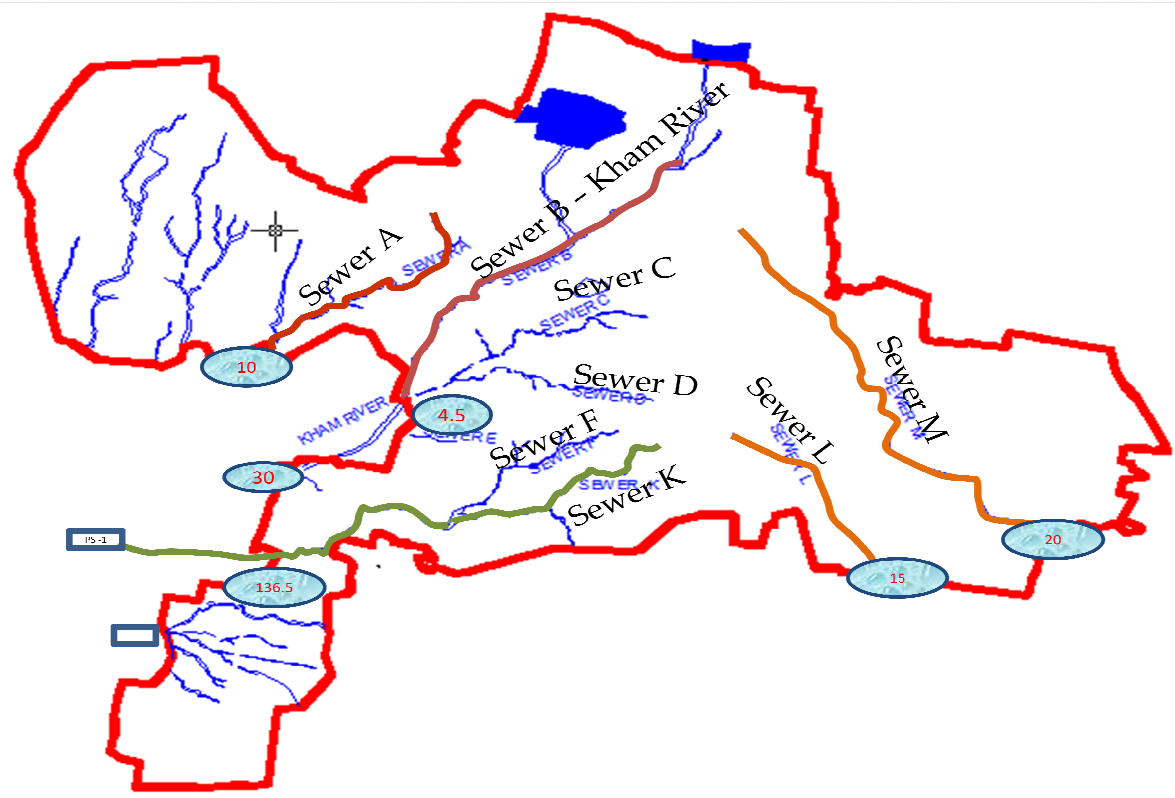
Sewer Name	Location		Diameter (mm)														Total Length (m)
	Start point	End Point	400	450	500	600	700	800	900	1000	1100	1400	1500	1600	1800	2000	
L	N-2 CIDCO	Sukhana River	204		2003	292	1476		1130	11							5116
M	Jadhav wadi	Sukhana River	1211		2147	2590	436	637	1689	1174							9884
Total Length of Main Sewers (M)			7610	195	9448	7042	6771	4411	6495	3488	2584	5673	1083	2646	2214	396	60056

5. Abstract of Sewer Pipeline including Main Sewers

DIA	Length (m)					Total Design Cumulative Length	Proposed Sewer Length
	Zone I	Zone II,III,IV	ZONE V	Zone VI A & B	Zone Salim Ali		
150 mm	125136	162702	20637	36152	6764	351391	70278
200 mm	7680	11916	2115	4606	1176	27494	27494
250 mm	6308	14444	3502	4145	848	29246	29246
300 mm	7720	11941	4408	3800	665	28533	28533
350 mm					250	250	250
400 mm	9257	12176	4930	5893	100	32356	32356
450 mm	1591	2337	0	0	684	4612	4612
500 mm	1114	7730	736	2085	13	11677	11677
600 mm	2972	3090	1575	4373	167	12177	12177
700 mm	2623	3575	334	2882	0	9414	9414
800 mm	567	3144	0	894	0	4605	4605
900 mm	2356	4103	0	3747	0	10206	10206
1000 mm	0	2387	0	17	0	2404	2404
1100 mm	0	2953	0	0	0	2953	2953
1200 mm	1639	2554	0	0	0	4193	4193
1400 mm	4116	320	0	0	0	4435	4435
1600 mm	2264	592	0	0	0	2856	2856
1800 mm	0	2157	0	0	0	2157	2157
2000 mm	272			0		272	272
Total (m)	**175613**	**248120**	**38237**	**68593**	**10667**	**541231**	**260118**

6. Details of Proposed STP

Sr. No	Name of STP	Capacity (MLD)	Type of Treatment.
1	Banewadi	30.00	(Modern technology) SBR/MBBR
2	Nakshatrawadi	136.50	(Modern technology) SBR/MBBR
3	Padegaon	10	(Modern technology) SBR/MBBR
4	Siddharth Garden	4.5	(Modern technology) SBR/MBBR
5	Zalta	20	(Modern technology) SBR/MBBR
6	CIDCO	15	(Modern technology) SBR/MBBR
	Total	**216 MLD**	



The total length of the collection network is about 541 Kms, comprising of 150mm to 300 mm dia. SWR pipes and 350 to 1800mm diameter RCC pipes. About 50% of the total length of sewer is proposed for up gradation. It is proposed to replace all the main sewers of length 60 Kms along the nalla which ultimately flow to Kham and Sukhana rivers.

Aurangabad Municipal Corporation (AMC) proposes to construct six number of STP and Seven numbers of pumping stations of intermediate and or terminal pumping stations with providing and laying of sewerage network of RCC non pressure, HDPE, DI pipelines in Aurangabad City under UIDSSMT Programme. The propose treatment plant shall be of

Modular type and state of art in its functioning so as to enhance the capacity to accommodate future flows.

The proposed treatment plant can be based on one of the three technologies described below followed by chlorination of the treated sewage before discharging in to the nearby major Nalla or into river. Bidder can suggest technology for different STP capacity considering cost optimisation and site suitability to treatment technology.

1. Activated Sludge Process (ASP)
2. Sequential Batch Reactor (SBR)
3. Moving Bed Bio Reactor (MBBR)

1.2. SITE INFORMATION

1.2.1. Geo-Technical Studies

The average water table is about 2.5m to 3.0 m below ground level. The water Net safe bearing capacity of the treatment plant site at a depth of 1.5 m to 2.0 m is about 18 T/m2. The bidder has to make his own assessment of the ground water table and safe bearing capacity while costing their proposal. In any case the approval of designs of the successful bidders shall be based on actual soil investigation report to be carried out by the successful bidder after award of work.

1.2.2. Location

Aurangabad city is situated about 350 km from Mumbai. Roughly triangular in shape, the southern side corresponds to the Godavari and the northern side to the northeast trending arm of the Ajanta ranges. With an extreme east to west distance of nearly 175 kilometers, this district is bounded by Jalgaon district on the north, Buldhana and Jalna districts on the east, Beed and Ahmadnagar districts on the south and Nasik district on the west. On the Eastern slopes of the North South Sahyadri Ranges.

The location co-ordinates for Aurangabad are N 19° 53' 47" - E 75° 23' 54". It is located512 meters above sea level. The city is surrounded by hills on all sides.

The topography of the city is typical of the region. The area lies in a broad east – west valley between ranges of flat-topped hills similar to those met with so often in Deccan.

The city stands in the Dudhana valley between Lakenvara range on the north and Satarahills on the south The old city contained within main fort walls lies on left bank of the Kham river basin whereas the eastern part lies in the Sukhana river basin. Though both the rivers are flowing South- West and South- East connects to the Godavari River.

1.2.3. Climate

It has moderate rains and the climate is dry throughout the year.

The climate is typical with three distinct seasons – summer, Rains, and Winter. The maximum and minimum temperature for the hottest month of May is 39.8°C and 24.4°C.

The same for the coldest month of December is 28.70°C and 13° C.

Annual temperature in Aurangabad range from 9 to 40°C. The highest maximum temperature ever recorded at Aurangabad was 46°C (114°F) on 25 May 1905. The lowest record temperature was 2°C (36°F) on 2 February 1911. The relative humidity ranges from 20% to 25%. Rainfall in Aurangabad varies from 9.0 to693 mm/month. Average annual rainfall is 725 mm and occurs in the month of June to September.

2. GENERAL TECHNICAL REQUIREMENTS

The Contractor should ensure technical feasibility of their tender offer, after inspecting the sites at all STPs. PS, and sewerage collection network in Aurangabad City. The tenderer shall be required to execute every such items of work which is considered necessary for satisfactory completion and commissioning of all the works mentioned under scope of work , even though such items are not explicitly specified in the tender documents.

All the works mentioned under the scope are to be designed and executed as per tender civil / electrical / mechanical/instrumentation technical specifications and requirements and after obtaining approval from the engineer-in-charge.

2.1. TIME LIMIT

Time of construction, erection and testing of the project as mentioned in the scope of work shall be 36 calendar months (inclusive of monsoon period) from the date of issue of work order. After 36 months there shall be start up and commissioning and performance run of 3 months followed by Operation and Maintenance for 10 Years.

2.2. SUBMISSION DURING EXECUTION OF THE PROJECT

The Contractor can take up the works of site clearance, dozing, grading and other mobilization works with the permission of the Engineer after award of the Contract. However, before taking up the construction, contractor shall be responsible for preparing and submitting for checking and obtaining approval at his cost of the following by the AMC / their authorised representative.

1. A leveling / contour plan gradation plan of the site.
2. Subsoil testing and investigations to be carried out by the contractor through a reputed and specialist firm approved by Engineer and recommendations regarding the safe allowable bearing capacity for the foundations of various structures of the sewage treatment plants , pumping stations ,connected buildings and Sewerage collection network area.
3. Collection system hydraulic design report, data and calculations are to be done on the basis of design parameters mentioned in the latest CPHEEO Manual on Sewage Treatment of Ministry of Urban Development, Govt. of India.
4. Process design, Process and instrumentation drawing and sizing of various units on the basis of criteria and specification mentioned in this document.
5. Hydraulic head loss design calculations are to be done on the basis of design parameters mentioned in the latest CPHEEO Manual on Sewage Treatment of Ministry of Urban Development, Govt. of India.
6. Layout plan of entire site showing the location of Sewage Treatment Plant and sewage pumping stations on the basis of process/sizing design indicating sizes of various units, channels, Sluice, Non-return valves, pipes, roads, Drainage, pumping station, switchgear and control room, transformer yard, compound wall etc. within the area of the site,. This drawing shall shows all treatment plant units, buildings / sheds, channels interconnecting piping, roads, pathways, storm water drains etc. The minimum distance between the two structures shall not be less than 3.0 m.
7. Hydraulic flow diagram shall be prepared on the basis of Hydraulic head loss calculations, indicating top water levels of each unit, from inlet channel to chlorine mixing chamber, side water depths, bed levels, invert levels, top of wall of each unit including all details of each units.
8. General arrangement drawings for each unit, buildings showing and finished ground levels based on the levels given herein after, necessary provision for civil/structural

works and electrical/mechanical works separately.

9. Civil structural design calculations, reinforcement drawings and drawings for bar bending schedule etc. are to be submitted. Structural design for all liquid retaining structures or structures in contact with sewage shall be done in accordance with the provisions made in I.S. code 3370 (part I to part IV) as Uncracked Section and other structures/building on the basis of IS 456-2000 (latest revision) unless otherwise stipulated in civil specification hereafter. M 30 grade of concrete shall be used for all liquid retaining structures and M 20 grade concrete for other structures. The plain cement concrete shall be nominal mix 1:2:4. Minimum thickness of PCC shall be 150 mm for water retaining structures and 100 mm for other structures.
10. Architecture drawings for all buildings, pumping station etc. An architect approved by AMC shall approve these drawings. Necessary charges for such approval shall be borne by contractor.
11. Design details for electrical and mechanical equipment, machinery including technical details of pipes, centrifuge, chlorinators, valves, gates and other drawings including single line diagrams etc. as per specifications mentioned in Mechanical specifications and Electrical Specifications.
12. Schedule for designs, drawings and execution, Bar Charts-CPM-Pert network for stage wise construction activities of sewage treatment plants, Pumping stations, disposal system and Sewerage collection network .
13. The contractor should get the approval on drawings and designs from the IIT/COEP, Pune or approved Government Engineering College and submit the copy of approved plan to the engineer-in-charge at his own cost.
14. Contractor shall be responsible for liasoning and getting clearances from all concerned authorities at his own cost and should submit the clearances obtained to AMC for their records. Contractor shall obtain consent from the Maharashtra State Pollution Control Board (SPCB) as per statute. Clearances shall also be obtained from Authorities of National & State Highways, Railways and other departments / agencies to expedite the project implementation.
15. The contractor should get the layout of electrical substation and general electrical layout from Electrical Inspector and also get the final inspection done for realising new connection at his own cost.
16. The contractor shall submit details of their environmental policy to carry out the Works with due consideration for the protection of the environment as required by the Contract. The environment policy shall be specific to the contract and address the major environmental hazards associated with construction of the Works. It shall include details of the organizational framework and the designation of the engineer to take overall responsibility and to manage the environmental control facilities on a day-to-day basis.
17. The contractor shall submit their Health & Safety policy in sufficient details to demonstrate the adequacy of the contractor to carry out the Works with due consideration for health and safety of his workforce and all people in the vicinity of the Works. It shall be shall be specific to the contract and address the major risks associated with construction of the Works. It shall also include details of the organizational framework and the designation of the engineer to take overall responsibility and to manage health and safety on a day-to-day basis.
18. The contactor should submit the quality control and quality assurance documents for all the works in the project. The document should be approved from the Engineer-in-Charge before start of the execution.
19. During the course of construction and its completion, the contractor shall submit the following drawings/documents for Civil, Mechanical and Electrical/ Instrumentation works.

- Revised drawings and design according to requirements of the Engineer.
- Six sets of final and approved drawings and design duly bound.
- Six sets of manual of operation and maintenance of the STP plants, Pumping Stations and collection network.

2.3. SOIL INVESTIGATION

The bidder/contractor has to carry out soil investigations and design all the structures based on the Safe Soil Bearing Capacity. For design purpose ground water table shall be considered at HFL.

2.4. EQUIVALENCY OF STANDARDS AND CODES

Wherever reference is made in the Contract to specific standards and codes to be met by the goods and materials to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise stated in the Contract. Where such standards and codes are national or related to a particular country or region, other authoritative standards which ensure an equal or higher quality than the standards and codes specified will be acceptable subject to the Engineer's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event the Engineer determines that such proposed deviations do not ensure equal or higher quality, the Contractor shall comply with the standards specified in the Bid Documents.

2.5. SIGN BOARD

The Contractor at his own cost, shall provide sign boards at approved locations, in English and Marathi at the site of the Works of approved size and design which provides (i) the name of the Project, (ii) the name and addresses of the Employer, the Contractor and the Consultant; (iii) the name and short description of the Project, (iv) the amount of the Contract Price; and (v) the starting and completion dates. Contractor shall take care of signboard and redo it in case of loss, damage, theft etc., as desired by the Engineer-in-Charge.

2.6. QUALITY ASSURANCE PROGRAMME/SAMPLE TESTS

The Contractor shall be responsible to develop a quality control program and to provide all necessary materials, apparatus, instruments, equipment, facilities and qualified staff for sampling, testing and quality control of the materials and the works under the Contractor. Without limiting the generality of the foregoing, the Contractor shall either (i) establish a testing laboratory at the site of Works which shall be adequately equipped and staffed to carry out all sampling and testing in accordance with the requirement set out in the tender document specifications and provide all field equipment and apparatus as necessary to conduct all specified in-situ tests and/or any Tests on Completion, or (ii) arrange for routine sampling, testing and reporting, as required, through a certified independent testing laboratory acceptable to the Engineer-in-Charge. The Contractor shall obtain the approval of the Engineer-in-Charge for the quality control programme developed by him and incorporate any modifications suggested by the Engineer-in-Charge at no extra cost.

All costs of such sampling, testing and reporting of test results will be borne by the Contractor, and the Contractor shall include sufficient provisions in his tendered rates to allow for independent sampling and laboratory testing under the direction of the Engineer in-Charge. The Contractor shall furnish certified copies of all test reports to the Engineer in-

Charge within 3 days of completion of the specified tests.

The Contractor shall, within 14 days after the date of the issue of Letter of Acceptance, submit to the Engineer-in-Charge for his consent a detailed description of the arrangements for conducting the quality control programme during execution of the Work, including details of his testing laboratory, equipment, staff and general procedures. If following submission, or at any time during the progress of Works, it appears to the Engineer-in-Charge that the Contractor's quality control programme is not adequate to ensure the quality of the Works, the Contractor shall produce a revised programme, as desired by the Engineer-in-Charge, which will be adequate to ensure satisfactory quality control. In case of the contractor will fail to ensure quality control program the action deem fit will be taken against the contractor. AMC shall carry out supervision and quality control and monitoring the progress of works.

2.7. PROTECTION OF UTILITIES

The Contractor is required to carefully examine the location of the Works and their alignments and to make special enquiries with all authorities concerning all utility lines such as water supply, sewers, gas pipe, telephone (underground and/or overhead) lines, electric cable (underground and/or overhead) etc., and to determine and verify to his own satisfaction the character, sizes, position and lengths of such utilities from authentic records. The Contractor shall be wholly responsible for the protection and/or facilitating relocation of such utilities as may be required and shall not make any claim for extra work or extra time that may be required to protect or facilitate relocating such utilities. If any major shifting or realignment of water supply, sewers, gas pipes, electric and telephone lines is necessary due to their interference with the proposed Works, the same may be done by the contractor. The cost of such relocations will be borne by the contractor.

2.8. DISMANTLING OF THE EXISTING UNITS

The existing structures at the site shall be demolished as directed by engineer-in-charge. Cost of the demolishing shall be included in the quoted price.

The scheme for demolishing shall be got approved from the Engineer-in-Charge before starting of the work. This however will not absolve the contractor from the responsibility of proper and safe demolition.

Necessary dropping, shoring and under pinning shall be provided for the safety of the adjoining work or property, which is to be left intact, before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damages is caused to the adjoining property.

Wherever required, temporary enclosures or partitions shall also be provided. Necessary precautions shall be taken to keep the dust nuisance down as and where necessary.

Dismantling shall be commenced in a systematic manner. All materials which are likely to be damaged by dropping from a height or demolishing roof, masonry etc. shall be carefully dismantled first. The dismantled articles shall be properly stacked as directed.

All material obtained from demolition shall be property of AMC unless otherwise specified and shall be kept in safe custody until handed over to Engineer-in-Charge.

Any serviceable materials obtained during dismantling or demolishing shall be separated out and stacked properly as directed with all lead and lift. All unserviceable material, debris etc shall be stacked as directed by Engineer-in-Charge. Disposal of the demolished material shall be done by contractor within AMC limit as directed by engineer-in charge at no extra cost.

On completion of work, the site shall be cleared of all debris rubbish and cleaned as directed.

2.9. INSPECTION

Bidders to note that various items to be procured / executed under this contract are subject to inspection by AMC or their authorised representatives at manufacturers premises. Cost of inspection shall be borne by contractor.

2.10. READY MIX CONCRETE

The contractor shall use RMC concrete for construction of treatment plant units Pumping Stations. The bidder should submit along with the tender, a copy of letter of consent from the approved RMC plant owner to the effect that he would be agreeable to do the RMC work for the said contract, if the tenderer does not possess his own RMC plant, approved by AMC.

Ready mix concrete prepared and transported will be as per IS 4926 of 1976 or the latest I.S. Code.

No dry mix shall be brought on site and water added thereat.

Ready mix concrete will be brought to the site from R.M.C. plant only by transit mixers (agitators).

Every transit mixer will carry delivery ticket, mentioning the minimum following details:-

- Name of Manufactures and Depot
- Serial No. Ticket.
- Date
- Truck No.
- Name of contractor to whom the R.M.C. is being supplied
- Location of contract
- Grade of concrete
- Specified workability
- Cement content and grade of cement
- Time of loading
- Quality of concrete

When the truck arrives on site, the drum should always be speeded to about 10 to 15 rev/min, for at least 3 minutes, to make sure the concrete is thoroughly mixed and uniform, before discharge.

Testing of Ready Mixed Concrete:- The sampling and testing requirements for ready mixed concrete are the same as those for site mixed concrete. As regards testing of workability, there is bit of problem because the standard requirement is that the sample should be made up of at least four portions taken at intervals from the complete discharge. This obviously involves discharging all the concrete, by which time, it is too late, for the workability, before discharge. The following procedure is one that has been accepted by many contractors, suppliers and clients, and recommended. After making sure that the concrete has been uniformly mixed, take a sample from the first 0.5 cum. Of concrete discharged, and do a slump (or compacting factor) test on the sample. If the result complies with specified requirements, then the load should be accepted. If the results are beyond limits, a further sample should be taken from the second 0.5 cum. of the discharged, if this is satisfactory, the load should be accepted, if not, the concrete should be rejected, as the same is not as

per the specified range. The specified slump is 50mm. While carrying out above tests, it may vary by ± 10 mm as per IS4926: 1976. cubes shall be cast at the plant as well as at the site, where the concrete is placed as per cube testing frequency mentioned in IS code

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested, that is, the sampling should be spread over the entire period of concreting and over all mixing units.

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following:

Quantity of Concrete in the Work (M3)	No. of Samples
1-5	1
6-15	2
16-30	3
31-50	4
51 and above	4 plus one additional for each additional 50 cum. or part thereof.

- The admixture used shall conform to IS 9103-1979 reaffirmed on 1990 or ASTM C-494 of 92

All taxes/duties etc. will be borne by the contractors and not by AMC. No extra payment will be made for the use of admixtures.

It will be the sole right of the Administration to allow or disallow the use of ready mixed concrete in specified works based on the site situation, number of works, distance of plant from the site of work, etc.

3. SCOPE OF WORK

3.1. BRIEF SCOPE OF WORK

The scope of work under this Contract includes the design and construction of all Works for the sewerage system as described in subsequent paragraphs, sufficient to collect and treat expected flows of raw water in all zones, and other works listed herein or any other works necessary to achieve the above objective and complete the system as per the specifications and Employer's Requirements. The Estimated Project is exclusive of Operations and Maintenance cost and Bidders are required to quote annual O&M cost for 10 Years separately.

The electric power required during construction of STPs, SPS and collection system shall be arranged by contractor. AMC will not pay any electricity charges incurred during construction phase of project. The connection at take-off structures with necessary equipment (such as insulators, ACSR, hardware, clamps and connectors etc.) shall be in the scope of Contractor.

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

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

i. Designing, Planning & Construction of Sewer Network, Manholes, property connections (House Sewer Connection) and all the ancillary structures.

ii. Designing, Planning & Construction of Intermediate & Terminal Sewage Pumping Station and all the ancillary structures.

iii. Designing, Planning & Construction of Sewage Pumping Main and all the ancillary structures.

iv. Designing, Planning & Construction of civil engineering works for all the units and all the ancillary structures.

v. Designing, Planning Supply, erection, testing & commissioning of all the mechanical equipment.

vi. Designing, Planning Supply, erection, testing & commissioning of all the electrical & instrumentation equipment.

vii. Designing, Planning Supply, erection, testing & commissioning of all the piping, valves and specials etc.

viii. Demolishing the existing structures, if any, on the site.

ix. Construction of civil engineering works for all the units plus all the ancillary structures as detailed in Volume IIB: Civil Specifications.

x. Supply, erection testing & commissioning of all the mechanical equipment as detailed in Volume IIC: Mechanical Specifications.

xi. Supply, erection testing & commissioning of all the Electrical & Instrumentation equipment as detailed in Volume IID: Electrical Specifications.

Supply, erection testing & commissioning of all the interconnecting piping & valves as

i. Detailed in Volume IIB: Civil Specifications.

ii. Providing walkways, platforms and RCC staircase of minimum 1.2 m width

iii. All water retaining structures shall be form finished.

iv. All reinforcement steel shall be Fe 415 TMT grade only

v. Swelling Gasket in paste form (Masterflex or equivalent) shall be used in all construction joints in concrete structure to avoid leakage

vi. Details with valve and pipe arrangement (min 200 mm dia) to all treatment plant units. All

drains shall be connected to the final treated sewage line.

vii. Hydraulic testing of all the water retaining structures

viii. Third party inspection.

ix. Submission of as built drawings

x. Removal of defects in laying & jointing of all sewers, fittings and manholes after testing and during defect notice period.

xi. Operation & Maintenance of Sewage Treatment Plant & Terminal Sewage Pumping Station for start-up/stabilization for a period of Three months or complete stabilization of the Plant process whichever is longer.

xii. Supply of all spares required during performance run and during 3 months of O & M period.

xiii. Zinc rich epoxy painting in two coats from inside for all shall water retaining structures.

xiv. Water proof acrylic painting in two coats of approved shade to all units from outside up to 0.5 m below ground level.

xv. Oil painting with anti-corrosive treatment to railing and all MS, CI and GIworks. Subsoil testing and investigation for water table and safe allowable bearing capacity to be carried out by the contractor through a reputed and specialist firm approved by Engineer-in-Charge. Based on soil investigation the contractor shall prepare structural design and drawings.

xvi. Bidders are advised to visit STP/ SPS and city area before quoting for the proposed Work.

xvii. Any other items of work which have not been specifically mentioned in the specifications but are necessary for construction of the plant as per good engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within the scope of work of this specifications and shall be provided by the contractor without any extra cost to the employer.

xviii. Operation & Maintenance of the Plant for a period of 120 months after stabilization of Plant process.

xix. During Operation and Maintenance period electricity charges for electric energy supplied through MSEDCL grid and genset shall be borne by the AMC to the extent of average guaranteed energy consumption quoted by the agency. If actual energy consumption exceeds average guaranteed energy consumption, the charges for the excess energy consumption shall be borne by the agency. **Electric energy consumption from MSEDCL grid shall be charged as per bill raised by MSEDCL, however electric energy consumption from genset (as per energy meter to be installed by agency) shall be charged as per rate fixed by EIC in writing.**

xx. Defect liability for a period of twelve (12) months after the completion of works.

xxi. Supply of equipment drawings, Technical specification/Catalogue.

xii. Supply of as built drawings after completion

xiii. Manufacturer manual for Operation & Maintenance of the equipment supplied.

Technical Bid shall consist of following documents duly filled & signed by the bidder.

(i) Notice inviting tender, instruction to bidders, forms of agreement & clauses.

(ii) Scope of work for capital works.

(iii) Scope of work for operation & maintenance.

(iv) Process calculations including pipe size calculation.

(v) Layout plan.

(vi) Hydraulic diagram and P&I diagram

(vii) A copy of the power of attorney in the name of the person signing the tender.

(viii) Deviations, if any, from the bid document.

(ix) Memorandum of understanding or agreement with the technology provider.

(x) Copy of one unpriced bid format as per tender duly signed, stamped and accepted confirming that no other condition is mentioned in the sealed price envelope.

(xi) Technology provider shall provide detailed documents indicating the features of process / process design criteria and operational philosophy. This must be supported by diagrams / photographs/video clips etc.

Notes:

1. The bidder's proposal must clearly specify the following information:
   - Proposed area for the Blower Room, MCC, PLC, Toilet, centrifuge shed, chlorination room, tonner shed, sludge storage platform etc.
   - Technical data such as no. of items, technical specifications, capacity and make of all the supply items including electrical & mechanical works, instrumentation ,pipes, valves and gates.
2. The following schedules duly filled in as per attached performa are to be submitted.

Electrical drive list

Pipeline schedule

Field instrumentation

Chemical requirement

1. Net present value of power consumption

Net present value of the average guaranteed power consumption indicated in the Price Bid shall be worked out on the basis of following parameters:

- Rate per KWh of energy consumption = Rs 4.50 per KWh
- Period of capitalisation = 15 years
- Rate of interest / rate of return = 10%

Example:

Average guaranteed power consumption = **A** kWh per day

Energy charges = Rs 4.50 per kWh

Annual Energy charges = 4.50 x 365 x **A**= Rs 1642.50 **A**

Net present value factor = **7.6061**

Net present value of power consumption = 7.6061 x 1642.50 **A**

= Rs 12493 **A**

Note: In case actual energy consumption exceeds the average guaranteed energy consumption, the charges for the excess energy consumption shall be borne by the contractor. These shall be deducted by the Department out of his running bills. Cycle for calculating excess energy consumption shall be bill to bill basis issued by the Electricity Department.

A. Investigations, Surveys and Submissions

Setting up fully equipped/staffed field offices to carry out the required surveys and investigations and preparing the necessary designs and drawings at the very start of the Contract. The design offices shall interact with the Employer's staff to ensure team work for early submission and approval of the design and drawings required.

Carrying out necessary topographical survey/sub soil investigations for sewage collection system, treatment plant, pumping stations and outfall sewers in consultation with the Employer's Representative so as to verify and check the data provided in the document.

Carrying out required subsoil investigations for design of foundations including the tests for determination of safe load. Carrying out various other subsoil investigations such as the type of soil, the strata, and the level of ground water, optimum moisture content, soil resistivity and chemical composition, bearing capacity, etc., as may be required.

Carrying out required raw sewage quality analysis.

Preparation of system designs where required (e.g. sewage collection system, sewage treatment plant, pumping stations, surge protection system, power supply system, automation, local SCADA systems for monitoring and control, communications etc.) for approval of the Employer's Representative. Contractor can provide his own Concept of SCADA system and may give his financial offer accordingly subject to approval by employer. The alternate proposal shall be included in the offer.

Planning, design and preparation of the working drawings for the proposed Works. Preparation and submission of the L-sections, layout plans and cross sections and conceptual drawings etc. and all other drawings at appropriate scale and details for planning and construction of all components of the project.

Submission of documents (designs, drawings, data sheets, etc.) and samples required according to the Contract for approval by the Employer's Representative of all design and drawings, material to be used, equipment specifications, etc., prior to construction.

Preparation and submission of General Arrangement Drawing (GAD) and Architectural Elevation drawings of all structures proposed to be constructed for approval.

Preparation of the structural design and drawings (including reinforcement detailing) for all the RCC Works taking into consideration the functional reliability and structural safety of the buildings.

Preparation and submission of all detailed working drawings on the basis of conceptual designs and plans approved by the Employer's Representative.

B. Works

Setting up of suitably equipped/manned field offices for supervision of the works for the Contractor's staff and the Employer's Representative and Engineers.

Development of suitable storage spaces for construction material and equipment to be received for the works.

Identification of suitable quarries/sources for construction material and get them approved from the Employer's Representative.

Setting up, and staffing with qualified engineers/ technicians, of suitable laboratories for following the Quality Assurance Program.

Setting up of suitable labor camps with all water and sanitation arrangements and other facilities required under the relevant Labor laws.

Implementation of all the environmental and relevant social mitigation measures as required.

Making arrangements for equipment and material required for maintaining safety of the sites and the workmen on site (helmets, boots, jackets, safety belts, gloves, scaffolding, barricading, etc.)

Submission of initial work program and updating the same every month for approval by the Employer's Representative.

Site clearance and leveling of site. Layout of the works as per the approved drawings.

Disposal of surplus soils as directed by Employer's Representative, construction of civil components of all the units, and maintaining the construction site in orderly manner.

Carrying out tests on materials received and finished works and maintaining complete records and registers required on site.

Manufacturing, shop testing, pre-dispatch inspection, packaging, transportation to site, providing transit insurance, storage, handling at site, installation, sectional testing, pre-commissioning testing, trial runs and commissioning of all components of the system including the pipes, fittings, hydraulic, mechanical, electrical, electro-mechanical and instrumentation equipment.

Providing spares, tools and tackles.

Remedying the defects during the Contract period

Site Clearance and tidying up and restoration of the premises after completion of the Works

Submission of 'As Built' drawings and Operation and Maintenance Manuals

C. Operation and Maintenance, Preventive Maintenance and Repair of Complete System for 10 Years.
D. Training of the AMC Staff on all Aspects of Operation and Maintenance of the Full System.
E. Handing Over of the Full System at the End of the O&M Period to AMC.

3.2. System Components

The project contemplates execution and satisfactory commissioning of Underground Sewerage Scheme to Aurangabad Municipal Corporation and the major components of the system are :

3.2.1. Collection & conveyance System

Designing ,Providing, Laying, Jointing, Testing and Commissioning of sewage collection network covering entire municipal limit with RCC NP-2, NP-3 & NP-4 /DI-k9/GRP/DWC HDPE pipes having diameters ranging from 150 mm to 2000 mm with ancillary structures like brick masonry and RCC manholes, ventilating shafts etc.

Contractor should follow following criteria/norms while designing sewage collection system.

General

This system design shall be essentially based on design criteria based on present practice as spelt in the manual on sewerage and sewage treatment published by CPHEEO, manuals and codes of other nations, studies reported in literature and papers in journals etc. Where possible, changes may be suggested to evolve a more efficient design to effect economy in cost, within the constraints of an acceptable performance level for individual components and without comprising engineering.

Design Year

The design year shall be considered for the wastewater system is 2045. i.e. 30 years from the year 2015.

Design Flow

The design flow shall be based on the wastewater expected to be generated in the year 2045 and would include wastes from domestic use in residential, commercial and institutional areas and non domestic use in industrial areas and infiltration.

Avg. dry weather flow [Q avg.] per manhole = {Population [P] X Sewerage Flow (Water Supply [lpcd] X Expected Sewer 80 % as per CPHEEO manual page No. 39 point 3.2.4)} + Infiltration 5% of flow.

Per Capita Wastewater Flow

For the purpose of design the wastewater generated shall be estimated considering population and water supply rate as 135 lpcd and it is assumed as 80% of the water supply to reach the sewers, i.e. 108 lpcd

Rate of Infiltration

The infiltration allowance may be considered as 5%

Peak Factor

The peak factors to be considered for design of sewers range between 2 to 3 as per the recommendations of CPHEEO manual based on contributory population. The peak factors shall be applied to the projected population for the design year considering an average per capita wastewater flow based on allocation.

As pipes deteriorate with age, a roughness coefficient shall be assumed for the design period assuming fair condition in sewers as per CPHEEO Manual.

Design of Collection System

Manning's formula may be adopted for the design of sewers.

vf = $1/n\ R^{2/3}\ S^{1/2}$ given that Where

vf = Velocity when pipe flows full in mps.

A = Cross sectional area of pipe in sqm.

n = Manning's roughness coefficient when pipe flows full

R = Hydraulic radius.

S = Slope of energy gradient

Design Aspects

Sewers are to be designed to carry estimated peak flows generated in the year 2045 and to run partially full at all flows. The pipes designed to flow at depths where the maximum permissible depth of flow in sewers for established velocity criteria shall be tabulated. From considerations of ventilation in wastewater flow, sewers shall be designed to flow partially full at ultimate peak flow. To ensure that deposition of suspended solids does not take place, minimum self-cleansing velocities to be attained once in a day need to be considered in the design of sewers. The minimum partial velocities during peak flow suggested are 0.8 m/s and the maximum velocity 3.0 m/s. This velocity is adequate to keep a wide range of particles encountered in the wastewater system in suspension.

Pipe Material for Collection System.

DWC-HDPE pipe ranging in the diameter 175 mm up to 315 mm and Reinforced Cement Concrete (R.C.C.) pipes, with rubber gasket at joints for diameter ranging from 400 mm to 2000 mm are proposed for sewers as those are proven.

Other Aspects

Minimum size of sewers

The minimum size of sewers may be adopted is 150 mm diameter for analysis and identification of proposed sewers under this study, along the major rods.

Minimum depth of cover

The minimum depth of cover on sewers shall be as 1.0 meters.

Recommended Maximum Depth of Flow in Pipes

All sewers shall be designed to flow 0.8 full at ultimate peak flow.

Type of bedding

Type of bedding for various pipes (first class bedding, concrete cradle etc.) depends on the depth at which the sewer is laid, type of pipes used, load due to backfill and super imposed load. Accordingly, suitable bedding A Class, B Class and C Class for pipes shall be provided.

Appurtenances

Manholes

Manholes will be provided at all junctions, change of sewer size, gradient and alignment. The maximum C/C distance between manholes shall be 30 m on a straight run.

The manhole frame and cover shall Brick Masonry type. As per IS 12542 (Part I) 1988 and Part II 1991, the clear opening of manholes shall be(1.) 560 mm as per IS 4111. (2).The bottom slab of manhole shall be of reinforced concrete, wherever required, depending on site conditions.

Flushing Arrangements

Flushing arrangements shall be provided to extreme upstream manholes of the systems wherever required .sudden enlargement depends upon the ratio of diameters.

Each individual case needs to be studied form various aspects such as operation of pumps, the specified limits, availability of land required for duplicating the main in future, etc.

3.3. STPs & Pumping Stations and Raw sewage pumping Mains

Since the scheme is based on decentralized waste water system, the Sewage Treatment Plants proposed are modernized with advance technology of Treatment plants because of scarcity of land in the city. There are six STPs proposed having treatment capacity Ranging of 4.5 Mld to 136.5 Mld.

The Scope for STPs is detailed below of this document

The details of Pumping stations and pump house with valve chamber is given below .The scope includes designing, providing, construction and O&M for 10 years of sewerage pumping stations and STPs.

Raw Sewage may have to be carried to STPs through force main, The size of the main should be determined by taking into account ultimate stage flow i.e.(2045) along with the initial cost of pipeline and cost of operation of pumping for different sizes of pressure main calculated for velocity of 1.1 to 1.5 m/sec for designing peak flows with a maximum velocity up to 2.0 m/sec.

Losses in values. Fittings, etc. Are dependent upon the velocity head $v^2/2g$ Loss in bends, elbows depend upon the ratio of absolute friction factor to pipe diameter, besides the velocity head. Loss due to sudden enlargement depends upon the ratio of diameters.

3.4. Flow Measurements

Electromagnetic/ultrasonic Flow meters with GSM capability to measure the inflow to the system and flow from STP are provided in estimates.

3.5. Miscellaneous Works at STP

3.5.1. Data acquisition and control system, Construction of Security Guard Rooms, Meter Rooms, Compound walls, at STPs and SPS. etc.

3.5.2. Computer, Plotters, GPS etc.

The municipal corporation is in the process of implementing sewerage scheme and this shall require considerable establishment for implementation & further operations & maintenance of the scheme. A provision towards equipment purchase like computers, scanners, plotters etc have been made.

3.5.3. Communication strategy, public awareness campaign for water tariff rationalization and judicious use of water assets

The treated water is supposed to be reused by industries and housing societies which requires an effective communication program & awareness campaign.

3.5.4. Shifting of Existing Utilities

Since the collection and conveyance pipelines are required to be laid on main roads which shall require shifting of existing utilities like telephone cables , electric cables , water pipelines etc.

All design procedure shall be as per CPHEEO manual with relevant IS codes.

Proposed Components

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

1. Design, construction, supplying, erection, testing and commissioning of six nos of STPs based on any of the three suggested technologies.
2. Design, Construction, supplying, erection, testing and commissioning of six numbers of terminal pumping Stations and one intermediate pumping station at ward no 98.
3. Survey, Design and Drawings of the total sewage collection network in correlation with proposed and existing alignment, line and levels of the existing network upto the sewerage treatment plants and assessment of the existing sewerage pipeline and manholes before upgradation/replacement of the existing pipelines.
4. Excavation of pipelines, manholes and all types of structures in all types of strata with minimum disruption to the traffic, including refilling, disposing of the excavated stuff as per the directions of Engineer-in-Charge.
5. Providing, lowering lying and testing RCC Non Pressure/DWC HDPE pipelines for sewerage network in Aurangabad City.
6. Construction of brick and RCC manholes, ventilating shafts, covered channels including successfully hydraulic testing/leakage tests.
7. Dewatering with the pumps and disposing/diversion of the water to nearby drains/channels/ nallas/river without disturbance to the traffic.
8. Traffic diversion including proper lighting, signages, safety and precautionary measurements at the workplace.
9. Required site development including levelling and grading to improve the aesthetics and to facilitate the vehicular movement.
10. Preparation of process, hydraulic, electrical, mechanical and piping design. Preparation all civil, mechanical, electrical and piping drawings including architectural, construction and as built drawings.
11. Demolishing the existing structures, if any, on the site.
12. Construction of civil engineering works for all the units plus all the ancillary structures as detailed in Volume IIB: Civil Specifications.
13. Supply, erection testing & commissioning of all the mechanical equipment as detailed in Volume IIC: Mechanical Specifications.

14. Supply, erection testing & commissioning of all the Electrical & Instrumentation equipment as detailed in Volume IID: Electrical Specifications.
15. Supply, erection testing & commissioning of all the interconnecting piping & valves as detailed in Volume IIB: Civil Specifications.
16. Providing walkways, platforms and RCC staircase of minimum 1.2 m width
17. All water retaining structures shall be form finished.
18. All reinforcement steel shall be Fe 415 TMT grade only
19. Swelling Gasket in paste form (Masterflex or equivalent) shall be used in all construction joints in concrete structure to avoid leakage
20. Drain with valve and pipe arrangement (min 200 mm dia) to all treatment plant units. All drains shall be connected to the final treated sewage line.
21. Performance Run of the constructed & hydraulically tested plant along with O & M of electrical & mechanical equipment for a period of Three (3) months and operation & maintenance for 120 months after performance run as per tender specifications including providing and installing all civil material, labour, tools and plants all complete on turnkey basis
22. Defects liability period of 12 months from the date of successful completion of O & M period.
23. Supply of all documentation for the plant such as As-Built drawings, Operation & Maintenance manuals (6 sets)
24. Supply of all spares required during performance run and during 36 months of O & M period.
25. Zinc rich epoxy painting in two coats from inside for all shall water retaining structures.
26. Water proof acrylic painting in two coats of approved shade to all units from outside upto 0.5 m below ground level.
27. Oil painting with anti corrosive treatment to railing and all MS, CI and GI works.
28. Subsoil testing and investigation for water table and safe allowable bearing capacity to be carried out by the contractor through a reputed and specialist firm approved by Engineer-in-Charge. Based on soil investigation the contractor shall prepare structural design and drawings.
29. Bidders are advised to visit STP site before quoting for the proposed STP.
30. Any other items of work which have not been specifically mentioned in the specifications but are necessary for construction of the plant as per good engineering practice and safety norms and operation and guaranteed performance of the entire plant shall be deemed to be included within the scope of work of this specifications and shall be provided by the contractor without any extra cost to the employer.

3.6. PROPOSED SEWAGE TREATMENT PLANT

Bidders can quote for any one of the following alternative treatment schemes which they think is most cost effective in terms of capital and operation cost as defined in tender.

1. Activated Sludge Process (ASP)
2. Sequential Batch Reactor (SBR)
3. Moving Bed Bio Reactor (MBBR)

Tenderer can suggest different technology for STP's considering cost optimisation and site suitability of the treatment technology and outlet parameters. Based on the above, there shall be only one suggested technology for each STP. Following are the details of treatment plants.

Sewage Treatment Plant Capacity (For all three treatment technologies)

DESIGN BASIS TABLE FOR SEWERAGE TREATMENT PLANTS

Design Parameters	STP Details						
	Unit	Nakshatrawadi	Banewadi	Siddarth Garden	Zalta	Padegaon	CIDCO Area
1	2	3	4	5	6	7	8
Avg. Flow to STP	MLD	136.5	30	4.5	20	10	15
Peak Factor	No	2.25	2.25	2.25	2.25	2.25	2.25

3.6.1. Inlet Raw Sewage Quality (For all three treatment technologies)

Inlet Raw water characteristics are indicated in the following table.

Sr. No.	Parameters	Unit	Raw Sewage Characteristics	Design Values
1	pH	-	5.5 to 9	7 to 8
2	Total Suspended Solids	mg/l	150 - 250	250
3	BOD5 at 20 0C	mg/l	100 - 250	250
4	Oil & Grease	mg/l	10- 30	30
5	COD	mg/l	250 - 400	400
6	Faecal Coliform	MPN/100 ml		> 1 x 107
7	Total Kjeldahl Nitrogen (as N)	mg/l	20 - 55	45
8	Ammonia Nitrogen (as N)	mg/l	4-10	10
9	Total Phosphorus (as PO4)	mg/l	5	5

3.6.2. Outlet Treated Sewage Quality (For all three treatment technologies)

The treated effluent parameters should conform to the following discharge standards:

Sr. No.	Parameters	Unit	Discharge Standards
1	pH	-	6 to 8
2	Total Suspended Solids	mg/l	< 30

Sr. No.	Parameters	Unit	Discharge Standards
3	BOD5 at 20 0C	mg/l	<20
4	Oil & Grease	mg/l	<10
5	COD	mg/l	<100
6	Faecal Coliform	MPN/100 ml	<1000
7	Ammonical Nitrogen	mg/l	<5
8	Nitrate Nitrogen	mg/l	<10
9	Total Phosphorous	mg/l	<5

3.6.3. Proposed Treatment Scheme

The raw sewage shall be treated by screening, degritting, primary treatment, secondary treatment followed by chlorination process to meet the desired discharged standards.

The average capacity of the sewage treatment plants are as per mentioned in table above. Raw sewage from wet well shall be taken to the inlet chamber through pumping main followed by fine mechanical screen and then to mechanical degritter to remove floating matter and grit particles.

Sewage after removing floating matter and grit matter shall be treated aerobically using modern adopted technology. Sludge from secondary basins will be taken into centrifuge for dewatering.

Overflow from Secondary basins shall be further taken to the chlorine contact tank for disinfection. Chlorine will be dosed into the chlorine contact tank from a vacuum type chlorination system. Chlorination system along with safety devices shall be installed in the chlorine house.

Treated sewage after disinfection shall be discharged through outfall structures or any other purpose as directed.

Interconnection of various units shall be made through MS, CI, SS, DI piping or RCC channels. Piping will be preferred over RCC channel wherever possible but the Engineer- in-Charge reserves the right to select any option.

The process considered is a well-established process for treatment of sewage. The tenderers are to adopt the same nomenclature used for various treatment units in their design report as used in the tender documents. The Tenderer is required to fill up/complete the Datasheets presented in this document as a part of the tender submission for the each STP. The proposed technology shall be subject to comments and suggestion received from Maharashtra Pollution Control Board

3.6.3.1. General Specifications for Activated Sludge Process

Raw sewage shall be treated by screening, degritting followed by activated sludge process to meet the desired discharged standards.

The average capacity of the all STPs proposed in tender are mentioned in the table above. Raw sewage shall be received in the wet well of Pumping Station through mechanical screens which pumped in to the inlet chamber using series of submersible pumps to inlet chamber and then taken to the mechanical screen channel followed by mechanical degritter

to remove floating matter and grit particles.

Sewage after removing floating matter and grit matter shall be taken to the primary clarifier. In primary clarifier suspended solids will be allowed to settle at the bottom of the clarifier. Floating matter in the form of scum shall be removed from the primary clarifier.

Primary settled sewage shall be treated aerobically in activated sludge process. Aerated sewage shall be taken to the secondary clarifier for solid liquid separation. The settled sludge from clarifier is recirculated back to the aeration tank to maintain bio mass concentration. Excess sludge shall be taken to sludge thickener for thickening of sludge.

Overflow from secondary clarifier is further taken to chlorine contact tank for disinfection. Chlorine will be dosed in the chlorine contact tank from a vacuum type chlorination system. A separate building will be provided to house the chlorination system along with all the accessories and its safety devices.

Treated sewage after disinfection shall be discharged to the nearby river or nallah through RCC pipes or open channel.

Primary sludge and excess sludge shall be taken to the sludge thickener for thickening of sludge. Thickened sludge then shall be taken to the anaerobic digester for stabilisation of sludge. Stabilised and digested sludge will then be taken to mechanical dewatering system for dewatering of the sludge. Filtrate shall be taken back in to the system for treatment.

Gas generated from the digester shall be taken to the gas holder.

Interconnection of various units shall be made through piping or RCC channels. Piping will be preferred over RCC channel wherever possible but the Engineer- in- Charge reserves the right to select any option.

Chlorine house shall be provided which includes chlorine dosing unit, tonners, booster pump etc. The chlorine house can be constructed above chlorine contact tank and size suitable for the various capacities of the treatment plants.

MEP room of min 50 m2 shall be provided near transformer yard.

Blower room of min 150 m2 shall be provided to accommodate working and standby blowers.

3.6.3.2. Sequential Batch Reactor Technology

Raw sewage shall be treated by screening, degritting followed by sequential batch reactor process to meet the desired discharged standards.

The average capacity of the all STPs proposed in tender are mentioned in table above. Raw sewage shall be received in the wet well of Pumping Station through mechanical screens which pumped in to the inlet chamber using series of submersible pumps to inlet chamber and then taken to the mechanical screen channel followed by mechanical degritter to remove floating matter and grit particles.

Sewage after removing floating matter and grit matter shall be taken to the sequential batch reactor (SBR) system for removal of SS and BOD.

Treated sewage after SBR shall be further taken to chlorine contact tank for disinfection. Chlorine will be dosed in the chlorine contact tank from a vacuum type chlorination system. A separate building will be provided to house the chlorination system along with all the accessories and its safety devices.

Excess sludge from SBR reactor shall be taken to sludge thickener followed by mechanical dewatering system for dewatering of the sludge. Chemical conditioning for thickening / dewatering shall be provided. Filtrate shall be taken back in to the system for treatment.

Interconnection of various units shall be made through piping or RCC channels. Piping will be preferred over RCC channel wherever possible but the Engineer- in- Charge reserves the right to select any option.

Chlorine house shall be provided which includes chlorine dosing unit, tonners, booster pump etc. The chlorine house can be constructed above chlorine contact tank and size suitable for the various capacities of the treatment plants.

MEP room of min 50 m2 shall be provided near transformer yard.

Blower room of min 150 m2 shall be provided to accommodate working and standby blowers.

3.6.3.3. Moving Bed bio reactor (MBBR)

Raw sewage shall be treated by screening, degritting followed by Primary and Secondary clarifier reactor process followed by chlorination treatment to meet the desired discharged standards.

The average capacity of the all STPs proposed in tender are mentioned in table above.. Raw sewage shall be received in the wet well of Pumping Station through mechanical screens which pumped in to the inlet chamber using series of submersible pumps to inlet chamber and then taken to the mechanical screen channel followed by mechanical degritter to remove floating matter and grit particles.

Sewage after removing floating matter and grit matter shall be taken to the Min two MBBR reactors system for removal of SS and BOD. Outlet of MBBR reactors shall be further treated with by addition of chlorination to remove the fecal coliform for desired outlet parameters as mentioned in tender document. Aerobic treatment can be aeration tank followed by secondary clarifier or Moving Bed Bio reactor followed by secondary clarifier.

Treated sewage after secondary clarifier shall be further taken to chlorine contact tank for disinfection. Chlorine will be dosed in the chlorine contact tank from a vacuum type chlorination system. A separate building will be provided to house the chlorination system along with all the accessories and its safety devices.

Sludge from MBBR reactor and from aerobic treatment shall be taken to the mechanical dewatering unit for dewatering of sludge. Chemical conditioning for thickening / dewatering shall be provided. Filtrate shall be taken back in to the system for treatment.

Interconnection of various units shall be made through piping or RCC channels. Piping will be preferred over RCC channel wherever possible but the Engineer- in- Charge reserves the right to select any option.

Chlorine house shall be provided which includes chlorine dosing unit, tonners, booster pump etc. The chlorine house can be constructed above chlorine contact tank and size suitable for the various capacities of the treatment plants.

MEP room of min 50 m2 shall be provided near transformer yard.

Blower room of min 150 m2 shall be provided to accommodate working and standby blowers.

All three processes considered are well-established processes for treatment of sewage. The tenderers are to adopt the same nomenclature used for various treatment units in their design report as used in the tender documents. The tenderer is required to fill up/complete the Datasheets presented in this document as a part of the tender submission for all the STPs separately..

3.7. SEWAGE TREATMENT PLANT SPECIFICATION

The detailed Scope of work as follows for all three treatment process.

3.7.1. DETAILED SCOPE OF WORK FOR ACTIVATED SLUDGE PROCESS

The project shall have following major units

1. Inlet Chamber
2. Mechanical and Manual Fine Screen Channels and Screens
3. Mechanical and Manual Grit removal facility
4. Primary clarifiers with sludge sump and pumps
5. Aeration Tank/basins with diffusers, air blowers
6. Secondary Clarifier with return sludge sump and pumps
7. Chlorine Contact Tank
8. Chlorine House
9. Sludge thickener with thickened sludge sump and pumps
10. Anaerobic sludge digester with digested sludge sump and pumps
11. Gas Holder
12. Gas mixing system for sludge digester.
13. Sludge dewatering system
14. Transformer yard and MEP room
15. Interconnecting Piping
16. Flow measurement units
17. Plant Utilities like Laboratory, staff Quarters, Compound wall, plantation, etc
18. Required site development including levelling and grading to improve the aesthetics and to facilitate the vehicular movement.

The sizes specified in the tender document are the minimum requirement and are for guidance purpose only. However this does not absolve the contractor from his responsibility of giving satisfactory plant performance and meeting desired discharge standards as specified in tender document.

3.7.2. Inlet Chamber

The Contractor shall have to construct an inlet chamber that will receive raw sewage from the raw sewage pumping station. Inlet chamber shall be designed for peak flow. The entire construction is in M 30 grade concrete and as per IS 3370. RCC access platform 1200 mm wide with SS railing as per specifications shall be provided to the Inlet chamber. RCC staircase 1200 mm wide shall be provided for access from the ground level to the top of the unit & to the operating platforms.

Detention period	:	60 sec
Min Free board	:	0.5 m
Number of Units	:	1.0 No

3.7.3. Screen Channels

Mechanical and manual screens are proposed in the screen chamber. The mechanical screens shall be working and manual screen shall be standby. The screen channels shall be designed for peak flow. The number of mechanical screen channel shall be more than one, then while operating all, they shall be able to deal with the peak flow.

The clear opening for mechanical screen shall be 6 mm and that of manual screen shall be 10 mm. The mechanical and manual bar screens shall be fabricated from 2 mm and 6 mm thick Stainless Steel (SS 316) flats respectively. Conveyor belt and chute arrangement shall be provided to take the screenings to the safe disposal. The screenings dropped from chute

will be collected in a wheeled trolley (to be supplied by contractor) of approx. 0.5 m3 capacity. This trolley will be housed in a roofed enclosure with proper access, screen washing arrangement and drain.

Manually operated aluminium gates are provided at the upstream and downstream ends of each screen channels to control the flow. Width of gates shall be equal to width of screen channels. The height of gates shall be 200 mm more than the maximum water depth.

RCC platforms shall be provided at the upper level to enable operation of the gates. SS Hand railings shall be provided around the entire periphery of the screen channel as well as for the platform. The entire structure is to be constructed in M 30 concrete and as per IS 3370 including the platform for the gates. RCC staircase 1200 mm wide shall be provided for access from the ground level to the top of the unit & to the operating platforms.

For inspection of the Screens, a walkable RCC platform shall be built on both sides of the Screen Chamber with perpendicularly aligned access platforms to reach the Screens for closer inspection of both Screens and Conveyor System.

Isolation of the Screens from the flow during either repairs or due to rotational standby shall be by Open Channel Gates with hand wheels at a suitable place. A local operating platform (with handrails) shall be provided for Gate operations. The screened sewage shall flow by gravity to the Grit Chambers suitably branched and sized Channels.

Design Basis:

Average Flow	:	As per table above
Peak Factor	:	As per table above
Number of Units	:	As per Design
Approach velocity at average flow	:	0.45 m/sec
Velocity through Screen at avg. flow	:	0.6 m/sec (minimum)
Velocity through Screen at peak flow	:	1.2 m/sec (maximum)
Free Board	:	0.5 m
Wheeled trolleys	:	2 nos.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.4. Grit Removal Channel

The Grit removal tanks shall be of RCC construction. The number of Grit removal unit shall be two, one mechanical and one manual type that when operating they shall be able to deal with the peak flow With provision of Drain valve.

Square Mechanical Detritor Tank for grit removal shall be provided for handling the peak flow of STP. Detritor tank chamber shall have the following:

Detritor tank chamber shall have the following:

1. One tapered inlet channel running along one side with deflectors for entry of sewage into the grit chamber. The minimum SWD of the units shall be adopted on the basis of design requirement of the unit,
2. One tapered outlet channel for collecting the degritted sewage, which overflow over a weir into the outlet channel. Outlet channel of adequate size and shape to ensure that no settling takes place.
3. One sloping grit classifying channel into which the collected grit will be classified.
4. The grit from classifier will be collected in a wheeled trolley (to be supplied by

contractor) of approx. 0.5 m3 capacity. This trolley will be housed in a roofed enclosure with proper access, grit washing arrangement and drain.

5. A grit scraping mechanism,
6. Adjustable influent deflector,
7. Reciprocating rake mechanism to remove the grit,
8. Two-mechanism support beams with railing & chequered plates over half the diameter of the chamber.
9. Organic matter return pump

Aluminium gates shall be provided at the entrance and at the outlet of the grit chamber. To enable easy operation of the gates, RCC platforms with SS railing shall be provided at the upper level. Also access is provided from this level to the mechanism support beam of the grit chamber. The entire construction shall be in M 30 grade concrete and as per IS 3370. RCC staircase shall be provided for access from the ground level to the top of the unit & to the operating platforms.

Mechanical unit

Design peak Flow	:	As per table above
No of working units	:	As per Design requirement
Type	:	Classifier
Size of grit particle	:	0.15 mm
Specific gravity of grit	:	2.65
Surface Overflow Rate	:	960 m3/m2/day
Free Board	:	0.3 m
Side Water Depth	:	0.80 m (minimum)
Wheeled trolleys	:	Min. 2 nos

Manual unit

Design peak Flow	:	As per Design basis Table
No of units	:	1 No
Size of grit particle	:	0.15 mm
Specific gravity of grit	:	2.65
Surface Overflow Rate	:	960 m3/m2/day
Free Board	:	0.30 m

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.5. Flow Measuring Unit

Number of Units	:	1 at downstream side of Degritting Tank and 1 at final outlet channel after chlorine contact tank
Type	:	Ultrasonic mounted on concrete channel having digital type Indicator, Integrator and Recorder fixed in the control room.

3.7.6. Division Box

The Division Box will receive the flow from the grit chamber. The flow will then be split into two equal parts with adjustable aluminium overflow weir plates and distributed to two primary clarifiers via pipe. Aluminium gates including all specials shall be provided on all two weirs for isolation. RCC access platform, staircase, railing and covers over division boxes

are provided as per requirement.

3.7.7. Primary Clarifier

Primary Clarifier will receive flow from grit chamber. There shall be two primary clarifiers. It is to be provided for settlement of suspended solids present in sewage. The inlet shall be from bottom central feed. The clarifier mechanism is provided in the primary clarifier tank to scrap the settled solids from the bottom of the tank such that the sludge moves to center sludge pocket.

The Primary Clarifier shall be circular radial flow type having suitable size and depth. The tank shall be constructed in 30 grade concrete and as per IS 3370. Each tank shall have central stilling box, Skimmer, Trough, Scum baffle, weir plate and sludge scraping mechanism spanning the diameter of the tank. Central stilling well shall be of FRP of 6 mm thick plate. RCC staircase 1200 mm wide shall be provided for access from the ground level to the top of the unit & to the operating platforms with SS railing.

Scum from primary clarifier shall be taken to the sludge digester. In case of pumps, working and standby arrangement shall be provided. The squeezes shall be of neoprene rubber. The V-notch weir for the Primary Clarifier Tank shall be of FRP and fixed to the RCC launder with adjustable fixtures for adjusting the level of the weir to have uniform flow throughout the periphery. The minimum thickness of the FRP plate shall be 6 mm and 300 mm wide. The inlet pipe and outlet launder shall be designed for peak flow.

All fasteners below the water level will be of SS 316 and the steel structure will be epoxy painted after sand/ball blasting to near white and after applying zinc rich primer.

The flow shall be received from the grit chamber by means of pipe of suitable dia. The pipe under raft of the clarifier shall be encased with CC 1:2:4 grade concrete. The central stilling box shall extend 100 mm above the maximum sewage level and will be designed to prevent short-circuiting.

Total Average Flow	:	As per Design basis table
Number of Units	:	2
Type	:	Central Feed, Centrally Driven, fixed bridge
Sludge Collection	:	Full Diameter Mechanical Sludge
Scraper		
Overflow Rate, m3/m2/day	:	35 (maximum for average flow)
Free Board, m	:	0.5
Side Water Depth,	:	3 m (minimum)
MOC of sludge scrapper mechanism	:	Generally MS with epoxy paint

Sludge from primary clarifier shall be withdrawn through pipe of suitable dia. telescopic arrangement and will be taken to RCC sump having desired capacity. The sump shall also have 2 (1W + 1S) submersible pumps of required capacity to transfer the sludge to sludge thickener.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.8. Aeration Tank with Diffusers & Air Blowers

There shall be two Aeration Tanks. Each aeration tank will receive flow from each primary

clarifier via pipe. Provision shall be made to receive active return sludge from return sludge pumps. Inlet and outlet launders / pipes shall be designed for peak flow.

Aeration tanks will be constructed in M 30 grade concrete and as per IS 3370. Tank shall have inlet launder, outlet launder. Isolating gates in inlet and outlet launders of each tank shall be provided for maintenance purpose. RCC staircase 1200 mm wide is provided to each aeration tank for access from the ground level to the operating platforms. All platforms and walkways shall be provided with SS hand railings as per tender specifications.

The outlet pipe of suitable diameter and length shall be provided from aeration tank to the secondary clarifier. The carrying capacity of this pipe shall be suitable for peak flow plus return sludge flow.

Each tank shall be equipped with air diffusers. Air shall be supplied through air blowers. Diffusers and air blowers shall be as per technical specifications. Air blower room shall be provided to house the air blowers.

Total Average flow	:	As per Design basis table
Type of aeration	:	Diffused aeration
F/M ratio	:	0.3
MLSS	:	2800 mg/l
MLVSS / MLSS	:	0.8
Kg O2 / kg BOD removed	:	1.2
Min free board	:	0.5 m
Max depth of aeration tank	:	6 m (liquid depth)

Diffusers

The aeration system shall comprise of fine bubbled diffused aeration and shall be of retrievable configuration for individual diffusers. The aeration system shall be capable of delivering the required air to the aeration tank.

Diffusers shall be submerged fine bubble / fine pore, high transfer efficiency, low energy consumption, low maintenance, non-buoyant type. Diffusers shall be disk / dome / tubular (membrane) type. Material of construction for diffusers and the entire under water system including accessories shall be of non corrosive material. Complete diffuser as a unit shall be assembled at the manufacturing factory level. Diffuser system shall be designed considering following minimum conditions.

Each meter of diffuser membrane shall have a minimum effective aeration area of 0.16 square meters. The diffuser design gassing rate shall not exceed 0.35 m3/min per diffuser assembly. The head loss through an individual diffuser shall not exceed 500 mm @ 0.17 m3/min. Upon the loss of air pressure the perforations shall close and the membrane shall seat tightly over the air supply working as a check valve. The entire assembly shall be located such that each diffuser centreline is 300 mm above the basin floor.

Each diffuser assembly shall include a manually operated isolation butterfly valve, flexible pipe for connection to the main air distribution piping.

Elevation of the plant above MSL	=	As per Design basis table
α factor	=	not greater than 0.65
β factor	=	not greater than 0.98
Min. temp of water	=	10 0C
Max. temp of water	=	32 0C
Bubble size	=	not greater than 0.8 mm
Average concentration of DO in the		
Aeration tank	=	not less than 2.0 mg/lit

Oxygen required under actual condition

For the entire plant (in both the aeration tanks together) = 550 kg/hr

Correction factor to calculate S.O.R. = not greater than 0.54

(Actual value will be supported by calculations)

In case of membrane type diffusers, the diffusers shall be tubular with diffuser OD not exceeding 90 mm. The inner support tube shall be in single piece with proper provision to hold the membrane in place. Membrane material shall be made of silicon base rubber.

The access / maintenance facilities required for diffusers (depending on system offered) shall be included in the bidders quoted price.

Installation of diffusers and air piping during execution shall be done based on detailed calculations to be furnished by the contractor and approved by AMC. Diffuser layout shall be vetted stamped and approved by the manufacturer.

Air Blower:

The blowers for air diffuser system shall be positive displacement (roots) type. The head for blowers shall be decided considering the losses between the governing point of delivery (diffusers) and the blowers. The number of standby blower shall be minimum 50% (fifty percent) of the number of working blowers. Blowers shall be complete with motor and accessories like base frame, anti vibratory pad, silencer, non return valve, air filter etc as per requirements. Vibration due to operation of blowers shall be minimum to avoid damage to structures. Further, blowers shall have acoustic enclosures to ensure that the noise level at 3 m from blowers is below 50 db level. The blower room shall have sufficient ventilation, lighting and working space. The room will be equipped with sufficient capacity EOT (Min 2 T) to facilitate removal of blower/motor etc. for repairs. The room will also have rolling shutter.

The blower and air diffuser system shall include PLC based control for diffuser operation. The operation and speed of blowers shall be automatically adjusted using controlled parameter (dissolved oxygen) and manipulated parameters like Total organic carbon (ToC) and/or flow and/or Timer such that the DO is supplied as per demand and power utilisation for operation of blowers is optimised.

All instrumentation system required to give output signal to VFD via PLC shall be included by bidders in their quoted price. Similarly expenses involved in carrying various analysis and tests to stabilise and demonstrate the power saving system shall be included by bidders in their quoted price.

Bidders shall furnish guaranteed power saving with the above system considering average flow of STP and average raw sewage BOD.

Bidders shall furnish detailed write-up for the energy saving system described above along with their bids for evaluation by AMC.

Air Piping:

The main air header/ring main shall be as per process design and as per relevant IS painted both outside and inside with corrosion resistant paint as per manufacture's recommendations. The header / ring main shall be supported on saddles at suitable intervals or will be protected against external corrosion in case they are laid below ground. The header shall have valves at all such locations, where regulating the airflow becomes necessary to ensure uniform supply of air to all the diffusers. The header shall supply air to diffuser grids at various locations through air supply pipes with isolation valve. There shall be isolation valve for each diffuser assembly. Air supply pipe below water level shall be in PVC as per relevant I.S. standards. Junction between air header and air supply pipe shall be suitably protected against corrosion due to dissimilar materials.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.9. Secondary Clarifier

The Secondary Clarifier tank is to be provided for settlement of sludge from the Aeration tank. There shall be two secondary clarifier tanks. Each secondary clarifier will receive flow from each aeration tank. The inlet shall be from bottom central feed. The clarifier mechanism is provided in the secondary clarifier tanks to scrap the settled solids from the bottom of the tank such that the sludge moves to center sludge pocket.

These shall be circular radial flow types having suitable size and depth. The tank shall be constructed in M 30 grade concrete and as per IS 3370. Each tank shall have weir plate and sludge scraping mechanism.

The clarifiers shall have a sloping bottom with central hopper. The flow shall be received from the Aeration tank by means of pipe encased with CC 1:2:4 concrete laid under the floor of the tank upto the central pier of the clarifier to a stilling box. The central stilling box (MOC shall be of shall extend 100 mm above the maximum sewage level and will be designed to prevent short-circuiting. Central stilling box shall be of FRP 6 mm thick.

The squeezes shall be of neoprene rubber. The V-notch weir for the Secondary Clarifier Tank shall be of FRP and fixed to the RCC launder with adjustable fixtures for adjusting the level of the weir to have uniform flow throughout the periphery. The minimum thickness of the FRP plate shall be 6 mm and 300 mm wide. The inlet pipe and outlet launder shall be designed for peak flow.

All fasteners below the water level will be of SS 316 and the steel structure will be epoxy painted after sand/ball blasting to near white and after applying zinc rich primer.

RCC staircase 1200 mm wide shall be provided for access from the ground level to the top of the unit & to the operating platforms and peripheral walkway with SS railing.

Total Average Flow	:	As per Design basis table
Type	:	Central Feed, Centrally Driven, fixed bridge
Sludge collection	:	Full Diameter Mechanical Sludge
Scraper		
Overflow Rate, m3/m2/day	:	15 (minimum for average flow)
Weir loading for each clarifier	:	Max 185 m3/m/day
Free Board, m	:	0.5
Side Water Depth,	:	3.5 m (minimum)
MOC of sludge scrapper mechanism	:	Generally MS with epoxy paint

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.10. Return Sludge Pump House

Return sludge sump shall be provided to collect the sludge settled at the bottom of the secondary clarifiers. There shall be one common sludge sump for both the secondary clarifiers. There shall be knife gate valves valve with chamber and cover arrangement to sludge pipe of each clarifier. Diameter of valve shall be same as that of sludge pipe.

Sludge from the sump shall be pumped to the inlet of aeration tank by means of common rising main. There shall be division chamber before aeration tank to divide activated sludge in two equal parts with adjustable aluminum overflow weir plates and distributed to two aeration tanks. Aluminium gates including all specials shall be provided on two weirs for isolation. RCC access platform, staircase, railing and covers over division boxes are provided as per requirement.

From common rising main there shall be provision of taking excess sludge to sludge thickener by providing T junction. Minimum dia. of excess sludge pipe shall be 150 mm.

Sludge tank shall be constructed in M 30 grade concrete and as per IS 3370. Above sludge sump there shall be pump house. This shall be RCC framed and brick masonry structure. Minimum clear height of the pump house shall be 4.5 m from the plinth level. It shall be provided with rolling shutter and doors and windows as per technical specifications. EOT of suitable capacity shall be provided in the pump house to lift the pump assembly.

Flooring of the pump house shall be IPS flooring. Pump house shall be plastered from inside and from outside as per tender specifications. Entire pump house from inside and from outside shall be painted with approved colour and make as directed by engineer-in-charge. Sludge sump shall be painted inside with bituminous paint.

Return sludge pumps

Type : Submersible

Head : Minimum 10 m

Drive : Electric motor of suitable HP

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.11. Sludge Thickener

Sludge thickener shall be provided for thickening of primary and secondary sludge. The tank shall have oil skimmer, trough, scum baffle, weir plate and sludge scrapping mechanism. There shall be provision of taking primary and secondary sludge either in one thickener or in both thickeners by suitable piping and valve arrangement.

Scum from thickener shall be taken to the sludge digester. In case of pumps, working and stand arrangement shall be provided. The scrapper shall have neoprene squeezes. The tank shall be provided with telescopic sludge withdrawal arrangement. The thickener shall have central drive with TEFC motor and reduction gear. The service factor for the gear will not be less than 2.5

The tank shall be constructed in M 30 grade concrete and as per IS 3370. MW ladder is provided for access to the top of the unit and to the operating platform.

No. of unit : 2

Solid surface loading	:	30 kg/day/m2
MOC of sludge scrapper	:	Generally MS with epoxy paint

Mechanism

Sludge thickener shall have provision of addition of dilution water from secondary clarifier outlet to meet hydraulic loading specified in CPHEEO manual. Pumps if required for this purpose shall be minimum 1W + 1S of suitable capacity.

Pumps min 1W + 1S of required capacity (minimum capacity of these pumps shall be 50 m3/hr), if required, shall be provided to transfer thickened sludge to sludge digester.

Supernatant from both thickeners shall be taken to aeration tank either by gravity or by pumping.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.12. Sludge Digester

Anaerobic sludge digester shall be provided to digest sludge from sludge thickener. There shall be two sludge digesters. Digester tank shall be constructed in M 30 grade concrete and as per IS 3370. RCC staircase of 1200 mm wide is provided for access to the top of the unit and to the operating platform. The digester shall be covered at top with RCC dome.

Digester shall be equipped with gas mixing system for effective mixing. Sampling ports at suitable points shall be provided in the digester. Minimum solid retention time shall be 20 days.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.13. Gas Mixing System

The gas re-circulation system shall provide complete and homogenous mixing of the digester contents including intermixing of the raw and digesting solids and breaking of scum blanket. For maximum intensity of mixing the full discharge of compressed gas shall have upward action minimizing the scum formation.

Gas will be taken from the gasholder and conveyed by pipes to the gas compressors, from where it will be fed to the digester. The pipe shall enter from top of digester dome such as to mix the entire digester contents with practically no dead zones and to prevent sand build-up on the floor. Gas flow indicator (sight glasses) to indicate flow of compressed gas through each pipe and facility to clean individual pipe by water pressure or flexible rods in case of chock up, without interrupting digester operation, shall also be provided. All connected piping with necessary fittings and support and safety/protective devices shall be provided.

All electrical motors, local control units and associated instrumentation, etc. mounted in the digester area shall be certified for use in a zone 1 hazardous area and have an flame proof enclosure.

Gas mixing system shall be complete along with necessary accessories such as gas meter for each digester, drip traps at suction and discharge pipes, electric controls, spare parts and lowering / hoisting arrangement required in the digesters.

Dial / manometer type pressure gauge on the suction line indicating pressure to the extent of + 300mm water column shall be provided. Dial type pressure gauge shall also be provided on delivery line.

Protective devices such as gas pressure relief valve cum vacuum breaker assembly and flame trap shall be provided. The gas pressure relief valve (water seal type) shall be

required to function between 200mm to 250mm water pressure.

3.7.14. Gas Holder

The gas produced in the Anaerobic Digester is to be led to the Gasholder through a moisture trap and gas flow meter. The tap-offs are provided after the gas pipe enters the Gasholder, one going to the generator room for supply to gas engines and the other to the gas flaring equipment.

The biogas holder will be of the wet type with a sealing of water. The biogas holder would be a RCC circular structure. The gas dome would be fabricated from mild steel plate having minimum 6 mm thickness. Guide rails embedded in RCC structure facilitate the vertical movement of the gas dome. The gas dome surface shall be coated with 350-micron thickness three coats of Epoxy coating.

One pressure release valve will be provided at the top of the dome, which will open out when the level reaches 100% value. One High-Level limit switch will be provided at 95% to give an audible alarm signal in the control room.

At low-level, say 20%, the running engines will be shut off and the biogas holder will be allowed to rise again. However, in case of heavy leakage, or otherwise, if the level goes to a very low level of say 5%, the Vacuum Breaking Glass will break and will prevent the biogas holder from any damages due to vacuum condition. The dome of clean gas holder shall have provision for placing weights to ensure desired required sewage gas pressure for 100% sewage based gas engine.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.15. Chlorine Contact Tank

For chlorination or disinfection of final treated sewage a provision shall be made so that no harm is caused to the receiving water such as river. Overflow from each secondary clarifier shall be collected in common chamber from where it shall be taken to chlorine contact tank by RCC channel. In the proposed CCT treated sewage from existing treatment plant is also taken. Necessary piping arrangement is to be done.

A Chlorine Contact Tank shall be provided for dosing of chlorine from the chlorination system to the sewage from secondary clarifier. The tank shall be constructed in M 25 grade concrete and as per IS 3370. RCC platform 1200 mm wide with railing as per specifications shall be provided. RCC staircase 1200 mm wide shall be provided for access from the ground level to the top of the unit and to the operating platforms.

Baffle walls shall be provided to achieve proper disinfection. The baffle walls shall be constructed in RCC with required thickness. The inlet and outlet pipes shall be designed for peak flow.

Design Flow	:	As per Design basis table
Number of Units	:	1 no.
Detention time (minimum)	:	30 minutes for average flow
Freeboard	:	0.5 m

3.7.16. Chlorination System

Average flow	:	As per Design basis table
Peak flow	:	As per Design basis table
Number of Units	:	2 (1W + 1S)
Type	:	Vacuum

Chlorine Dosing	:	Max 5 mg/l
Residual chlorine	:	0.5 mg/l

Chlorination system covering chlorine cylinder, chlorinator, and water feed pumps, piping and
other ancillary shall be provided in the chlorine house. Chlorine house arrangement and EOT of min 2 T capacity etc complete. Of minimum 80-sqm plinth area shall be provided. It shall have sufficient ventilation as per latest norms for safety purpose with necessary lifting.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.17. Sludge Dewatering System

Sludge dewatering system shall comprise of centrifuge house which includes digested sludge sump, mixer, centrifuge feed pumps, poly dosing tank with mixers and centrifuge unit.

Filtrate from the sludge shall be taken to aeration tank either by gravity or by pumping.

3.7.17.1. Digested Sludge Sump and Mixer

Digested sludge from sludge digester is collected in the digested sludge sump. The entire civil construction shall be in M 30 grade concrete.

Slow speed mixer (100 RPM) shall be provided to ensure proper blending of polyelectrolyte into the sludge and to keep the sludge in suspension. The material of construction of the mixer shall be SS 316.

3.7.17.2. Polyelectrolyte Dosing

The polyelectrolyte will be dosed and blended with the sludge in the Filter Press sump. Minimum does of polyelectrolyte shall be 2.5 kg/T of dry solids in sludge. There shall be two poly-dosing tanks. Min volume of each dosing tank shall be 9 m3. Each tank shall be equipped with slow speed mixer (100 RPM) to prepare polyelectrolyte solution. To feed the solution into sludge sump by dosing pumps.

3.7.17.3. Centrifuge Feed Pump

The sludge pumps will be positive progressive cavity displacement types. There shall be two pumps (One Working + One Standby) for pumping this sludge to the Centrifuge. The minimum capacity of the pump shall be 7 m3/hr. Pumps will have solid handling capacity of not less than 40 mm sphere.

Pump and motor will be mounted on a common GI fabricated base frame. The coupling will be flexible coupling. The motor will be TEFC and driven through belt drive.

3.7.17.4. Centrifuge

Digested sludge shall be pumped to the centrifuge unit for dewatering. Centrifuge shall be fully automatic. It shall be provided at suitable elevation for the dried sludge from centrifuge to be collected in a trailer/container situated below it.

Centrifuge shall be operated for 16 hours in a day and floor mounted. It shall be suitable to handle combined digested sludge from digester. The centrifuge unit shall be suitable to take sludge of 6% concentration.

The material of construction of all parts coming in contact with the liquid shall be in SS 316.

Number of Units	:	2 (1W + 1S)
Operation	:	16 hours running per day

Dry solids in dried sludge	:	20 - 25 percent
Capacity of the each centrifuge unit	:	Minimum 7 m3/hr

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

3.7.18. Outlet Channel through Closed Conduit

Treated sewage after chlorine contact tank shall be taken to the river through RCC Pipe/channel. Parshal flume along with ultrasonic flow meter shall be provided after chlorine contact tank in the RCC channel to measure the flow. The length of the channel shall be as per approved layout. Capacity of the channel should be such that it can carry peak flow.

The hydraulic design of the entire treatment plant shall be such that the invert level of the outlet channel/pipe at final discharge point (at river or Nallah) shall be 0.3 m above the HFL.

3.7.19. Interconnecting Piping and Valves

All interconnecting piping including valves, specials and other appurtenances, auxiliaries and accessories required as per process design and scope of work. All the piping, valves, specials shall be designed for peak flow. All valves shall be Knife gate valves.

In case of pumping mains thrust blocks shall be provided whenever required. In case of buried pipes warning tapes shall be provided of the appropriate colours.

All interconnecting piping unless otherwise stated shall be DI K-9. Minimum diameter of the any pipe shall be 150 mm.

3.7.20. Electrical Works

The Employer will make available power supply from their local transformer to the proposed STP's main electrical panel room. The entire plant will be operated on 415 V, 3-Phase, 50 c/s, 4-wire system. The electrical system proposed for the STP shall include the following components;

1. 415V Switchgear,
2. Motor Starters,
3. Safety Earthing,
4. Cables and Cabling System,
5. Internal Lighting, and
6. Plot and area Lighting.

The scope also includes lighting and earthing. The Sub Contractor shall work out the details based on his equipment's power consumption. The execution should take care of I.E. rules, Electricity Board's requirement and other local authorities and site condition.

The sub-panels are to be provided and located near the respective load centres. All motors and panels for operation of various are to be supplied as part of the equipment, the same have not been considered as part of scope of work for electrical work. However, these should meet the requirements as specified under electrical works. The major items of work for the electrical works will be as under:

1. L. T. Panels generally will be as following:
2. Main Electrical Panel (MEP)
3. Power distribution panel (PDB)
4. L.T. Power and control cabling with cable accessories
5. Local Push Button Stations

6. Lighting for all buildings, panel room and workshop
7. Earthing
8. Instrumentation including Instrument-cum-Annunciation panel

3.7.21. Operation and Maintenance

The proposed treatment plant shall be operated and maintained by the contractor for a period of 120 months as per the scope of work mentioned in the tender document.

3.7.22. Plant Utilities

Fire Extinguishers

The portable fire extinguishers with ISI mark of approved make shall be provided at the MEP room, chlorine house and centrifuge house.

Each building shall be provided with following portable fire extinguishers

- Dry chemical powder type fire extinguishers of 3.2 kg capacity - 6 cylinders
- Buckets filled with dry clean sand - 6 Nos

All buildings shall be provided with manual fire alarm system connected with main control panel. The alarm system shall be with pillboxes and hooters. The layout of the fire alarm system shall be in accordance with the relevant ISI.

3.8. DETAILED SCOPE OF WORK FOR SEQUENTIAL BATCH REACTOR

The project shall have following major units

1Inlet Chamber

2. Mechanical and Manual Fine Screen Channels and Screens
3. Mechanical and Manual Grit removal facility
4. Sequential Batch Reactors with air diffusers and air blowers
5. Chlorine Contact Tank
8. Chlorine House
9. Sludge thickener with thickened sludge sump and pumps
10. Sludge dewatering system
14. Transformer yard and MEP room
15. Interconnecting Piping
16. Flow measurement units
17. Plant Utilities
18. Required site development including levelling and grading to improve the aesthetics and to facilitate the vehicular movement.

The sizes specified in the tender document are the minimum requirement and are for guidance purpose only. However this does not absolve the contractor from his responsibility of giving satisfactory plant performance and meeting desired discharge standards as specified in tender document.

For scope of work for Inlet chamber, manual and mechanical screens, mechanical and

manual grit removal system refer the clause Nos. 3.7.2, 3.7.3 and 3.7.4

3.8.1. Sequential Batch Reactor

There shall be multiple independent streams. Each stream should be capable of handling average flow and peak flow as per design basis table.

From grit chambers sewage shall be taken to the SBR unit by gravity. Outlet of SBR unit shall be taken to the chlorine contract tank by gravity.

Biological treatment for removal of carbonaceous BOD shall be provided by Sequential Batch Reactor System (SBR). The SBR system shall be designed in such a way that it shall have continuous raw sewage inflow and outflow. The system shall be designed to take care of peak flow and shall have following features.

- Complete Mix Kinetics
- DO Control in proportion to organic loading within the current operating cycle.
- Quiescent settling for optimizing the clarification process.

The system shall provide for:-

1. Equipment for mixing and aeration, wherever required, to enable separate time phases
2. Withdrawal of treated sewage at suitable velocity to prevent short circuiting.
3. Efficient scum withdrawal system.
4. Dynamic control of Air Blower operation to achieve a minimum preset DO of 2 mg/l within the SBR system.

Design criteria for SBR

Maximum F/M ratio - 0.1
Minimum HRT - 17 Hrs.
Minimum SRT - 20 days.

SBR process basins will be constructed in M30 concrete and as per IS 3370. RCC staircase is provided to the basin for access from the ground level to the operating platforms. Walkways / platforms with chequered tiles shall be provided as per requirement during detail engineering with SS railing. All platforms and walkways shall be provided hand railings. 1.2m plinth protection along periphery shall be provided. Entire structure from inside and from outside shall be painted with approved colour and make as directed by engineer-in-charge.

Decanter

The Decanter shall be Mechanical, Moving, Trough type. The wetted Decanter components shall be in SS 304. All piping shall be in SS 304 / FRP. Any other components shall be in SS 304.

Bidders shall provide evidence of having supplied, installed, commissioned and operated similar type of Decanter in a plant of the size required for qualification Bidders shall provide cross sectional drawing to clearly establish the above requirement.

The SBR System shall have the following Controls:

The control system shall be designed to optimize the SBR process while minimizing operator attention and to accommodate the continuous maximum daily flow without adjusting cycle structures. The control software program shall be factory tested prior to installation at the jobsite.

The control system shall be a timer based system with level overrides and shall provide control, sequence, monitoring, and alarm annunciation capabilities. The operator shall be able to access the timer values and set points through the operator interface panel to allow for

adjustment of cycle times and system flexibility. The control system shall be designed to automatically accommodate the plant's full range of loads and flows.

A complete control system (consisting of two identical panels) shall be provided as described in the following and as shown on the contract drawings. The control system shall include 220 Volt control circuit breaker, microprocessor control, operator interface display, indicator lights, and HAND-OFF-AUTOMATIC selector switches.

PLC based control system

REMOTE ACCESS MODEM

Shall provide with facility of remote monitoring, control and diagnosis of plant

OPERATOR INTERFACE DISPLAY

Shall provide with facility of Local monitoring, control and process parameter adjustments

SOFTWARE

The PLC function shall be to control, sequence, and monitor the continuous flow and constant level SBR system.

PHASE CONTROL, the regulation of the process cycles of the continuous flow and constant level SBR system up to the maximum daily flow of the plant.

AERATION CONTROL, the regulation of the aeration and mixing systems to achieve optimum process control.

COMPONENT MONITORING the monitoring of components for fault conditions and the orderly alarming and logging of the fault.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

Diffusers, air blowers and air piping shall be provided as per clause No. 3.7.8.

Outlet of SBR unit shall be taken to the chlorine contact tanks by gravity. Chlorination contact tank and chlorination unit shall be provided as per clause No. 3.7.15 and 3.7.16.

Excess sludge from SBR unit shall be taken to the sludge thickener and mechanical sludge dewatering unit. The sludge thickener and sludge dewatering unit shall be provided as per clause No. 3.2.17 respectively.

Scope of work for outlet channel, electrical works, O & M and plant utilities shall be as per clause No. 3.7.18, 3.7.19, 3.7.20, 3.7.21 and 3.7.22.

3.9. DETAILED SCOPE OF WORK FOR MOVING BED BIO REACTOR (MBBR) TREATMENT

The project shall have following major units

1Inlet Chamber

2. Mechanical and Manual Fine Screen Channels and Screens
3. Mechanical and Manual Grit removal facility
4. Clari-Tube Floculator
7. Chlorine Contact Tank
8. Chlorine House
9. Sludge thickener with thickened sludge sump and pumps
13. Sludge dewatering system

14. Transformer yard and MEP room

15. Interconnecting Piping

16. Flow measurement units

17. Plant Utilities

18. Required site development including levelling and grading to improve the Aesthetics and to facilitate the vehicular movement.

For scope of work for Inlet chamber, manual and mechanical screens, mechanical and manual grit removal system refer the clause Nos. 3.7.2, 3.7.3 and 3.7.4

3.9.1. Moving Bed Bio Reactor

The bioreactor shall be designed to treat the sewage with aerobic attached growth moving bed process.

There shall be minimum two nos. reactors constructed in series of suitable size to take the organic & solid load in the raw sewage & to deliver consistently the outlet sewage quality as per treated waste water quality mentioned. There shall be a 1.2 m wide platform with pipe railing & a RCC Stair of 1.2m width.

Each reactor shall have minimum 150 mm diameter DI / CI pipe with ISI marked Gate valve in a separate valve pit having provision for extended rod with wheel for draining, rungs in all valves chambers & reactors, for maintenance & shall be connected to sludge sump for drainage of reactors by gravity.

The media shall be of polypropylene polyethylene with 0.94 to 0.98 gm/cm³ specific gravity, non degradable. The media quantity shall be adequate to provide sufficient surface area for maintaining the microbial strength as required achieving the quality.

The surface area of media to be used for designing purpose shall not be less than 500M² / M³.

The oxygen requirement for BOD5 removal shall not be less than 1.2 Kg O2 / kgs of BOD5 removed. The air quality required shall be sufficient for maintaining minimum 2 PPM necessary dissolved oxygen at 30° C liquid temperatures at all times & mixing conditions at 10000 MLSS whichever is more. The blowers for air diffuser system shall be positive displacement (roots) type.

The diffusers used shall be suitable for coarse bubble air diffusion & for design Purpose O2 transfer efficiency shall be considered not more than 17%. The air agitation or diffusion is to be applied continuously to circulate the media & keep in suspension.

The piping for distribution of air in reactor shall be of MSEP material & diffusers of SS 304. The entire wetted portion shall be of SS material.

Provision to maintain bio film carriers in reactor by providing screens suitably designed at peak flow with suitable clear spacing between two flat bars each of suitable thickness at each tank inlet / outlet.

This shall include supply, erection, testing and commissioning of all mechanical equipment/systems associated with MBBR such as Air Diffusion system , Carrier Media , Inlet Screens , Media Retaining Screens, drain valves.

Moving Bed Bio Reactors : 1 streams with minimum 2 in series in each stream.

Clari –Tube Flocculator

The Clari Tube Flocculator with flocculators & tubes settler shall be provided .There shall be one

Clari Tube Flocculator and designed at 10 - 15 M³ / M² / Day surface Loading for clarification (Tube Settler)zone at average flow rate with the Flocculation retention time not less than 20minutes at average flow rate. Clari Tube Flocculatorshall be provided with inlet DI / CI pipe / RCC duct or RCC pipe of suitable size with central column. The Clari Tube Flocculator shall be with peripheral driven centrally supported MSEP Bridge with suspended scrappers shall be provided having minimum 1.2 m wide walkway with 6 mm thick chequered plate / grating. The Clari Tube Flocculator shall have minimum 4no. of Flocculators.The Clari Tube Flocculator shall have Radial launders of for allowing 185 M³ / M / Day maximum weir loading for collection of clarified water. The tube media shall be square type of 50mm x 50mm size. The material of tube media shall be PVC.

The sludge hopper will be designed to collect the sludge & allow moving towards drain pit with mechanical scrappers. The solids separated shall be drained out with established frequency for further disposal. Preferable sludge so produced should be totally digested.

There shall be minimum 200 mm diameter CI Motorised Butterfly valve with for intermittent withdrawal of sludge from the clarifier. The valve shall be provided with manual over-ride facility.

The Valve shall be installed in a separate pit with rungs.

This includes supply, erection, testing and commissioning of Clari Tube Flocculatormechanism with or without tube settler suitable for installation in the RCC tank proposed by the bidder to meet the requirements specified in the scope of civil works.

Clari Tube Flocculator : 1 Nos.

(Peripheral driven moving bridge type)

Diffusers, air blowers and air piping shall be provided as per clause No. 3.7.8.

Outlet of MBBR unit shall be taken to the chlorine contact tanks by gravity. Chlorination contact tank and chlorination unit shall be provided as per clause No. 3.7.15 and 3.7.16.

Excess sludge from MBBR unit shall be taken to the sludge thickener and mechanical sludge dewatering unit. The sludge thickener and sludge dewatering unit shall be provided as per clause No. 3.7.17.

Scope of work for outlet channel, electrical works, O & M and plant utilities shall be as per clause No. 3.7.18, 3.7.19, 3.7.20, 3.7.21 and 3.7.22.

3.10. Miscellaneous Works common for all STP's

3.10.1. Storm Water Drainage

Storm water drains adjacent to the proposed approach road shall be sized for a rainfall intensity of 50 mm/hr, allowing for 100% runoff. Drains adjacent to roads/pathways shall be in RCC in situ type. The Drains shall be covered with CI/RCC gratings.

The storm water drainage system shall be designed and connected to cater for the run-off from the plot and structures, and discharged into the city drainage network nearby storm drain or nallah.

3.10.2. Pathways

Paved pedestrian (Pathways) access ways shall be constructed to provide a network of logical routes inter-linking entire plant areas and road network. Minimum width of pathways shall be 2 m. Pathways shall be in coloured and glossy interlocking blocks. Damage to any existing roads, on account of their use by the Contractor shall be made good to the satisfaction of the PMC.

Hardstanding areas in coloured and glossy interlocking blocks 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.

The work of approach road and storm water drainage shall be carried out as per approved layout during execution of the contract.

3.10.3. Road Works

The roads width constructed in STP shall have min width of 6.0 m. Roads to be constructed by one layers of soling 230 mm thick ,one layer of 80 mm trap metal of 200 mm thick, one layer of 40 mm trap metal of 200 mm thick including supplying and spreading of stone dust, watering compaction and 75 mm thick bituminous bound macadam with cold emulsion and bituminous macadam of 50 mm thick with bitumen of S-65 grade and 25 mm thick asphalt concrete with S-35 grade of bitumen including compaction by vibratory roller of all layers and providing and applying tack coat of 50 Kg / 100 m2 on black top surface and bitumen contained of 250 Kg / 100 m2 for B.B.M. surface and disposal of surplus clay / soil and side of the road fixed with kerbstone etc., complete. Pipeline trenches of various diameter of pipes etc., complete

3.10.4. Fire Extinguishers

The portable fire extinguishers with ISI mark of approved make shall be provided at the MEP room.

Each building shall be provided with following portable fire extinguishers

Dry chemical powder type fire extinguishers of 3.2 kg capacity - 6 cylinders

Buckets filled with dry clean sand – 6 Nos

All buildings shall be provided with manual fire alarm system connected with main control panel. The alarm system shall be with pillboxes and hooters. The layout of the fire alarm system shall be in accordance with the relevant ISI.

3.10.5. Landscaping

Landscaping involves beautification of Sewage Treatment Plant site by cultivating Lands, Plants and Trees of environmental value and suitably modifying the appearance of STP site. It shall add scenic value to the STP site and to obtain maximum visual impact. Contractor has to develop proper landscaping in the STP site.

3.10.6. Lawns:

Lawns should be drained with great care in order to keep it lush with green. The soil should be drained effectively and water should not be allowed to be collected in pools. The ground must be dug upto a depth of 30 - 45 cms to remove stones with weeds and the soil should be exposed to sunlight for proper sterilization. The grass for the lawn should be preferably Cynodon dactyl on or Bermuda grass. The lawn must be prepared by one of the approved methods like from seeds, by turfing, by turf - plastering or by dibbling roots. Lawns once formed should be subjected to regular rolling, moving, watering, and restoration of patches. In the absence of rain the lawn must be provided with every 5 days, heavily soaking the soil to a depth of at least 15 cms. To keep the lawn in perfect condition it should be seeded once a month with liquid manure by dissolving 45 gms of Ammonium sulphate or 20 gms of Urea in 5 litres of water. Bone meal at the rate of 100 kgs per 1000 sq.m is recommended in one year. Neem cake should also be applied once or twice a year at the rate of 200 kgs per 1000 sqm. Raking and scraping for thatch control must be carried out. Weed control measures should also be undertaken during the twelve months of defect liability period.

3.10.7. Flowerbeds:

Flowerbeds add a special charm to any place. They should be simple in design, either square, rectangular, circular or oval. The number and size of the flowerbeds are determined by its

extent with type. The tallest growing species should be planted at the back of borders or in beds on lawns far away from the structures. The medium sized plants should be planted in the central area of the garden and the dwarfish ones should be planted in front. There should be a harmonious blending of colours to create a pleasing appearance. Flowerbeds should be dug up to at least 15-20 days before sowing or bedding out small plants. For most annuals it would be enough as the soil is worked to a depth of 45 cms but for deep rooting plants such as Sweet Peas, Cannas, etc. the bed should be dug up to 60 cms. A basket of 10 kg of manure should be applied for about 2 sq. metres of flowerbed area. The bed should be leveled in such a way that it slopes slightly with uniformly from the centre to the edge. A clear space of 7 to 15 cms should be left unfilled by plants by the edge of the bed.

3.10.8. Shrubs:

Shrubs are plants, generally with woody stems, rather smaller than trees with bigger than most herbaceous plants. In a typical shrub, there are several woody stems arising from the same root. Shrubs are either deciduous or evergreen. A well-designed shrub border should consist of a suitable admixture of choice deciduous with evergreen shrubs. The preferred shrubs are Ixora, Thuja, Bougainvillaea, and Euphorbia leucocephala, Poinsettia, Mussaenda, etc. Shrubs should be planted by preparing cubic pits of 60 cms, pits about a metre each away should be fitted with good soil mixed with 2 to 4 baskets each of well decomposed manure. The ground should be well prepared in between by digging it about half metre deep with removing all weeks. They should be spaced at suitable distances so that when they mature and reach their maximum growth. They should not be allowed to grow straggly or form clumps by throwing suckers from the base. Manure should be applied to the shrubs at least once a year by providing plenty of compost materials.

3.10.9. Plantation:

Plantations are to be done all along the boundary wall just to provide a green barrier. Big trees should be planted 3m apart from each other within a range of 5m wide. Space adjustment should be done taking the site condition into consideration. Cubical pit of 60cm should be proposed and should be filled with good soil mixed with 2 go 4 baskets of 5 kg each of well decomposed manure. The ground should be well prepared in between by digging it about half metre deep with removing all stones and weeds. The trees should be planted at suitable distances so that when they mature and reach their maximum growth.

3.10.10. Administrative Building

The administration building shall be G + 1 structure. Each floor shall be of min 50 m2 and maximum 200 m2 of area. Entire first floor shall be for admin block. The admin block shall accommodate office, conference room, hall and washroom, Laboratory Room and Panel Room. The structure will be for the sole use of the Employers representative, his staff and consultants that shall be provided by the contractor at site. The decision regarding the area of the admin building shall be taken by the AMC. The contractor shall provide, erect, furnish, clean, maintain and subsequently hand over the office and associated furniture/items to the employer after the completion of the works. Contractor shall provide luster type painting to whole admin block. The proposed office building shall meet the following carpet requirements.

- Engineering room – 2 nos. 4 m x 5 m each with attached toilets
- Computer/SCADA/Panel room. (Total 5 tone capacity Air conditioned)
- Conference room – 1 no. x 6 m x 4 m. (Total 5 tone capacity Air conditioned)
- Record room – 1 no. 3 m x 3m
- Toilets with basins – 4 nos. 1.5 m x 2 m each
- Separate Toilet facility shall be provided for laborers comprising of the following: -
- WC – 2 Nos.
- Urinals – 4 Nos.
- Bathrooms – 2 Nos.

The walls shall be 230 thick brick masonry, plastered and painted with oil bound distemper on the inner face and snow white cement on the outer face.

Filling of conference room shall be provided with POP. Layout for interior decoration shall be as approved by Engineer-in-charge.

RCC slab roofing with roof height of 4.5 meters from the floor painted with all bound distemper shall be provided. The doors shall be of first quality wood and aluminium-sliding windows of approved quality shall be provided.

Before commencing the construction of the office, the contractor shall submit to the Employers Representative for his approval a drawing of the proposed building with all the architectural and finishing details fully shown. The location of the office building shall be finalized after taking approval of the Employer's representative. The Employer's representative's office should be ready in all respects within 90 days of handling over the site. The office shall be maintained throughout the contract period with office boy, power, water and housekeeping. Power and water supply shall be arranged by the contractor either with the available resources or from independent sources (DG sets. bore well, etc.)

The office building shall be provided with adequate forced ventilation and exhaust fans. Flooring for the office shall be of Ceramic tiles.

Adequate number of toilets and washbasins shall be provided separately for men & women. A covered service water tank shall be suitable provided to cater to the water requirements of the laboratory and office building.

Separate workshop & tool room of 5.0m x 5.0m shall be provided. It shall be provided with RCC walking platform, cabinets to store spares & accessories. Room should be also provided lockers.

Space for keeping plant records shall be provided in the administration building. Following furniture shall be provided in the office.

- One wooden conference table 3m x 1.5 m with twelve chairs
- Six nos. 1.5m x 0.9m tables with both side drawers
- Four nos. 1.2 m x 0.75 m table with drawers on both sides
- 2 nos. 0.9 m x 0.6 m tables with single side three drawers
- Twelve nos. chairs
- Chairs for computers
- Four nos. steel cupboards (store well or any other approved make)
- Two nos. filing cabinet with 4 drawers
- Vertical blinds to all windows
- Water supply, plumbing electrical complete
- Telephone with STD facility

○ The fittings shall include:

- 4'-0' long tube lights in each room except in conference room and toilet (1no.per 3 sq.m. floor area)
- 6 rube lights 4'-0" long in conference room
- 2 Nos. of 48" ceiling fan in conference room
- All rooms with 4 plug point each
- Passage 4" long tube light at every 20" distance

One number sign board of suitable size shall be provided which includes name and capacity of treatment plant, name of employer etc as directed by engineer in charge. The whole building should have attractive cladding externally.

The Contractor can suggest any other alternate technology other than mentioned above satisfying the criteria provided the financial and effluent characteristics, space etc. are fulfilled.

3.10.11. Specifications of Laboratory

The Admin Building shall be provided with a laboratory in STP area for analyzing sewage samples. The minimum floor area for laboratory shall be 25 m2. The walls shall be 230 thick

brick masonry, plastered and painted with oil bound distemper on the inner face and snowcem on the outer face. The walls shall be painted with all bound distemper. The doors shall be of first quality wood and aluminium sliding windows of approved quality shall be provided.

The laboratory building shall be provided with adequate forced ventilation and exhaust fans.

Flooring for the laboratory shall be of Ceramic Tiles/ mosaic tiles .

3.10.12. Laboratory Equipment

The laboratory shall be equipped with instruments, equipment, chemicals and other infrastructure that is necessary to perform the routine analysis for the specified parameters (All electrical instruments must be supplied with suitable stabilizer).

Sr. No.	Item Description	Qty.
1	Analytical Balance	
	Electronic Analytical Balance Catalog No: BS224 Make: Sartorius Capacity: 220g Readability: 0.1gm Pan Size: 80mm	1
2	**Drying Oven Hot Air**	
	OVEN, LABORATORY 240V 50/60HZ Catalog No: 14289-02 Make: HACH, USA	1
3	**Hot Plates**	
	PERISTALTIC PUMP type SP 311/60 Catalog No: 10.0174 Make: VELP	1
4	BOD Incubator	
	BOD INCUBATOR-110 Liters Catalog No: OR 405 Make: ORLAB	1
	Specifications: Volume: 110 Liters Temp. Setting: 5 to 50 deg. C Temp Stability: +/- 2 Deg. C Power: 230 V, 50 Hz, and 2 Amps Refrigerant: R134 (CFC Free) External Dimensions 126cm X W 48cm X D 60 cm Heating Power: 150 W Cooling Power: 110 W Temperature Display: 3 digit LED display Temperature setting: Digital keypad Ambient Temperature: 0 to 50 deg C Temperature Control: Automatic Microprocessor based	
	Temperature Sensor: PT 100	

Sr. No.	Item Description	Qty.
5	Magnetic Stirrers	
	MAGNETIC STIRRER type MICROSTIRRER Catalog No: 10.0161 Make: Velp	1
6	**COD Apparatus**	
	DRB200 w/VDE 220V,WITH 15 WELLS Catalog No: LTV082.15.40001 **Make: HACH, USA** DRB200- Digital Reactor Block (Single Block: 15 wells for 16mm vials)	
	DRB200 Digital Reactor Block for multipurpose use for COD, TOC, TNT Total Nitrogen, Unicell (Metal Prep) for Sample digestion. Features: Ø Pre-programmers for all Hach standard digestion for COD, Unicell, TNT tests for digestion. Ø One touch operation for Hach tests. Ø Adjustable Temperature setting 37°C to 165°C in 1°C steps. Ø Adjustable Time settings 1 to 480minutes Ø Up to 3 user enter digestion/reaction storable applications Ø Digital countdown timer with automatic shut off and alarm signal Ø Separate locking and transparent protective lids	1
	Specifications: Temperature Range: 37° to 165°C with 1°C Pre-programmes: For Hach standard digestion Temperatures (100°C/105°C/150°C) User Programmes: up to 3 user enter digestion/reaction storable applications Capacity: Block: 15 wells for 16mm vials Accuracy: As per DIN, EN, ISO, EPA Methods Timer: 1 to 480minutes (8hours) Warm-up time: Less than 10minutes 150°C Power supply: Single-Block: 230V/450VA Compliance: CE, GS, cTUVus (includes UL)	
	COD Reagents	

Sr. No.	Item Description	Qty.
A	COD DIGESTION VIAL, LR HW PK/25 Catalog No: 21258-25 Make: HACH, USA	1
B	COD DIGESTION VIAL, HR HW PK/25 Catalog No: 21259-25 Make: HACH, USA	1
C	COD DIGESTION VIAL, HR+ PK/25 Catalog No: 24159-25 **Make: HACH, USA**	1
7	**Muffle Furnace**	
	FURNACE, MUFFLE 1093C 240V 50/60 Catalog No: 14296-24 **Make: HACH, USA** **Description:** Digital temperature control. Insulation made of high-purity alumina-silica with a low thermal mass. Means faster heat-up time and reduced electrical consumption. Embedded heating elements for structural strength and longer life. Perforated bench case design keeps bench top cool. Accurate percentage input control. Chamber dimensions (W x H x D), 10 x 10 x 11 cm (3.9 x 3.9 x 4.3"). Outer dimensions, 20 x 32 x 22 cm (7.9 x 12.6 x 8.7"). 1050 W. Maximum operating temperature: 1093°C. Thermally.	1
8	**Water Bath**	
	UTRASONIC BATH, 0.75 GAL 230V Catalog No: 24895-02 Make: HACH, USA	1
9	**Portable pH Meter**	
a	6230MKBportable pH, mV (ORP), Temp. Meter kit Cat. No: 6230MKB Make: JENCO Features: Economical, user friendly and have the right features for everyday field pH measurements. **40 Memory for Data storage (6230M and 6231M)** RS-232 computer interface with software BNC connector for pH/reference pH and mV 8 pin DIN connector for 10k thermistor Separate pin plug connector for reference pH AC adaptor or battery power	1

Sr. No.	Item Description	Qty.
	Specifications: **pH:** Range: -2.00 to16.00 Resolution: 0.01pH Accuracy: ±0.1% ± LSD **mV:** Range: -1999 to 1999 mV Resolution: 1.0 mV Accuracy: ±0.1% full scale ± LSD **Temperature:** Range: -5.0-125.0^{0}C Resolution:0. 1 ^{0}C Accuracy: ±0.5 ^{0}C PH Temp Compensation: Auto/Manual –10.0 to 120.0^{0}C PH Calibration: 1,2 or 3 points **Scope of Supply:** Handled pH, mV (ORP), and Temp meter **with RS-232C** interface. PH/Ref/Temp. Electrode; Electrode cable.	
b	**Benchtop pH Meter**	
	6173R KB Benchtop pH,mV (ORP), Temp. Meter Kit Model: 6173R KB Make: Jenco	**1 No.**
	Features: Quick and Easy pH measurements Built in Buffer Temp. Coefficient auto lock Power down memory 50 Memory location for data storage RS-232 interface with software Automatic temperature compensation **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	

Sr. No.	Item Description	Qty.
	Temp : 0.1°C ***Accuracy*** pH : ±0.01 pH mV : ±0.05 % full scale ± 1 LSD Temp : ±0.5°C Scope of supply: Large LCD Bench Meter **with RS-232** interface. pH, mV (ORP), Temp. pH/Ref./Temp. Electrode, 3' Electrode Cable, 230 VAC Adapter	
	Buffers used with 6230MKB Meter kit & 6173RKB Meter Kit	
	Buffer capsules, vial of 10 each. Slopes meter at 4.01 pH Catalog No: 6B4 Make: JENCO	**1**
	Buffer capsules, vial of 10 each. Standardize meter at 7.00 pH Catalog No: 6B7 Make: JENCO	**1**
	Buffer capsules, vial of 10 each. Slopes meter at 10.01 pH Catalog No: 6B10 Make: JENCO	**1**
	Electrode holder	
	Catalog No: 007N Make: Jenco	**1**
10	**DO Meter**	
	DO Meter, 12 ft Probe & Cable Catalog No: 55-12 Make: YSI Scope of Supply: YSI D.O.Meter 55-12FT Probe Cable | Battery Alkaline 4nos 1.5V Each | Instruction Manual | Hardware Kit Fitted | KCL Soln, Membrane Booklet And O-Ring Set (5775).	**1**
11	**Vacuum Pump**	
	PUMP, VACUUM 1.2 CFM 230V 50HZ Catalog No: 28248-02 Make: HACH, USA	**1**
12	**MPN Tubes (Durham's)**	

Sr. No.	Item Description	Qty.
	LAURYL TRYPTOSE/MUG SOLN PK/15 Catalog No: 21821-15 Make: HACH, USA	1
13	**Readymade media**	
	BRILLIANT GREEN TUBES PK/15 Catalog No: 322-15 Make: HACH, USA	1
	Note: Incubator is mandatory	
	EC/MUG W/O DURHAM TUBES, PK/15 Catalog No: 24715-15 Make: HACH, USA	1
14	**Incubator**	
	MEL INCUBATOR BATTERY PACK Catalog No: OR 503 Make: ORLAB	1
	MEL INCUBATOR POWER SUPPLY Catalog No: OR 502 Make: ORLAB	1
	Required Apparatus	
	BAG, STER W/THIOSULFATE PK/100 Catalog No: 20753-33 Make: HACH, USA	1
	GERMICIDAL CLOTH, PK/50 Catalog No: 24632-00 Make: HACH, USA	1
	INOCULATING LOOP AND HANDLE Catalog No: 21121-00 Make: HACH, USA	1
	DECHLORINATING REAGENT PP PK/100 Catalog No: 14363-69 Make: HACH, USA	1
	BUFFER DILUTION WATER PLWS PK/25 Catalog No: 21431-66 Make: HACH, USA	1

3.11. PUMPING STATION SPECIFICATION

The all Sewage Pumping Stations (intermediate or Terminal) mentioned in following table shall have following minimum units

- Terminal Manholes

- Receiving Chamber and Screen Chamber
- Raw Sewage Pump House
- Raw Sewage Pumps
- Rising Main
- EOT
- Flow Measuring Unit
- Knife Gate Valves
- Non Return Valves
- Electrical Works
- DG room
- Miscellaneous Works
- Operation & Maintenance

All the civil components shall be designed and constructed for ultimate stage flow (2045) and pumping machinery shall be provided for intermediate flow (2030) of capacity mentioned table.

Details of Pumping Machinery for Six Terminal Pumping Station and One intermediate Pumping Station.

Sr. No.	Name Of Pumping Station	Pump Capacity m^3/hr	No of Pumps Head	HP	
1	**Banewadi**				(4W + 2S)
	Peak Flow	630	20	80	
	Avg Flow				
2	**Cidco**	825	20	100	(2W + 1S)
	Peak Flow				
	Avg Flow				
3	**Golwadi**	1479.14	28	300	(6W +3S)
	Peak Flow				
	Avg Flow				
4	**Pedegaon**	639	20	80	(2W + 1S)
	Peak Flow				
	Avg Flow				
5	**Sidharth Nagar**	187.5	20	30	(2W + 1S)
	Peak Flow				
	Avg Flow				
6	**Ward 98**	266	25	40	(2W + 1S)
	Peak Flow				
	Avg Flow				
7	**Zalta**	640	20	80	(4W + 2S)
	Peak Flow				
	Avg Flow				

Note: Based on the design capacity of the Sewage Treatment Plants, The nos. of the battery of the pumps may vary for peak/average flow and should be finalized as per the

direction of Engineer-in-Charge.

Receiving chamber and Screen Chamber

The Contractor shall have to construct an receiving Chamber followed by a Screen chamber to receive raw sewage from the gravity sewer line. Before inlet chamber there shall be manhole at a distance of about 15 m. The contractor shall construct this manhole (having nearly same invert level as that of inlet chamber) and lay the gravity sewer from manhole to inlet chamber. This gravity sewer line shall be RCC NP 4. The pipe and inlet chamber shall be designed for peak flow. There shall be two screen channels in this chamber. The entire construction is in M 30 grade concrete and as per IS3370 & IS 456.

The screen chamber shall have mechanical coarse screen and manual coarse screen in each channel in series. Clear opening between the bars for coarse screen shall be 20 mm.

The screenings from manual screens shall be collected manually.

Electrically operated CI sluice gates shall be provided at the upstream and downstream of each channel to isolate the flow. Entire super structure from inside and from outside shall be painted with approved colour and make as directed by engineer-in-charge. All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

There shall be overflow / by pass arrangement from inlet chamber. The by-pass and overflow arrangement of both gravity and pumping type. The bypass and overflow arrangement shall be provided with necessary valves and Gates.

MOC of overflow pipe shall be RCC NP3. This over flow pipe shall take the flow from SPS to nearby water body. There shall be manholes at appropriate locations as per CPHEEO manual.

Raw Sewage Pump House

There shall be wet well and pump house above wet well. The entire structure shall be suitable to install submersible pumps, delivery pipes, valves, EOT, Panels and all the electrical Equipments etc. The wet well is to be constructed in RCC M 30 grade concrete as per IS 3370.

The pump house above wet well shall be in RCC framed and brick masonry structure. It shall have proper doors, windows and rolling shutter at main entrance as per tender specifications.

Plastering and painting from inside and outside shall be carried out as per specifications. Flooring shall be done as per civil specifications. The minimum clear height of the pump house shall be 5.0 m.

EOT of minimum 2 T capacity shall be provided in the pump house to lift the pump assembly, valves and specials. There shall be MCC room and operator room in pump house. It shall have proper doors, windows and rolling shutter at main entrance as per tender specifications. Plastering and painting from inside and outside shall be carried out as per specifications. Flooring shall be done as per civil specifications.

Arrangement of wet well and EOT shall be suitable for installation of future pumps also.

The capacity of the Wet Well should be kept such that the detention time in the Wet Well shall be minimum 5 minutes of Peak Flow and the maximum detention time shall not exceed 30 minutes at average flow.

Following criteria shall be considered to size the Sump:

1. That the pump of the minimum duty / capacity would run for at least 5 minutes considering no inflow or,

2. The capacity of the Sump is to be so kept that with any combination of inflow and pumping, the operating cycle for any pump will not be less than 5 minutes and
3. The arrangement of the submersible pumps as per Manufacturer's data i.e. spacing between pumps, minimum space between pump and wall etc.
4. The side water depth (live liquid depth) shall be minimum 2.5 m. In addition to the above liquid depth, an additional depression shall be provided to ensure adequate submergence of the pump as per the Manufacturer's recommendations. Pumping Station should have a Room adequate for installing electrical Panels. Suitable arrangement should be provided for lifting of pumps.
5. The effective liquid volume shall be provided below the invert level of the incoming sewer after leaving provision for a minimum of 0.5 m.

IS: 3370 and IS: 4111 (Part 4) shall be followed for the design and construction of Wet Well. The pumps shall be submersible Raw Sewage Pumps with Centrifugal, Non-clog type design. The speed of pump shall be less than 1500 rpm. The impeller should be of a non-clog design with smooth passage and solid handling capability of 100 mm size. The pumps shall handle raw sewage having specific gravity of 1.05. Plinth level: 0.5 m above HFL.

The arrangement and levels shown in the Tender drawing of SPS are indicative. Actual levels may change marginally to suit the site conditions during executions. All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

While designing pumping station due consideration shall be given to safety and ease of O & M.

Raw Sewage Pumps

The submersible pumps shall be provided as per tender specifications. The details of the pumps are as follows: -

Type : Submersible non-clog, solid handling.

Max solid size : 100-mm non-compressible.

Drive : Suitable motor.

Accessories : Panel, guide rail, lifting chain, duck foot bend etc.

Ultrasonic level transmitter shall be provided in the raw sewage sump so that the pumps shall operate as per the level of the sewage in the sump. The pumps should stop at low water level.

All the pumps shall be provided with delivery pipe along with Knife Gate valves and non return valves at the delivery side up to common header. MOC of delivery pipe and common header pipe inside SPS shall be CI.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

Electrical Operated Trolley (EOT)

EOT is proposed in the pump house to lift pumps, valves and specials from the pump house. The capacity of the EOT shall be 1.5 times the maximum load to be lifted.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

Flow Measuring Unit

Ultrasonic/ Electromagnetic type flow measuring unit mounted on common header to measure the total flow pumped.

Flow measurement: Min 100 MLD and as required at site

Gate Valves

Gate valves are provided on the delivery side of each pump for isolation of the pumps.

No. of valves : As per requirement

Pressure rating : PN 1.6

Material of construction : Cast Iron

Non Return Valves

Non return valves are provided on the delivery side of each pump and on common header to avoid back pressure on the pumps.

No. of valves : As per requirement

Pressure rating : PN 1.6

Material of construction : Cast Iron

Electrical Works

The Employer will make available power supply from their local transformer to the proposed four pole structure. The entire pumping station will be operated on 415 V, 3-Phase, 50 c/s, 4-wire system. The electrical system proposed for the pumping station shall include the following components;

- 415V Switchgear.

- 415V TPN Bus Duct.

- Transformer Yard

- Motor Starters, local push button stations.

- Earthing system and Safety equipments.

- Cables and cabling system.

- Internal lighting and area lighting.

The scope of work starts from providing four pole structure and further distribution upto MEP room. The contractor shall complete power distribution from MEP to the individual motor terminals by providing sub panels. The cabling work shall be done by providing proper cable trays. The scope also includes indoor /outdoor lighting system as well earthing & safety equipment.

The execution should take care of I.E. rules, Electricity Board's requirement and other local authorities and site condition.

DG Room

One DG set room of minimum size 4.0 m x 4.0 m shall be provided. It shall be RCC framed structure. The inside wall shall be provided with two coats of oil bound distemper of approved quality of colour over a coat of primer for the outside walls two coats of waterproof cement paint of approved quality and colour shall be provided. The flooring shall be provided with minimum 20 mm thick mosaic tiles and the make, quality and colour shall be got approved by the Engineer-in-charge.

All other accessories, whether specified or not, but required for completeness shall form part of contractors scope.

Valve Chamber: The construction of Valve chamber shall be of RCC in M30 Grade with

provision of required size platform for maintenance and operation of gates, valves and etc. The common header shall be of DI pipe material with necessary provision of Mechanical joints air valves and necessary fittings required for completion of work. The valve chamber shall be constructed with suitable access ladder with drainage facility.

3.12. SEWERAGE COLLECTION SPECIFICATION

The total length of Sewerage pipelines proposed for replacement/up gradation /new areas are as below.

DIA	Proposed Sewer Length	Material of Pipeline
150 mm	70278	DWC-HDPE
200 mm	27494	DWC-HDPE
250 mm	29246	DWC-HDPE
300 mm	28533	DWC-HDPE
400 mm	32606	RCC
450 mm	4612	RCC
500 mm	11677	RCC
600 mm	12177	RCC
700 mm	9414	RCC
800 mm	4605	RCC
900 mm	10206	RCC
1000 mm	2404	RCC
1100 mm	2953	RCC
1200 mm	4193	RCC
1400 mm	4435	RCC
1600 mm	2856	RCC
1800 mm	2157	RCC
2000 mm	272	RCC
Total (m)	**260118**	

4. ERECTION, TESTING, TRIAL RUN, COMMISSIONING AND TESTS AFTER COMPLETION

The Contractor's staff shall include adequate and competent erection engineers with proven, suitable, previous experience on similar Contracts to supervise the erection of the Works and sufficient skilled, semi-skilled and unskilled labor to ensure completion of Works in time. The Contractor shall not remove any representative, erector or skilled labor from the Site without prior approval of the Employer's Representative.

The Contractor shall ensure that no installation or erection work shall commence until full and unconditionally approved working drawings, signed and stamped by the Employer's Representative are available at Site.

The Contractor's erection staff shall arrive on the Site on dates to be agreed by the Employer's Representative. Before they proceed to the Site, however, the Contractor shall first satisfy himself, as necessary, that sufficient plant of his (or his sub-contractors) supply has arrived on Site so that there will be no delay on this account.

The Contractor's representative responsible for erection shall be an erection engineer who is conversant with the erection and commissioning of the complete Works. If there are more than one erector, one of them will be in charge and the Contractor shall inform the Employer's Representative in writing which erector is designated as his representative and is in charge. Erection engineer is to report to Project Manager.

The Contractor shall be responsible for setting up and erecting the plant to the line and levels of reference and of the positions, levels dimensions and alignment, appliances and labor in connection therewith. The checking of setting out of any line or level by Employer's Representative shall not in any way relieve the Contractor of his responsibility for the correctness thereof.

Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other contractors or operating staff who may be present at the time. Before commencing any erection work, the Contractor shall check the dimension of structures where the various items of Plants are to be installed and shall bring any deviations from the required position, lines or dimensions to the notice of the Employer's Representative. Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the approved drawings. Unless otherwise directed by the Employer's Representative, the Contractor shall adhere strictly to the aforesaid approved drawings. If any damage is caused by the Contractor during the course of erection to new or existing Plant or buildings or any part thereof, the Contractor shall, at no additional cost to the Employer, make good, repair or replace the damage, promptly and effectively as directed by the Employer's Representative and to the Employer's Representative satisfaction.

The Contractor shall align all equipment and holding down bolts and shall inform the Employer's Representative before proceeding with grouting-in the items concerned. The Contractor shall ensure that all equipment is securely held and remains in correct alignment before, during and after grouting-in.

The approval by the Employer's Representative of the Contractor's proposals for rigging and hoisting any items of the Plant into their final positions shall not relieve the Contractor from his responsibility for 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, electrical, architectural, or of any other description, promptly and effectively to the satisfaction of the Employer's Representative.

No Plant, equipment or other loads shall be moved across the floors of structures without

first covering the floors with timber of sufficient size so that applied loads will be uniformly transferred to floor beams and girders. If it is required to reduce bending stresses and deflection, the beams and girders shall be provided with temporary supports.

During erection of the Plant the Employer's Representative will inspect the installation from time to time in the presence of the Contractor's Site representative to establish conformity with the requirements of the Specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Employer's Representative.

4.1. LEVELLING AND GROUTING OF MACHINERY

Contractor shall undertake, sufficiently in advance, chipping of any unevenness of concrete on foundations, anchor bolt pockets, cut outs etc., to achieve uniform level of reference for erection. All concrete surfaces receiving grout shall be chipped as required to ensure better bonding with the grouting.

Contractor shall undertake the inspection of all components to be erected sufficiently in advance to check their soundness and conformity to drawings and the inspection records shall be signed by the Employer's Representative as approval for undertaking the installation of the components. Any damage, shortfalls etc. shall be made good to the satisfaction of the Employer's Representative.

All grout for equipment shall be carried out using non-shrinkable continuous grout materials with suitable framework of at least 12mm thickness. Surfaces to receive the grout shall be chipped and roughened and laitance shall be removed by wire brush or blast of air. Concrete surface shall be blown off by compressed air before commencing grouting. Grouting shall be done in one continuous operation from one side such that grout flows in a single wave until grout reaches all confined spaces with no air pockets and air from all confined spaces is expelled. A hydrostatic head of 150 mm shall be maintained during grouting operations. All grouting shall be carried out in the presence of the Employer's Representative. All lines and levels shall be checked after grout is set. Block outs shall be closed using cement concrete of the same grade as that of the parent structure.

4.2. RECORDS, PROCEDURES AND REPORTS

The Contractor shall maintain records pertaining to the quality of installation / erection work and inspection, testing, compliance with all technical requirements in respect of all his works as described in the previous paragraphs. The reporting formats shall be in the approved formats. The Contractor shall submit such records to the Employer's Representative after the completion of any particular work before submitting the bill of supply / progress of work. Such report shall comprise shop inspection reports, shop testing reports, material test reports, based on which dispatch clearances are provided, and all the quality control reports of welding, erection and alignment records.

All the above mentioned records shall be submitted in the final form duly countersigned by the Employer's Representative attesting conformity to specifications and his approval of installation, and duly incorporating all the additions, alternations, and information as required by the Employer's Representative, on the basis of preliminary reports giving the progress of the work. Such records notwithstanding, any records submitted earlier with bill of supply / progress, etc., shall be duly bound and submitted to the Employer's Representative in six copies by the Contractor on his notification of the mechanical completion of erection.

4.2.1. GENERAL PREPARATIONS BEFORE COMPLETION OF THE PLANT

The documents listed scope of work, civil and mechanical specifications volume should be completed in accordance with the Contract schedule before completion of erection. The Employer's Representative and the Contractor shall preserve and control these documents

in a safe and appropriate place on Site in order that both parties' personnel can make use of them at any time.

4.2.1.1. Technical Documents:

- Operation and Maintenance manual
- Design documents including the Contractor's design data, drawings and Specifications.
- Tools and test equipment list
- Spare parts list
- Lubricant list

4.2.1.2. Procedures:

- Mechanical testing procedure
- Electrical testing procedure
- Instrumentation testing procedure
- Detailed pre-commissioning and commissioning procedures
- Detailed Performance Test procedure

4.2.1.3. General and Coordination Documents:

- Detailed organization charts for pre-commissioning and commissioning showing lines of authorities and responsibility, and functions of all key personnel
- Job description of the members of the team
- Scheduled dates of assignment of each member to pre-commissioning and commissioning organization.
- Detailed schedule showing the time sequence which the Contractor anticipates to follow for the various steps in completion of erection, pre-commissioning and commissioning of each unit and equipment.
- Regulations for safety, hygiene and discipline
- Practical organization of the relationship (meetings, reports, etc.) between the Contractor and the Employer's Representative at the phases of pre-commissioning and commissioning.
- Emergency communication route.

4.2.1.4. Manpower:

Required manpower shall be provided as agreed between the Contractor and the Employer's Representative in a Manpower Mobilization Plan, which shall include the number and qualifications of the operator and maintenance personnel to be furnished by the Employer's Representative for the Plant.

4.2.2. COMPLETION OF ERECTION

The completion of Plant under erection by the Contractor shall be deemed to occur if all the units of the Plant are structurally and mechanically complete and will include, among other such responsibilities, the following:

- Plant in the Scope of the Contract has been erected, installed and grouted as per specifications.
- Installation checks are completed and approved by the Employer's Representative.
- Erected Plants are totally ready for commissioning checks.

At the stage of 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 tests on completion and subsequent pre-commissioning checks.

Upon achieving the completion as described above, the Contractor shall, after having given 21 days advance notice of the expected date for carrying out the inspection, notify the Employer's Representative by a written notice intimating completion of erection and notify the Employer's Representative for inspection. The Employer's Representative shall proceed with the inspection of such units within 24 hours of such a notice.

The Employer's Representative shall certify completion when there are no defaults in the Works or provide the Contractor with a list of deficiencies for rectification, hereinafter referred as the "Punch List". The Contractor shall complete the rectification work within a jointly agreed period before pre-commissioning activities and obtain the Employer's Representative's acceptance or approval before proceeding with the same.

The Employer's Representative may inform the Contractor that the works are accepted with the Punch List (items which do not hamper operability, safety or maintainability) and allow the Contractors to proceed with the pre-commissioning checks when the Contractor undertakes to complete such outstanding works within an agreed time prior to or during the defects liability period. Taking over shall be based on rectification of all deficiencies which are to be completed before acceptance, as advised by the Punch List.

The erection period indicated by the Contractor would be deemed to cover all the activities up to Completion as stipulated in previous paragraphs, notice of completion by the Contractor, inspection by the Employer's Representative for Completion, and Contractor's rectification of all deficiencies as noticed by the deficiency/Punch List, and acceptance by the Employer's Representative of such rectification's, prior to Tests on Completion.

Minor defects, which in the opinion of Employer's Representative do not hamper operability or maintainability, will not be taken into account for deciding Mechanical Completion. Such defects shall be rectified concurrent to commissioning checks before Tests on Completion. However, the Employer's Representative's decision in this regard is final.

The commissioning period as notified by the Contractor shall include all periods of pre-commissioning, trial runs and tests on completion.

It is in the Contractor's interest to offer the section/units/systems, progressively under Identified milestones within overall erection period, duly completed for rectification of any deficiencies pointed out by the Employer's Representative and to achieve mechanical completion before undertaking the tests on Completion within the specified erection period. The Employer's Representative also reserves the right to withhold the cost as estimated to be equivalent to the rectification of deficiencies pointed out to the Contractor until such a time as the deficiencies are rectified by the Contractor to the satisfaction of the Employer's Representative.

4.2.3. PRE-COMMISSIONING

After the completion of erection, pre-commissioning activities listed below shall be carried out to make the Plant ready for commissioning. All instruments, materials and provisions necessary for conducting site tests shall be provided by the Contractor at his own cost.

Upon completion of erection of each piece of equipment, facility or discrete part of the plant, mechanical checks and tests shall be carried out according to the Contractor's checklist. The mechanical checks and tests shall be to establish that:

- The Plant is erected in accordance with the Contractor's construction drawings, pipe work drawings, instrument diagrams, etc., issued for the Plant;
- Materials are installed and mechanically function in accordance with the Contract; and
- Applicable codes as listed in the Contract are followed for materials and workmanship.

Items such as painting, thermal insulation and final clean up which do not materially affect the operation or safety of the Plant will be excluded. All these items shall be listed and

completed after pre-commissioning or commissioning at the discretion of the Contractor, but before acceptance.

The Contractor shall prepare and maintain at Site test forms and records, which shall include:

- Description of type of test or check;
- Date and times of test or check;
- Identification of equipment and facilities;
- Test pressure, test data and results, including remarks, if any; and
- Signature of the Contractor's personnel attesting to data recorded; if any. The Contractor's construction forces thereof shall carry out checks, tests and records.

Wherever the Employer's Representative's witnessing or attesting of the check or test is required, the Employer's Representative's personnel shall attend such check and test. For this purpose, the Contractor shall keep the Employer's Representative informed of a day-to-day test plan schedule. The test plan schedule may be revised from time to time to reflect the actual progress of the work and test.

Any items found incomplete or requiring repair or adjustment shall be marked as such on the test records and reported by the Contractor to the Employer's Representative and the Contractor's personnel in charge of the relevant construction area.

Checking procedures shall be repeated until all the items on the checklist are cleared.

A complete set of test records shall be handed over to the Employer's Representative on completion.

The tests on the different mechanical and electrical equipment shall include but not be limited to:

4.2.3.1. Pumps, Piping and Valves

- Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.
- Operating tests shall be conducted on valves.
- The pumps shall be tested for mechanical performance. The vibration and noise levels shall be checked to be within the specified limits.
- Pump performance tests shall be conducted for all raw water and clear water pump sets with initial duty impellers. Each pump shall be tested at a time. For Malpura only one pump is to be tested at a time.
- To check and verify efficiency of each pump and vibration of pump.

4.2.3.2. Pump Motors

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

4.2.3.3. Instrumentation Testing Requirements

(a) Tests on Cables

i. Check details are in accordance with the specification

ii. Check for physical damage

iii. Megger test between each core and armour / sheath

iv. Continuity check

v. Connections

(b) Continuity of Signal/Control/Power Supply Cables

After laying of the field signal/control/power supply cables and prior to connection up to the control panels/instruments, the following procedures shall be adopted:

i. The signal/control/power supply cables shall be disconnected from each termination point in turn when the wires shall be 'rung-through' for identification and tagged.

ii. The signal/control/power supply cables shall be reconnected to the termination points and again 'rung-through'.

(c) Loop Test

After testing and calibration of individual instruments forming the various loops, simulated functional test of the whole loop shall be performed before pre-commissioning. The procedure for conducting these tests shall be decided by the Employer's Representative and results shall be recorded. During loop test, it is the Contractor's responsibility to ensure that the calibration of instruments is intact and in order and if any instrument is found defective in calibration, he shall recalibrate the same without any extra cost. After the loop test is over, he shall connect back all the terminations and connections removed for loop test.

(d) Tests on Electrical Installation

i. Check all closing, tripping, supervision and interlocking of control devices.

ii. Check operation of all alarm circuits.

(e) Test on Complete Control System

i. On completion, the functioning of the complete control system shall be tested to demonstrate its correct operation in accordance with the Specification.

ii. For control system testing, the Contractor may provide temporary means to simulate operating conditions, but the system will not be finally accepted until correct operation has been demonstrated to the satisfaction of the Employer's Representative when all the Plant is operating.

iii. The system shall be shown to operate correctly whatever the selection of duty and standby equipments may be.

iv. Conditions to be tested shall include:

- Normal automatic operation
- Normal manual operation
- Emergency manual operation

(f) System Validation

i. The services of factory trained and field experienced instrumentation engineer(s) shall be provided to validate each system and verify that it is operational and performing its intended function within system tolerance. System tolerance is defined as the root-mean square sum of the system component published specified accuracy from input to output.
ii. Each system shall be validated by simulating inputs at the first element in loop (i.e. sensor) of 10 %, 50 % and 90 % of span, or on/off and verifying loop output devices (i.e. indicator, alarm etc. except controllers).
iii. During system validation, provisional settings shall be made on levels, pressure, alarms etc.

iv. Correct operation of controllers shall be verified by observing that the final control element moves in the proper direction to correct the process variable as compared to the set point. All logic sequences shall be verified to operate in accordance with the specifications.
v. All defects and malfunctions disclosed by tests shall be corrected immediately. New parts and materials shall be used as required and approved and tests shall be repeated.
vi. A report certifying completion of validation of each instrument system indicating calculated system tolerances, verification that the system meets these tolerances and any provisional settings made to devices shall be provided. The report shall be made in the format required by the Employer's Representative and shall be certified by the Employer's Representative when he approves it.

(g) Final Operational Testing and Acceptance.

i. Upon completion of instrument calibration and system validation, all systems shall be tested under process conditions.
ii. The testing shall include, but not limited to all specified operational modes, taking process variables to their limits (simulated or process) to verify all alarms, failures, interlocks and operational interlocks between systems and/or mechanical equipment.
iii. Any defects or malfunctions shall be immediately corrected using approved methods and materials and the tests shall then be repeated.
iv. Upon completion of final operational testing, a report shall be submitted, indicating that the total control system provided meets all the functional requirements specified herein. This report shall be made in the format required by the Employer's Representative. The Employer's Representative shall certify this report when he approves it and it shall constitute final acceptance of the control system.

4.2.4. ELECTRICAL

The commissioning engineer may verify any commissioning tests / completion checks to satisfy him that the plant is fit and sound.

The commissioning tests / completion checks to be carried out shall include, but not be limited to, those described in subsequent paragraphs, as applicable to the individual equipment / system.

4.2.4.1. Commissioning Tests / Completion Checks

Preliminary Checks

In general, the following checks shall be carried out on all the equipment/systems, as applicable.

a) Name plate details according to approved drawings / specifications
b) Any physical damage or defect and cleanliness
c) Tightness of all bolts, clamps and connections
d) Oil leakages and oil level
e) Condition of accessories and their completeness
f) Clearances
g) Earthing connections
h) Correctness of installation with respect to approved drawings / specifications
i) Lubrication of moving parts
j) Alignment
k) Correctness and condition of connections

General tests

a) Commissioning Tests of Motor

- Insulation resistance test of motor windings and cables. (PI for MV motors only)
- Continuity check for power and control cables.

- Winding resistance measurement in case of motors rated 55 kW and above.
- Control, interlock and protection schemes.
- Operation and setting of timer, in case of Star Delta starters.
- Phase sequence and rotation.
- No load trial run for observation of vibrations, noise and temperature of bearings etc.
- On load operation, starting and running load current (also observe vibrations, noise and temperature of bearing and winding).
- Relay setting as per relay co-ordination chart
- Simulation check of motor control circuit by local/ remote closing and tripping

b) Commissioning Tests of Transformer:

i) Test oil for dielectric strength, tan delta, acidity, resistivity and dissolved gases, Insulation resistance test of windings.

ii) Capacitance and tan delta test of condenser type bushings, before assembly.

iii) Test the transformer for the following:

- Voltage / turns ratio at all the taps.
- Winding resistance at all the taps.
- Short circuit impedance (at low voltage)
- Magnetic balance.
- Core loss at normal tap at low voltage.
- IR and PI.

iv) Vector group test.

v) Phase sequence test.

vi) Test the current transformers for following:

- Continuity test.
- Polarity test.
- Insulation resistance test.
- Magnetization characteristics.
- Measurement of secondary winding resistance.

vii) Line connection as per phasing diagram.

viii) Winding resistance.

ix) Insulation resistance of control wiring.

x) Buchholz relay operation (for alarm and trip).

xi) OLTC control indicating and alarm circuit.

xii) Operation test of all protective devices (electrical and mechanical) and interlocks.

xiii) Calibration of temperature indicators (oil and winding) and temperature relays.

c) Commissioning Tests of Switchboard:

i) Checks on relays.

ii) Insulation resistance test

iii) High voltage test

iv) Millivolt drop test for busbar joints

v) Checks on motors/ simulation check.

vi) Setting of relays, other alarms, tripping devices and interlocks as per scheme.

vii) Phase angle checks, measurement of magnitude and phase angle of current transformer secondary currents and potential transformer secondary voltage.

viii) Functional checking of all power and control circuits e.g. closing, tripping, control, interlock, supervision and alarm circuits including proper functioning of the component equipment.

d) Commissioning Checks of Relay:

i) Check operating characteristics over the entire range by secondary injection.

ii) Check minimum pick up voltage.

iii) Check operation of electrical / mechanical targets.

iv) Relay settings.

e) Commissioning Checks of Meter:

i) Check calibration.

ii) Megger all insulated portions.

iii) Check CT and VT connection with particular reference to their polarities for relevant meters.

f) Commissioning Test of Circuit Breaker:

i) Check control wiring for correctness of connections, continuity and IR values.

ii) Manual operation of breaker.

iii) Power closing / operating manually and electrically.

iv) Breaker tripping and closing time.

v) Trip free and anti pumping operation.

vi) IR Values, resistance and minimum pick up voltage.

vii) Contact resistance.

viii) **Simultaneous closing and mechanical interlocks provided.**

ix) Check electrical and mechanical interlocks provided.

x) Checks on spring charging motor, correct operation of limit switch and time of charging,

xi) Checks on CTs.

xii) High voltage test,

xiii) All functional tests.

g) Commissioning Tests of Voltage Transformer:

i) Insulation resistance test.

ii) Polarity test.

iii) Ratio test on all cores.

iv) Line connections as per connection diagram.

v) Open delta test with low voltage, wherever required.

h) Commissioning Tests on Current Transformer:

i) Megger between windings, winding terminals and body.

ii) Polarity test.

iii) Ratio identification checking of all ratios on all cores by primary injection of current.

iv) Magnetization characteristics, secondary winding resistance.

v) Capacitance and tan delta test.

vi) Dielectric test of oil (wherever applicable).

i) Commissioning Checks of Cable:

i) Megger test between each core and armour / sheet.

ii) Continuity check.

iii) Connections.

iv) High voltage test for cables above 3.3kV.

j) Commissioning Checks for Battery:

i) Specific gravity test.

ii) Cell voltage test.

iii) Capacity test.

iv) Initial charging/ discharging cycle.

k) Commissioning Checks of Battery Charger:

i) Functional check of auxiliary devices, such as alarms, indicating lamps etc. and operational checks.

ii) Insulation test of all circuits.

iii) Measurement of voltage regulation and efficiency.

iv) No load current and voltage (AC) and voltage and current (both AC and DC) at different points.

v) Voltage at tap cell (While boost Charging)

l) Commissioning Checks of Capacitor:

i) Measurement of capacitance

ii) Capacitor loss tangent measurement (for above 1000V)

m) Commissioning Checks of Neutral Grounding Resistor:

i) High voltage test

ii) Ohmic value test

n) Lighting System

Commissioning tests stipulated in applicable standards and code of practice covering all lighting system equipment

o) Earthing System

Continuity of all conductors and joints shall be checked. The Employer's Representative may ask for earth continuity tests, earth resistance measurements and other tests, which in his opinion are necessary to prove that the system is in accordance with design, specification, code of practice and electricity rules. Earth grid resistance value should be not greater than one ohm.

p) Tests for Trial run and commissioning of the 33kV Transmission System:

1. General

   Before the line is energized, visual inspection of the line shall be carried out to check that all the nuts and bolts are tight and insulators and accessories are in position. The earth connections shall be checked to verify that these are in order.

2. Testing

   Before commissioning the line, the following tests shall be carried out:

   a) Conductor continuity test – The electrical resistance of the conductor shall be measured with a Wheatstone or other suitable instrument to ensure proper electrical connection of the line.

   b) Insulation resistance test – This test may be carried out with the help of a 5kV meggar to ascertain the insulation condition of the line.

3. The line shall be kept charged on no load at the power frequency voltage preferably for 72 hours for the purpose of full scale testing.

4.2.5. INSTRUMENTATION AND CONTROL

i) The list of tests to be carried for SAT along with test instruments to be used shall be furnished for review by the Employer's Representative.
ii) The testing of all the equipment and accessories shall be carried out as per latest applicable Indian/International standards recommendations.
iii) Prior to testing, all relevant documentation and sufficient briefing about the tests shall be given to Employer's Representative who would witness the testing.
iv) After installation and commissioning, the Contractor shall demonstrate, by tests in the field, compliance of the values, functionalities, quality and reliability of the complete system and its components, both hardware and software, as specified and as per guarantees.
v) Contractor shall be fully responsible for interfacing to the equipment of Others as indicated in the scope of works. It shall be Contractor's responsibility to ensure satisfactory functioning of the system in conjunction with related equipment like exchanges, data equipment and other communication equipment of the Employer's Representative. Problems relating to such interconnections shall be mutually resolved.
vi) After tests as above, the complete system shall be on continuous uninterrupted service with all functionalities and interconnections without any failures or manual interventions for correction, modification, rectification or replacements in the Contractor's system.
vii) Additional specific tests, if required, would be decided mutually.

SAT on local SCADA, UPS systems shall include the all tests covered under FAT documents except tests such heat run test and those tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated local SCADA, UPS systems testing at site with all field equipments/instruments

4.2.5.1. Site Calibration

Standard calibration procedures shall be used for calibrating all field instruments. All reference equipment, used for calibration, shall be certified from an authorized certifying agency, to be arranged by the Contractor at his own cost. At the time of calibration, standard calibration norms shall be adopted and the same will be documented for record purposes.

Calibration shall be performed in the presence of the Employer's Representative. The instrumentation shall be calibrated while being commissioned in order to verify that the high quality calibration carried out during FAT is not being disturbed (No undue adjustments shall be made for minor deviations). The Contractor will monitor and check the instrument calibration throughout the Operation and Maintenance period.

4.2.5.2. Instrumentation Installation and Pre-Commissioning Checks

a) Check the exact location of the instrument with reference to the pipe and instrumentation diagram and/or the General Arrangement drawing.

b) Check that tag plate with tag no. and description is provided for each instrument.

c) Check the model No. and instrument type with reference to the technical specification requirements.

d) Check all mounting and fixing arrangements and required accessories such as isolation valve, nuts and bolts, siphon etc.

e) Check that the instrument installation is as per the installation drawing.

f) Check the cable type, connections for power supply as well as signal cables.

g) Check that cable shields for the instruments are properly terminated.

h) For the flow meters, check that the flow rate and totalized flow reading on the various displays match.

i) Check that the earthing is as per manufacturer's recommendation.

j) Check that there are no leakages.

k) For the level switches check that the level electrodes are connected to the correct level control units.

l) For the temperature scanners, check that the communication port of temperature scanner is properly configured and interfaced with the PLC system. Also check that the alarm and trip signals for various channels of temperature scanner are properly configured.

m) Check the loop continuity for every circuit. While this is being done, the power supply to the instrument shall be cut-off.

n) Calibration checks of the instruments shall be carried out to ensure integrity with the manufacturer's factory test reports. (No undue adjustments shall be made for minor deviations

o) After switching on the instrument/system, it shall be monitored hourly and the data obtained shall be recorded and compared with the reference norms to ascertain whether any recalibration is required. If recalibration is required it shall be carried out using standard reference equipment/instruments at no extra cost.

4.2.5.3. Instrumentation Commissioning

a) Each control loop and interlock shall be tested independently, in manual mode first and then in auto mode from the PLC and local SCADA system. The operation shall be checked for conformity with the approved logic in both modes. All pump control ON/OFF shall be checked in manual mode first.
b) Annunciation system shall be checked as performance testing by simulating the condition and by passing in actual mode and then individual loop will be checked for annunciation system.
c) All motorized valves shall be checked in manual mode first, from controls on the control panel, and feed-back from the field for valve on/off shall be checked on the panel.

4.2.5.4. Programmable Logic Control (PLC)

a) The PLC system and software shall be loaded by the representative of the PLC manufacturer.
b) Testing, commissioning and stabilization of the software shall be carried out by the authorized representative of the PLC manufacturer. The following checks shall be carried out:
   - All indicators and indicating controllers will be put in manual mode after independent checking.
   - Check that the PLC is properly configured and installed as per the approved drawings.
   - Check that the PLC wiring is as per approved drawing.
   - Check that the cables terminating in the PLC are properly dressed.
   - Check that the PLC is earthed as per manufacturer's recommendations.
   - Check that the PLC on-line battery is functioning properly.
   - Check that the PLC is correctly time synchronized with the local SCADA system

- Check that the signals and events are getting correctly time stamped.
- Check the PLC response when input signal is out of range.
- Check that the correct ladder program is loaded in the PLC.
- Check the PLC ladder program by simulating various normal and abnormal conditions.
- Check that the data sheets and drawings are updated to reflect the as-built status.
- All analogue inputs shall be connected to the PLC system first. All digital inputs shall be checked at terminals before connecting to the I/O card of PLC system. PLC system shall be installed and checked first, before connecting any control signals/cables. Software shall be loaded in the PLC first, before connecting I/O cards with signal cables. After complete checking of the system in manual mode, system shall be put in Auto mode.

c) The PLC system manufacturer/supplier shall provide assistance/commissioning support at the time of commissioning, to be arranged and coordinated by the Contractor. Details regarding commissioning shall be provided prior to commissioning and any required modifications or changes shall be advised in advance.

4.2.5.5. Control Panel

a) Check name plate details of every piece of associated equipment for conformity with the specifications.
b) Check the tightness of all bolts, clamps, connecting terminals.
c) Check for physical damage.
d) Check cleanliness
e) Check switch development
f) Each wire shall be traced by continuity tests and it should be confirmed that wiring is as per the relevant drawings. All interconnections between panels/equipment shall be checked
g) Megger test on all wires.
h) Check on meters
i) Check that the primary devices are set as per the system requirements.
j) Checks on the control circuit for the functional requirements
k) Check that the control panel front fascia layout is as per approved drawings.
l) Check that the panel and all the panel equipment (viz. panel indicators, alarm annunciators, etc.) are connected to the proper earth.
m) Check that spare cutouts on the control panel are blanked.
n) Check that the panel indicator tag plates reflect the tag no. and the correct service description.
o) Check whether the panel meters are fixed properly in their cutouts.
p) Check that the instruments are identified inside the panel.
q) Check that the panel meter instrument ranges are as per approved data sheets.
r) Check that panel meters are provided with password protection facility.
s) Check that the alarm inscription details are as per approved drawings.
t) Check that the MCBs are identified by their function.
u) Check that safety guards are provided for power supply terminals.
v) Check the cables terminating in the control panel are properly dressed.
w) Check that proper node addresses are given to the panel meters/ scanners connected on the communication bus.
x) Check that the communication bus is terminated properly.
y) Check working of alarm annunciator by simulating alarm conditions.
z) Check that the panel meter readings match with other displays.
aa) Check that the no. of decimal places and unit of measurement are same for all the displays.
bb) Check that the data sheets and drawings are updated to reflect the as-built status.

4.2.5.6. Tests for Local SCADA

SAT on local SCADA systems shall include all the tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's

Representative) in addition to integrated local SCADA, communication system and UPS systems testing at site with all field equipment/instruments.

4.2.5.7. Tests for UPS

SAT on UPS systems shall include the all tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated local SCADA, UPS systems testing at site with all field equipments/instruments.

4.2.5.8. Tests for EPABX System

SAT on EPABX systems shall include the all tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated trunks and VHF communication systems testing at site with all telephone instruments

4.2.5.9. Tests for VHF Communication System

SAT on VHF communication systems shall include the all tests covered under FAT documents except tests which cannot be conducted at site (such tests shall be approved by the Employer's Representative) in addition to integrated with EPABX system at site with all handheld mobile sets. Site acceptance test shall include check of the antenna in use, and include the following four main characteristics of interest:

i) Type of antenna
ii) Height of the antenna
iii) Direction of main lobe
iv) Gain of the antenna

The radio base stations shall be confirmed as being located at the address as shown on the license. Contractor shall resolve such matters before proceeding with the station inspection. If a radio base station has moved a short distance so that the coverage area is little changed, the licensee should be informed, to regularize the licensing position, rather than closing the station down.

4.2.6. COMMISSIONING

After the completion of pre-commissioning activities the final checks and preparations necessary for start-up of the plant shall be carried out. The Contractor shall submit to the Employer's Representative a written Notice of Mechanical Completion, which shall include:

1. Identity part of the Plant considered mechanically complete.
2. Copies of all relevant completed test reports.
3. Date on which the completion of the tests was achieved.
4. Check list.
5. Request for issuance of a Mechanical Completion Certificate in respect of that part.
6. Within fourteen (14) days from the date of receipt of the Contractor's written Notice, the Employer's Representative shall:

- In the case of acceptance, issue a Mechanical Completion Certificate.
- In the case of objection, submit a rejection statement setting forth-remaining items to be completed or defects or deficiencies to be corrected before Mechanical Completion status can be accepted. When the Employer's Representative rejects the Contractor's Notice the Contractor shall take any necessary action to complete or correct the items

marked and give the Employer's Representative a second Notice of Mechanical Completion.

7. After the issuance by the Employer's Representative of a Mechanical Completion Certificate, commissioning activities listed below shall be carried out to enable the start-up and operation of the Plant. Procedures are described as below:

   A) Commissioning procedure shall be carried out in a methodical sequence as follows

   - Warming up
   - Start-up
   - Initial running
   - Operability adjustment
   - Stable operation
   - Final adjustment

8. At all stages of commissioning sequence, the Plant shall be operated at optimum Plant conditions. To ensure this, the Contractor may make minor adjustment to the conditions indicated in the Operation and Maintenance Manual as necessary.

9. The Contractor shall check the operating conditions of the Plant by constantly monitoring operating data.

10. The Contractor shall specify for each discrete part of the Plant the operational data to be recorded and the manner in which the data is to be taken.

11. The Employer's Representative on the forms to be mutually agreed shall record all the operating data. The Employer's Representative shall make a copy of the operating log and analytical data from initial operation through to the completion of Performance Test available to the Contractor for evaluation.

12. The Contractor shall carry out commissioning tests in the presence of the Employer's Representative. The evaluation of test results and decision passed by the Employer's Representative regarding the test results will be final and binding on the Contractor. Any additional tests or repetition of tests to establish satisfactory operation of any equipment shall be carried out by the Contractor, if so desired by the Employer's Representative, at no extra cost.

13. All checks and tests shall be as per the Manufacturer's drawing manuals, relevant codes of installation and as per commissioning checklists.

14. Among other commissioning tests, the following shall be carried out at site after completion of installation. Contractor shall ensure to use calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National Standards / International Standards. All tests to be carried out in the presence of Employer's Representative.

4.2.6.1. Commissioning Tests

Following commissioning tests are to be carried out on all the equipment/systems, as applicable.

- 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

4.2.7. SAFETY PROCEDURE AND PRACTICE

Following safety procedure and practice should be provided by the Contractor in the switchboard room/ substation as per latest edition of I.S. 5216.

a) Rubber matting in front of HV, MV and LV switchboard and other panels in switchboard room

b) Shock treatment chart in switchboard / electrical equipment room

c) Caution/Danger Board on -

- HV, MV and LV switchboard and other LV panels
- Lighting distribution board
- Transformer yard.

d) Sand bucket in switchboard / electrical equipment room/ transformer yard

e) Fire extinguisher in switchboard/ electrical equipment room

f) One set of hand gloves in switchboard room

g) First aid box in switchboard / electrical equipment room

4.2.7.1. Fire Safety

The requirement of hand appliance in switchboard room, electrical equipment room shall be as per the latest edition of Fire Protection Manual by Regional Tariff Committee.

4.2.7.2. Contractor's Licence

- The Contractor shall obtain the necessary Licence/ Authorization from the Licensing Board of the locality/ State for carrying out the installation work. The persons deputed by the Contractor should also hold valid permits issued/ recognized by the Licensing Board of the locality/ State in which the work is to be done.
- The electrical installation work shall be carried out by licensed electricians only and approved by appropriate authorities. It is the responsibility of Contractor to get approval of complete system from the appropriate authority.

4.2.8. PIPELINE WORKS

4.2.8.1. Test on Pipe Line

The sectional testing of MS pipeline shall be done as per the provisions set out in the mechanical specification along with the laying of pipelines. The tested pipeline will be joined by gap pieces to complete the total physical completion of works. The maximum length for sectional testing in case of MS pipeline shall be as specified in Subsection 3 except for cases where, according to the Employer's Representative, the criteria cannot be met due to specific Site conditions.

The laid pipeline will be joined with respective manifold through valves. Just before the commissioning the complete transmission main will be checked for:

i. All the motorized valves in the system will be inspected for proper lubrication, manual and electrical operation.
ii. All air valves shall be inspected for proper fitting and operation of isolating valves.
iii. All flange joints/ expansion joints/ couplings will be checked for tightness of all bolts, clamps, etc.
iv. The entire transmission system shall be checked for proper soil cover/ backfilling/ thrust and anchor blocking, etc.
v. The structures will be checked for any constructional defects.
vi. The valve chambers and their surroundings will be checked for its cleanliness.
vii. The rectifiers, batteries, battery chargers at all CP stations will be checked for their functioning along with pipe to soil potentials (PSP) at every test lead point for proper soil potential. All CP stations, test stations to be monitored regularly during the commissioning and trial run period and data related to PSP, individual anode current, energy consumption, battery performance, etc., to be incorporated in the log-book.
viii. Surge protection system shall be checked for the proper functioning.

4.2.8.2. Leakage Test

The entire pipeline shall be subjected to a hydraulic test as follows, to the required test pressure as per IS: 5822.

If a drop in pressure occurs, the quantity of water added in order to reestablish the test pressure should be carefully measured. This should not exceed 0.1 liter/ mm of pipe diameter per kilometer of pipeline per 24 hours for each 30 m head of pressure applied.

All the joints, valves, fittings which are not tested during sectional testing shall be physically checked for leakages and leakages repaired if found.

The Contractor shall provide and maintain all requisite facilities, instruments, for the field testing of the material. All pipes, specials, valves and civil works shall be replaced by the Contractor free of cost if damaged during testing.

4.2.8.3. Surge Protection Test

The effectiveness of the surge protection system shall be checked as follows,

- Install pressure gauges at the pressure gauge points such as immediately afterpumps, at summits, at valleys, at critical points, etc.
- Run all the pumps at a time at least for one hour and then shut off all the pumps at a time.
- Record the pressure gauge readings before and after shut off.
- Inspect working of the various equipment of the surge protection system.

The pressure gauge readings at any point should show the pressure increase less than as specified for design of surge protection system given in Subsection 6. Vacuum pressure of -3.0 m (minus three meters) is allowed in the system. No leakages should occur other than the

places observed above in the leakage test. The surge protection system shall work smoothly without any visual distress, failing which the Contractor shall take necessary measures to improve/correct /replace the surge protection system.

4.2.8.4. Cathodic Protection System Test

The effectiveness of the cathodic protection system shall be checked by monitoring the current requirements at all the Cathodic Protection (CP) Stations, If the current requirement is more than that stipulated in the Subsection 4, then the corrective steps shall be taken to bring the current requirement within specified limit.

4.2.8.5. Hydraulic Tests

All equipment subject to water pressure including castings, pressure vessels, pumps, pipes, fittings, and valves, shall be hydraulically tested to the pressure specified or in accordance with the applicable standard. Hydraulic test facility shall be made available at the manufacturer's works.

Any of the hydraulically tested items shall be subject to the Employer's Representative inspector's random item proof re-test and notice of testing dates shall be submitted to the Employer's Representative.

4.2.8.6. Site Testing

The Contractor shall arrange for the full site testing of all items of equipment and shall include provision of:

a) All skilled and qualified operating and test staff for the testing of all equipment;

b) Provision and disposal of all services, lubricants, and fuels other than electricity;

c) All measuring and testing instruments to demonstrate equipment operates to the fulfillment of the works test;

4.2.8.7. All Loading Weights for the Load Testing of all Lifting Equipment

The Contractor shall carry out all the tests to the satisfaction of the Employer's Representative. The Contractor shall be responsible for coordinating the programme of site testing of all items and to ensure that all parties concerned are present during any tests to obligate their responsibilities.

4.2.8.8. Documentation

Set of documents shall be prepared and maintained by the Contractor and one set of the latest revised documents shall always be kept at site. The following documents shall be prepared by the Contractor:

- All latest approved L-sections and alignment drawings.
- All up-to-date as built drawings.
- Data sheets for instrument specification and selection
- List of electrical equipment along with data sheet/ literature
- Erection/ Instruction manual of electrical equipment
- Commissioning manual of electrical equipment
- Instrument Schedule
- Electrical cable schedule and inter-connection diagram
- Instrumentation schedule

- Instrumentation cable schedule
- Loop drawings for instruments in the field and control panel
- Instrument test and calibration report
- Instrument installation drawings
- As built drawings and G.A. Drawings for equipment and instrument installation

The Contractor shall keep on site two sets of the latest revised Operation, Maintenance and Calibration manuals for all field instruments and sub systems, annunciation system, data loggers, indicating controllers and PLC system etc.

4.2.9. Tests for Water tightness of Water-retaining structures

Water retaining structures for water supply purposes shall satisfy the following tests for water tightness, before external finishes are applied (if any). The water for testing shall fill the first 1.25 meters and may be filled as quickly as supply permits. Between this and top water level, the rate of filling shall not exceed a steady rate of 300 mm per 24 hours unless otherwise directed. After filling to top water level no further water shall be introduced for 7 days. After expiry of seven days and 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 hours over a period of seven days and the structure shall satisfy the test if at the end of this week no leakage is apparent and or the water level does not drop more than 40 mm over the period of 7 days. The Employer's Representative shall decide on the actual permissible nature of this drop in surface level, taking into account whether the tanks are open or closed and the corresponding effect it has on evaporation losses. Foregoing visible leakages and sweating will not be accepted.

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 seven days and the if specified limit is then reached the structure may be considered as satisfactory.

Following satisfactory completion of the tests the Contractor shall empty the structures and dispose of satisfactorily the contents. He shall clean and disinfect the structures and any equipment therein of all deposits left by the testing.

5. START UP AND PERFORMANCE RUN

This section is valid for three treatment process

5.1. TEST ON COMPLETION

5.1.1. General

Prior to the commencement of Tests on Completion the Contractor shall submit for approval the following:

- Site Acceptance Test Documents
- As-Built Drawings
- Operation & Maintenance Manuals

Tests on Completion shall not be commenced until the aforementioned documents are approved.

The initial charges necessary for Tests on Completion shall be provided by the Contractor. Electricity required for Tests on Completion will be provided by AMC free of charge for a period not exceeding 30 days. In case the test on completion period exceeds 30 days, the cost of power till start of performance run shall be borne by contractor.

The cost of any consumables and chemicals required for the Tests on Completion shall be borne by the Contractor.

5.1.2. Dry Test Requirements

5.1.2.1. General

As a minimum requirement, the following dry tests shall be carried out as a general requirement:

- a general inspection to check for correct assembly and quality of workmanship,
- 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 aperture between building structure , chambers, etc. and the outside.

5.1.2.2. 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.

5.1.2.3. 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 Plant.

5.1.3. Electrical Works

As a minimum requirement the following dry tests shall be carried out on the electrical systems:

- Check phasing and polarity
- Carry out point to point check on all cables;

- Check on security of cable terminations
- Check on completeness and adequacy of earthing systems;
- Check setting on protection relays, sizes of fuses and motor overload settings;
- Carry out checks on cabling systems in accordance with the requirements of the relevant standards;
- Check operation of main circuit breakers by secondary injection methods;
- Check rotational direction of plant;
- Check instrument loop integrity, functionality and calibration;
- Check operation of standby generator installation and mains/generator changeover procedures; a 4 hrs load test (using the normal load of the Works) shall be carried out on the generator when the load is available;
- Check plant functionality
- Check functionality of the central MMI and its power supply;

5.1.4. Process Plant Item / Equipment

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

5.1.5. Hydraulic Wet Test Requirement

Hydraulic wet tests shall be carried out on completion of dry tests.

Potable water shall be used for hydraulic wet tests. The purposes 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 maximum rated load throughout for a period of at least seven days at twenty-four hours intervals.

In order to ensure a sufficient supply of potable water to carry out these tests the Contractor shall provide facilities for the disposal off site in an approved manner.

- 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 as per IS:3370;
- 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
- Carry out valving, diversion etc. to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element;
- Demonstrate correct functionality of electrical, control and instrumentation systems.

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 loop etc.

During these tests a check on the performance of Plant shall be made, as far as site facilities will allow, to compare its site performance with the factory test data and to identify and constraints on performance due to site conditions.

5.1.6. Process Wet Test

On approval by the AMC the Contractor shall carry out process wet tests.

Raw water shall be used as the primary feed stock for process wet tests. These tests shall be carried out to demonstrate the process performance of the Works. In order to demonstrate this, the Contractor shall ensure that each part of the Works is located to its rated throughput (including a period of overload if required in order to demonstrate compliance with the Employer's Requirements) for continuous stable operating period of not less than

48 hours.

The Contractor shall provide facilities for the disposal off site in an approved manner.

The following tests inter alia shall be carried out;

- Check and rectify leakage on civil structures, pumps and pipework;
- 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 where the solution pumped is different from that pumped during hydraulic wet tests;
- Carry out calibration of instruments;
- Carry out valving, diversion etc to fully hydraulically load each process element (or where there is a requirement to withstand an over load), overload each process element;
- Demonstrate correct functionality of electrical, control and instrumentation systems not checked during dry or hydraulic wet tests or which may have changed as a result of the different operating conditions now prevailing.

On completion of process wet test on the various parts of the works the Contractor shall run the plant as a whole in order to demonstrate the full functionality and performance of the Works at various throughput rates for a continuous period of not less than 7 days. In this period power utilised by the contractor shall be compared with the guaranteed power consumption given by the contractor. This shall be considered as completion of 'Test on Completion' and shall be certified by AMC.

5.2. PERFORMANCE RUN AFTER START UP

5.2.1. General

On successful completion of 'Test on Completion' i.e. Start up and commissioning, certified by AMC, Contractor should start the performance run of the plant for 3 months.

The Contractor is to carryout Operation & Maintenance (O&M) of the whole plant including civil works for 3 (three) months under performance run. AMC shall monitor the operation and maintenance by the Contractor.

During performance run period, the Contractor shall provide following as minimum for round the clock operation.

Staff

Plant in charge One

Chemist: : One

Operators : One for each shift

Maintenance unit Helpers : One fitter, One electrician :

Watchmen One for each shift

Chemicals and consumables: As required

Spares: As required for replacement during performance run period. The spares used from the spare supplied under the contract shall be replaced by the Contractor.

AMC shall supply power and water during Performance Run period free of cost. All other material such as chemicals, consumables, lubricants, tools & plants, spares etc shall be provided by the contractor. The contractor, if required, shall provide activated sludge or any other material for the stabilisation of the plant.

The Contractor shall provide operators for various units/plants for three shifts and other staff/supporting personnel in general shift.

The Contractor shall submit a weekly report to the Employer, about the operation and maintenance indicating the manpower, electric power, chemicals and other consumables consumed and also problems faced and rectified.

During this period, the Contractor shall ensure that the design treated sewage quality standards are met in accordance with the specification within the rate of power and chemical consumption as committed by the Contractor. The raw and treated sewage analysis pH, SS, BOD and oil & grease shall be carried out on daily basis from the day of commissioning at a reputed laboratory as approved by Engineer-in-Charge. 90% of the treated sewage samples should fall within prescribed limits of the treated sewage. The sampling location for raw sewage shall be at raw sewage sump and that of treated sewage shall be at outlet of chlorine contact tank.

The analysis of sewage for the above parameters at different locations such as outlet of secondary clarifier shall also be carried out on weekly basis. The Contractor shall take immediate steps to correct the operation of the plant to meet the guaranteed performance. The charges for analysis at the laboratory are to be borne by the Contractor.

The Contractor's responsibility includes the safety and security of the works/plants during the course of performance run of three month.

The Contractor shall provide the key personnel for performance run with the minimum qualification and experience as given below.

Sr.	Category	Qualification and Experience
1.	Plant in Charge	Graduate in Engineering/Technology (Civil/ Environmental Engineering) having5 years of experience in O & M/Maintenance of water /wastewater treatment plant.
2.	Plant Operator	Diploma in Engineering/Technology (Civil/ Environmental/Chemical Engineering) having 3 years of experience in Operation/ Commissioning of water/wastewater treatment plants.
3.	Chemist	Graduate in Environmental Science/ Chemistry having 5years of experience in sampling/ analysis in water/wastewater treatment plants.
4.	Electrician / Fitter	Diploma in respective field with 5 years of experience in erection, commissioning and O&M of M&E equipment in water/ wastewater treatment plants.

5.3. PERFORMANCE RUN CERTIFICATE

The conditions for issuance of a Performance Run Certificate as detailed in the Conditions

of Contract shall comprise:

1. The completion of the three months operation and maintenance under performance rum of the treatment plant to the satisfaction of AMC.
2. 90% of the treated sewage samples fall within the prescribed limits of the treated sewage as mentioned in the tender document.
3. The O & M Manuals have been updated following three month's operational experience and approved by AMC.
4. All defects identified during the three months operation of the works have been rectified

AMC shall issue a Completion Certificate for "Performance Run of Plant" after successful completion of Performance Run of plant for 90 consecutive days by Contractor to the satisfaction of AMC.

6. OPERATION AND MAINTENANCE

6.1. General

The contractor has to maintain sewage collection system along with pumping stations and STPS as per specification mentioned in Operation and Maintenance volume.

The contractor is to operate, maintain and monitor STPs 10 years after successfully completing performance run. The scope of work is given below but not limited to the following. This may include other incidental items of work connected with the regular operation & maintenance of the treatment plant as decided by Engineer-in-Charge from time to time.

1. The contractor shall ensure proper running of the plant to give the desired effluent standards i.e. BOD less than 10 mg/l, TSS less than 30 mg/l, Oil & Grease less than 10 mg/l. The contractor shall also be responsible for overall maintenance of the plant i.e. civil, electrical, and mechanical system. The contractor shall also be responsible for all repairs of equipment/machinery.
2. The contractor shall monitor the quality of raw and treated sewage. The contractor shall intimate and take adequate action to ensure smooth and satisfactory running of the plant. The raw and treated sewage analysis for pH, SS, BOD and oil & grease shall be carried out on weekly basis during O & M period at a reputed laboratory as approved by Engineer-in-Charge.
3. The contractor shall prepare and implement an effective plant maintenance programme in consultation with Engineer-in-Charge (E&M). It shall be absolutely contractor's responsibility to look after all sorts of maintenance whether preventive or break down. The contractor shall maintain the operational activity record as prescribed in this volume.
4. The contractor shall be responsible for keeping updated record of documents including History-Card for equipment and maintaining every day logbook relating to running of machinery, consumption of energy, and other consumables etc. and various analysis performed. In addition to above the contractor shall maintain the operation and maintenance data for the following.

   - Daily status record of STP
   - Daily flow record
   - Daily analysis record
   - Operation records of mechanical screens
   - Operation record of grit channel
   - Operation record of Surface aerators
   - Operation record of Secondary clarifier
   - Operation record of Return sludge pumps
   - Operation record of chlorination system
   - Record of quantity of sludge generation
   - Operation record of Centrifuge unit
   - Performance data of Aeration tank.
   - Performance data of Chlorination system through SCADA report
   - Performance data of Electricity consumption through SCADA report

- Any other allied works required by EIC during O&M.

5. The Contractor shall submit a monthly report to AMC, about the operation and maintenance indicating the manpower, electric power, chemicals and other consumables consumed, problems faced and rectified along with various analysis performed for raw and treated sewage.
6. The contractor shall be responsible to carry out day to day as well as periodic maintenance necessary to ensure smooth and efficient performance/running of all equipment/instruments installed at the Sewage Treatment Plant. The contractor shall hand over the machinery & site to the employer after expiry of the contract period in good running condition.
7. The contractor shall maintain all treatment plant and pumping station units and other civil structures in the STP premises including boundary wall in sturdy manner to complete its natural / designed life. He should paint all MS / CI / GI structures at least once in a year to prevent rusting as and where required and as directed by EIC.
8. The contractor shall also be responsible for proper upkeep of administrative block, Staff quarter of the Sewage Treatment Plant.
9. He shall be responsible for proper maintenance of all the pumps and allied items including mechanical screens, gates, Aerators, sludge pumps, chlorinator etc.
10. He shall be responsible for timely removal and safe disposal of the dried sludge including transportation, loading and unloading etc. He should get approval for the location of the disposal of the dried sludge from AMC.
11. He shall be responsible for maintenance of streetlight, poles & fixtures also.
10. The sewerage system in the STP premises, roads and pathways provided at the sewage treatment plant shall be maintained properly.
13. Round the Clock watch and ward of the entire premises including plants/machinery etc. will also be the responsibility of the contractor.
14. The entire STP premises including Administration building will be kept neat and clean.
15. The records maintained by the contractors shall be produced periodically to the Engineer-in-charge for proper monitoring as desired by him.
16. Operation & maintenance of boundary wall of STP, Landscaping and Forestation done in the Sewage Treatment Plant premises etc. shall be carried out.

6.2. General Terms and Conditions

1. During O & M period the contractor is to keep their staff engaged continuously without any break for Operation, Maintenance and Monitoring of STP.
2. The contractor will supply all consumable and reagents. The contractor will employ its own staff for testing purpose. However the employer will be at liberty to get random sampling & testing done on its own or from any other agency, to the entire satisfaction of Engineer-in-charge. In case of testing from other agency, charges will be borne by AMC
3. Contractor's labourers and supervisors shall have to normally observe office timings of general shift.
4. Plant and equipment covered under this contract shall be totally attended to by the contractor including any "Trouble Shooting" to ensure smooth and trouble free operation.

5. For effective maintenance of STP, the contractor shall employ sufficient staff with proper qualification. For his guidance the pattern and no. of minimum staff to be engaged is described in this chapter.
6. The maintenance period shall be 10 years from the date of completion of successful performance run of sewage treatment plant and the contract for subsequent stages of 10 years for operation and maintenance shall be given on the performance of 1st years.
7. The contractor shall take operational measures that there shall be no flooding of STP area.
8. The contractor shall abide by all central/state govt. /Semi govt. /Local Bodies rules regulations, pertaining to this contract, without any extra cost.
9. In the event of any damage/loss of life/theft of property, due to negligence on the part of contractor, the contractor shall be solely responsible and liable for compensation and damages, regarding negligence and the decision of Engineer-in-charge shall be final.
10. The contractor should maintain all kinds of securities in the premises round the clock for that he should arrange manpower to prevent theft, robberies and malpractice. No unknown person shall be allowed to enter the STP premises except municipal staff, officials and elected representatives of the AMC body without permission. Educational study visits of the students are permissible only on written permission from EIC.
11. The site will be open for inspection by the designated officers/official of AMC at all times during the contract period.
12. The contractor should observe all safety rules and regulations corresponding to electricity, factory act, bio-chem. process fire and as per building codes. Any accident causing by over sighting the rules, the contractor at his own cost and risk shall handle the related cases. Insurance of the entire staff at site is compulsory under insurance policy drawn from Govt. of Maharashtra. The copy of the cover note should be submitted to AMC.

6.3. Financial Terms and Conditions

During the operation and maintenance period Electricity charges will be borne by the employer. The electricity charges will be paid directly to M.S.E.B.by AMC on actual basis as per electricity bill raised by the M.S.E.B. All other consumables, materials and required staff for Operation & Maintenance will be provided by contractor.

The operation & Maintenance cost approved by the Employer shall be payable on monthly basis on completion of every month on submission of bill by the contractor. The contractor shall maintain the attendance record of the staff employed by him, which can be checked by the employer any time. The contractor will also submit copy of all the data sheets every month for evaluation.

The Sludge available from Sewage Treatment Plant shall be property of the contractor and suitable credit for the same shall be considered by the contractor while offering his price bid. The wastewater will not be sold by the Contractor. However, employer is at liberty to do so, and retain the proceedings, if any.

All sorts of Tool & Plant, required for proper operation & Maintenance of the plant, shall be arranged by the contractor at his own cost.

6.4. Description of staffing

Details of minimum staff required to be employed for the operation and maintenance of each of the sewage treatment plant for 15 years is given below. However, additional staff, if required for proper operation and maintenance of each STP, will be provided by the contractor without any additional charges.

Sr.	Personnel	No.	Main Task of the Personnel
1	Plant In Charge (Civil Engineer)	1	Coordination of activities for satisfactory performance of the STP & pumping station and reporting to the Engineer-in-charge and responsible for the proper functioning & maintenance, data collection of STP & pumping station.
2	Operators (ITI Qualified)	4	Responsible for overall operation for STP and pumping station.
3	Electrician (ITI Qualified)	1	Responsible for maintenance of electrical equipment.
4	Fitter (Mech.) (ITI Qualified)	1	Responsible for maintenance of mechanical equipment.
5	Helpers	4	Responsible for keeping the STP premises clean and neat. Also they will assist operators in day to day activities
6	Watchman	2	To protect the plant from the trespassers, animals etc.
7	Gardener	1	To maintain the garden/landscaping of the plant

6.5. Deployment of Staff During Operation and Maintenance Period

The Contractor shall arrange at his cost the staff required during the Operation and Maintenance period of 10 years. The Lump sum tender cost shall also include all expenditure likely to incur for repairs/replacement of any items executed in the tender during this period.

The Contractor should submit detailed information regarding the staff likely to be deployed by him during O&M period of 10 years.

6.6. Taking over

The plant will be taken over on satisfactory completion of the operation and maintenance of the contract for 10 years provided that,

- The plant/equipment are in running condition
- The result of the treated sewage quality during O & M of the plant is within the limits specified for 90% of time.
- All treatment plant units including interconnecting piping, hand railings, ladders, staircases, buildings, various tanks, machines, panel etc are neatly painted.
- All records of operation and maintenance during the 10 years period are handed over to AMC in proper condition.
- The O & M manuals have been updated following 10 years operational experience and approved by AMC.

In case taking over is delayed on account of Contractor's failure, the O & M period will be extended further till it meets the above requirement without any extra cost to AMC.

7. BID DRAWINGS

7.1. BID DRAWINGS

The bid drawings provided for bidding purposes are listed below and are enclosed in this Volume.

1. Key Plan
2. Collection Network for all zones
3. Standard Drawings

8. DATA SHEETS

8.1. PROCESS AND CIVIL UNITS

8.1.1. Civil Units for Sewage Treatment Plant

Sr.	Units	Details
I	General & Process	
i)	Process details	
	Average flow	
	Peak factor	
	Peak flow	
	Raw sewage BOD_5 at 20 ^0C	
	Raw sewage SS	
	Treated sewage BOD	
	Treated sewage SS	
(ii)	Total head loss (m) in STP (Water level in Inlet Chamber to water level in outlet channel near river).	
(iii)	Total land area (hectare) proposed for STP and all units as mentioned above and specified elsewhere in the tender document.	
II	Sewage Treatment Plant	
(a)	Inlet Chamber	
(i)	Design peak flow	
(ii)	No of units	
(iii)	Detention period	
(iv)	Liquid depth (m)	
(v)	Length (m)	
(vi)	Width (m)	
(vii)	Water level (m)	
(b)	Screen Channel	
(i)	Design peak flow	
(ii)	No of units	
	2 W (mechanical) & 1 S (manual)	
(iii)	Clear spacing through bars	
(iv)	Width of channel (m)	

Sr.	Units	Details
(v)	Length of channel (m)	
(vi)	Liquid depth (m)	
(vii)	Upstream water level (m)	
(viii)	Downstream water level (m)	
(ix)	Head loss (mm)	
(c)	Degritting System	
(i)	Design flow	
(ii)	No of units	
(i)	Particle size to be removed (mm)	
(ii)	Specific gravity	
(iii)	Efficiency of removal (%)	
(iv)	Length of channel between screen chamber and grit chamber (m)	
(v)	Width of channel between screen chamber and grit chamber (m)	
(vi)	Degritting units	
	- Capacity (MLD)	
	- Size (m)	
(vii)	Surface overflow rate (cum/sq.m/day)	
(viii)	Water level (m)	
(ix)	Number of gates (nos.)	
(ix)	Size of gate openings (m)	
(d)	Flow Measuring Channel	
(i)	Width of Flow Measuring Channel	
(ii)	Length of Flow Measuring Channel	
(iii)	Depth of Flow Measuring Channel	
(iv)	Size of Parshal Flume	
(e)	UASB Reactor	
(i)	Size of the reactor	
(ii)	Solid retention time	
(iii)	Sludge bed concentration	
(iv)	Sludge bed height	
(v)	Average Upflow velocity	
(vi)	Maximum Upflow velocity	
(vii)	Aperture velocity	
(viii)	Angle of gas deflector	
(ix)	Hood width	
(x)	Feed inlet pipe distance	
(xi)	Overlap of gas deflector	
(xii)	C/C distance of gas domes	

Sr.	Units	Details
(xiii)	Aperture percentage	
(xiv)	Angle of deflection beam	
(xv)	Retention time in settling zone	
(xvi)	Volumetric loading	
(xvii)	Free board	
(e)	SBR Reactor	
(i)	Size of the reactor	
(ii)	No of reactors	
(iii)	Inlet BOD, mg/l	
(iv)	Inlet SS, mg/l	
(v)	BOD removal efficiency	
(vi)	SS removal efficiency	
(vii)	F/M ratio	
(f)	Aeration Tank	
(i)	Inlet BOD, mg/l	
(ii)	Inlet SS, mg/l	
(iii)	BOD removal efficiency	
(iv)	SS removal efficiency	
(v)	F/M ratio	
(vi)	MLSS, mg/l	
(vii)	MLVSS / MLSS	
(viii)	Yield coefficient, day $^{-1}$	
(ix)	Decay coefficient, day $^{-1}$	
(x)	MCRT, days	
(xi)	Water depth in tank	
(xii)	No of tanks	
(xiii)	Kg O2 / kg BOD removed	
(xiv)	Min power requirement for mixing	
(xv)	Details of each tanks	
	- Volume (cum)	
	- Hydraulic Retention Time (hours)	
	- Side Water Depth (m)	
	- Length (m)	
	- Width (m)	
	- Freeboard (m)	
	- F/M ratio (kg BOD removal / kg of MLVSS/day)	
(xvi)	Length of Inlet Weir (m)	
(xvii)	Length of Outlet Weir (m)	
(xviii	Size of pipeline/channel to Secondary Clarifier Tank (m)	
(xix)	Length of pipeline/channel to Secondary Clarifier Tank	

Sr.	Units	Details
	(m)	
(xx)	Material of Construction of pipeline to Secondary Clarifier Tank (m)	
	Diffusers for any technology	
(i)	Type of diffusers	
(ii)	Make	
(iii)	Material of diffusers	
(iv)	Dia and length of each diffuser	
(v)	Total no of diffusers	
(vi)	Air flow through each diffuser	
	Air blowers for any technology	
(i)	Type of air blower	
(ii)	Make	
(iii)	No of working blowers	
(iv)	No of stand by blowers	
(v)	Capacity of blower	
(vi)	Head of blower	
(vii)	Motor rating	
(g)	Secondary Clarifier Tank (SCT)	
(i)	Number of Secondary Clarifier (SCT) (nos.)	
(ii)	Diameter (m)	
(iii)	Side Water Depth (m)	
(iv)	Freeboard (m)	
(v)	Volume (cum)	
(vi)	Hydraulic Retention Time (hours)	
(vii)	Surface Overflow Rate (cum/sq.m/day)	
(viii)	Weir Loading Rate (cum/sq.m/day)	
(ix)	Bottom floor slope	
(x)	Diameter of Influent pipe(s) to SCT (mm)	
(xi)	Material of Construction of Influent pipe(s) to SST	
(xii)	Diameter of pipe(s) from SCT to Return Sludge Sump for sludge withdrawal (m)	
(xiii)	Length of pipe(s) from SCT to Return Sludge Sump for sludge withdrawal (m)	
(xiv)	Material of Construction of pipe(s) from SCT to Recycle	

Sr.	Units	Details
	Sludge Sump for sludge withdrawal (m)	
(h)	Chlorine Contact Tank (CCT)	
(i)	Number of Tanks(nos.)	
(ii)	Size of tank (m x m)	
(iii)	Side Water Depth (m)	
(iv)	Freeboard (m)	
(v)	Volume (cum)	
(vi)	Hydraulic Retention Time (hours)	
(vii)	Diameter of pipe from SCT to CCT	
(viii)	Material of construction of pipe from SCT to CCT	
(i)	Plant Utilities	
(ii)	Storm water drain provision (size, length in m)	
(iii)	Water Supply and Sewerage Provision (Yes / No)	
	- Capacity and size of water storage tank(cum)	
	- Capacity and size of overhead tank (cum)	
(iv)	Numbers and size of Culverts, road crossing, etc.	
(v)	Area allocated for green belt (sq.m)	
(vi)	Width of approach road to site (m)	
(vii)	Length of approach road to site (m)	
(viii)	Width of roads inside the plant (m)	
(ix)	Length of roads inside the plant	
(x)	Length of compound wall (m)	
(xi)	Height of compound wall (m)	
(xiv)	Size of security shed (m)	
(xv)	Number of MCC rooms (nos.)	
(xvi)	Size of MCC rooms (m x m)	
(j)	Reclamation/Site Development	
(i)	Proposed area of Reclamation (sq.m)	
(ii)	Top levels after Reclamation (m)	
(iii)	Average depth of filling (m)	
(iv)	Total quantity of earth required	
(v)	Side slope of the filling	
(vi)	Slope Protection Measures	
	- Provision of retaining wall (Yes / No)	
	- Height of retaining wall	

Sr.	Units	Details
	- Width of retaining wall	
(vii)	Proposed compaction equipment to be deployed (Type and Numbers)	
(viii)	Test apparatus to be provided in field soil laboratory	
(ix)	Proposed open channel dimension	
	- Top width (m)	
	- Bottom width (m)	
	- Side slope	
	- Longitudinal slope	
	- Length (m)	
(x)	Bottom slope protection for open channel	
(xi)	Proposed equipment (type and number) for excavation handling, transporting	
(k)	Miscellaneous	
	The Tenderer shall list here details of any other/ additional items required for a complete installation and successful Commissioning of the plant.	

8.1.2. Process Design

The Tenderer shall provide following documents / drawings in details along with the tender documents:

1. Process design of all units
2. Hydraulic design and head loss calculations for all the units, pipes, etc.
3. Schematic, mass balance and hydraulic flow diagram
4. Layout Plan and Process & Instrumentation Diagram
5. Single Line Diagram
6. Mechanical equipment data sheets as mechanical specifications of this document
7. Electrical system design, rating, etc. for all the power cables earthing system and instrumentation systems as per electrical specifications of this document
8. Instrumentation & Automation System design, rating, etc. as per Instrumentation Specifications of this document

8.2. MECHANICAL EQUIPMENT

8.2.1. Pumping Machinery

8.2.1.1. Return Sludge Pumps

Sr.	Description	Unit	Particulars
(a)	General		

Sr.	Description	Unit	Particulars
(i)	Make		
(ii)	Model		
(iii)	Type		
(iv)	Numbers of Working pumpsets		
(v)	Numbers of Standby pumpsets		
(b)	Performance		
(i)	Capacity	cum/hr	
(ii)	Total head	mlc	
(iii)	Speed	rpm	
(iv)	Overall efficiency (Pump + Motor)	%	
(v)	Motor Rating	kW	
(vi)	Motor Enclosure		
(c)	Materials of Construction		
(i)	Impeller		
(ii)	Casing		
(iii)	Shaft		
(iv)	Delivery pipe		
(d)	Induction Motor		
(i)	Make		
(ii)	Rating	kW	
(iii)	Speed	rpm	
(iv)	Efficiency		
	- Full Load	%	
	- ¾ Load	%	
(v)	Power Factor		
	- Full Load		
	- ¾ Load		
(vi)	Class of Insulation		
(vii)	Temperature rise by resistance method	°C	
(viii)	Type of enclosure		
(ix)	Degree of protection		
(x)	Weight	kg	

8.2.1.2. Centrifuge feed Sludge Pumps

Sr.	Description	Unit	Details
(a)	General		
(i)	Make		

Sr.	Description	Unit	Details
(ii)	Model		
(iii)	Type		
(iv)	Numbers of Working pumpsets		
(v)	Numbers of Standby pumpsets		
(b)	Performance		
(i)	Capacity	cum/hr	
(ii)	Total Head	mlc	
(iii)	Efficiency	%	
(iv)	Maximum pump input at 50 Hz for single pump operation		
(v)	Shut off Head	mlc	
(vi)	Speed	rpm	
(vii)	Size of solids that can be handled	mm	
(c)	Construction		
(i)	Type of Impeller (Enclosed / Semi open)		
(ii)	Number of Impeller vanes		
(iii)	Stuffing box sealing liquid		
(iv)	Surface hardness of shaft sleeve	BHN	
(v)	Suction/discharge	mm/mm	
(vi)	Weight	kg	
(d)	Materials of Construction		
(i)	Impeller		
(ii)	Casing		
(iii)	Shaft		
(iv)	Casing ring		
(v)	Shaft Sleeve		
(vi)	Stuffing box packing		
(vii)	Base Plate		
(e)	Testing and Inspection		
(i)	Pump Performance testing Standard		
(f)	Performance		

Sr.	Description	Unit	Details
(i)	Maximum velocity of vibration	mm/sec	
(ii)	Maximum noise level	dBA	
(g)	Induction Motor		
(i)	Make		
(ii)	Rating	kW	
(iii)	Speed	rpm	
(iv)	Efficiency		
	- Full Load	%	
	- ¾ Load	%	
(v)	Power Factor		
	- Full Load		
	- ¾ Load		
(vi)	Class of Insulation		
(vii)	Temperature rise by resistance method	°C	
(viii)	Type of enclosure		
(ix)	Degree of protection		
(x)	Weight	kg	

8.2.1.3. Centrifuge Feed Pumps

Sr.	Description	Unit	Particulars
(a)	General		
(i)	Make		
(ii)	Model		
(iii)	Type		Positive Displacement
(iv)	Numbers of Working pumpsets		
(v)	Numbers of Standby pumpsets		
(b)	Performance		
(i)	Capacity	cum/hr	
(ii)	Total head	mlc	
(iii)	Speed	rpm	
(iv)	Overall efficiency (Pump + Motor)	%	
(v)	Motor Rating	kW	
(vi)	Motor Enclosure		

Sr.	Description	Unit	Particulars
(c)	Materials of Construction		
(i)	Impeller		
(ii)	Casing		
(iii)	Shaft		
(iv)	Delivery pipe		
(d)	Induction Motor		
(i)	Make		
(ii)	Rating	kW	
(iii)	Speed	rpm	
(iv)	Efficiency		
	- Full Load	%	
	- ¾ Load	%	
(v)	Power Factor		
	- Full Load		
	- ¾ Load		
(vi)	Class of Insulation		
(vii)	Temperature rise by resistance method	°C	
(viii)	Type of enclosure		
(ix)	Degree of protection		
(x)	Weight	kg	

8.2.2. Sluice Gates

Sr.	Description	Unit	Particular
(i)	Make		
(ii)	Size	mm x mm	
(iii)	Opening required on the wall to mount the wall thimble	mm x mm	
(iv)	No of gates		

8.2.3. Screening Equipment

8.2.1.4. Mechanical Screen

Sr.	Description	Unit	Particulars
(a)	General		
(i)	Make		
(ii)	Model		

Sr.	Description	Unit	Particulars
(iii)	Type		
(iv)	Numbers		
(b)	Screen		
(i)	Width	mm	
(ii)	Height	mm	
(iii)	Raking speed	m/mm	
(iv)	Motor rating	kW	
(c)	Materials of Construction		
(i)	Frame		
(ii)	Rake carriage		
(iii)	Screen bars		
(iv)	Fasteners		
(v)	Canopy		
(d)	Conveyor System		
(i)	Material of belt		
(ii)	Width of conveyor	mm	
(iii)	Speed of conveyor	m/sec	
(iv)	Thickness of belt and ply		
(v)	Make of the belt		
(vi)	Motor rating	kW	
(e)	Unit Control Panel		
(i)	Make		
(ii)	Over all dimensions	mm x mm x mm	
(iii)	Degree of protection		
(iv)	Timer		
(v)	Make		
(vi)	Type		

8.2.1.5. Manually Raked Bar Screen

Sr.	Description	Unit	Particulars
(a)	General		
(i)	Make		
(ii)	Size	mm x mm	
(iii)	Numbers		

Sr.	Description	Unit	Particulars
(b)	Screen		
(i)	Width	mm	
(ii)	Height	mm	
(iii)	Bar size	mm x mm	
(iv)	Clear space between bars	mm	
(c)	Material of Construction		
(i)	Screen bars		
(ii)	Guide channel		

8.2.4. Grit Removing Equipment

Sr.	Description	Unit	Particulars
(a)	Reduction Gear		
(i)	Make		
(ii)	Type		
(b)	Drive Motor		
(i)	Make		
(ii)	Speed	rpm	
(iii)	Rating	kW	
(c)	Material of Construction		
(i)	Scraper		
(ii)	Frame		
(d)	Classifier Mechanism		
(i)	Make		
(ii)	Type		
(iii)	Drive System		
	- Make of reduction gear		
	- Make of motor		
(iv)	Material of rake		
(e)	Organic Return Pumpset		
(i)	Make		
	- Pump		
	- Motor		

Sr.	Description	Unit	Particulars
(ii)	Motor rating	kW	
(iii)	Materials of Construction		
	- Impeller		
	- Shaft		

8.2.5. Secondary Clarifier

Sr.	Description	Unit	Particulars
(a)	General		
(i)	Tank size		
(ii)	Type		
(iii)	Make		
(iv)	Feed Inlet		
(v)	Overflow		
(vi)	Sludge Scraper		
(vii)	Type of Bridge		
(viii)	Scum removal		
(ix)	Overload protection		
(x)	Direction		
(xi)	Torque		
(b)	Drive Mechanism		
(i)	Drive System		
	- Prime Mover		
	- Make		
	- HP/RPM		
(ii)	Gear Box		
	- Gearbox		
	- Make		
(iii)	Center Mechanism		
(iv)	Transmission		
(v)	Gear reducer		
	- Make		
	- Type		
(vi)	Motor		
	- Make		
	- Rating	kW	
(c)	Material of Construction of Rake Arms		
(i)	Feed Well		

Sr.	Description	Unit	Particulars
(ii)	Rake Arms		
(iii)	Blades		
(iv)	Overflow Weir		
(v)	Squeezes		
(vi)	Bridge		
(vii)	Walkway		
(viii)	Railings		
(ix)	Fasteners		
(d)	Painting		
(i)	Submerged Parts		
(ii)	Other Parts		

8.2.6. Chlorination System

Sr.	Description	Unit	Particulars
(a)	General		
(i)	Make		
(ii)	Type of injector		
(iii)	Injector capacity	kg/h	
(iv)	Injector Pressure	Bar	
(v)	Accuracy as a percent of actual rate in the operating range	± %	
(b)	Automatic drum changeover device		
(i)	Make		
(ii)	Type		
(c)	Booster Pumps		
(i)	Make		
(ii)	Capacity	cum/hr	
(iii)	Total head	m	
(iv)	Motor rating	kW	
(d)	Chlorine Leak Detector		
(i)	Make		
(ii)	Type		
(iii)	Range	Ml/cum	
(e)	Chlorine Residual monitoring equipment		
(i)	Make		

Sr.	Description	Unit	Particulars
(ii)	Type		
(f)	Ventilation System for Container Store Area and Chlorinator Room		
(i)	Make		
(ii)	Capacity	cum/h	
(iii)	Power rating	kW	
(g)	EOT Crane for Chlorine Drum Storage Area		
(i)	Make		
(ii)	Capacity	Tonne	
(h)	Weighing Equipment		
(i)	Make		
(ii)	Type		
(iii)	Number		

8.2.7. Centrifuge

Sr.	Description	Unit	Particulars
(a)	General		
(i)	Make		
(ii)	Model		
(iii)	Type		
(iv)	Numbers	nos.	
(vi)	Capacity of each Centrifuge	cum/hr	
(vii)	Duration of Operation of each Centrifuge per day	hours	
(viii)	Dry solids in dried sludge	%	
(b)	Material of Construction		
(i)	Plates		
(ii)	Cloth		
(iii)	Skeleton		
(c)	Motor		
(i)	Make		
(ii)	Motor Rating	cum/hr	
(iii)	Speed	rpm	
(iv)	Efficiency		
	- Full load		
	- 3/4th load		
(v)	Power Factor		
	- Full load		

Sr.	Description	Unit	Particulars
	- 3/4th load		
(vi)	Class of Insulation		
(vii)	Type of Cooling		
(viii)	Degree of Protection		
(ix)	Type of Enclosure		
(x)	Class of temperature rise		
(d)	Weight	kg	

8.2.8. Mixers - Lime Solution

Sr.	Unit	Details
(i)	Number of working units (nos.)	
(ii)	Number of standby units (nos.)	
(iii)	Type	
(iv)	Tank Size (mm x mm)	
(v)	SWD in Tank (mm)	
(vi)	Tank Type	
(vii)	Material of Construction	
(viii)	Drive	
(ix)	Motor	
	- Make	
	- Power Supply	
	- Motor Rating	
	- Efficiency	
	- Speed	
	- Type of cooling	
	- Type of enclosure	
	- Degree of Protection	
	- Class of insulation	

8.2.9. Mixers - Polyelectrolyte Solution

Sr.	Unit	Details
(i)	Number of working units (nos.)	
(ii)	Number of standby units (nos.)	
(iii)	Type	
(iv)	Tank Size (mm x mm)	
(v)	SWD in Tank (mm)	
(vi)	Tank Type	
(vii)	Material of Construction	
(viii)	Drive	

Sr.	Unit	Details
(ix)	Motor	
	- Make	
	- Power Supply	
	- Motor Rating	
	- Efficiency (%)	
	- Speed (rpm)	
	- Type of cooling	
	- Type of enclosure	
	- Degree of Protection	
	- Class of insulation	

8.2.10. Mixers - Sludge

Sr.	Unit	Details
(i)	Number of working units (nos.)	
(ii)	Number of standby units (nos.)	
(iii)	Type	
(iv)	Tank Size (mm x mm)	
(v)	SWD in Tank (mm)	
(vi)	Tank Type	
(vii)	Material of Construction	
(viii)	Drive	
(ix)	Motor	
	- Make	
	- Power Supply	
	- Motor Rating	
	- Efficiency (%)	
	- Speed (rpm)	
	- Type of cooling	
	- Type of enclosure	
	- Degree of Protection	
	- Class of insulation	

8.3. ELECTRICAL POWER CONSUMPTION

Bidders to give the power consumption of the proposed STP as per following format on their letter head.

8.3.1. Load List for the plant (100 % flow)

Sr. No.	Equipments, Buildings, area lighting, yard lighting	Rating (kW)	Quantity		No of hrs of operation	kW consumed / absorbed at rated duty	Power consumed per day in kWH
			W	S			
	Guaranteed power Consumed						

8.3.2. Load List for the plant (50 % flow)

Sr. No.	Equipments, Buildings, area lighting, yard lighting	Rating (kW)	Quantity		No of hrs of operation	kW consumed / absorbed at rated duty	Power consumed per day in kWH
			W	S			
	Guaranteed power Consumed						

"We confirm that that we have included all process equipment required to operate the plant and this shall be sum total of maximum power consumed by the STP for its operation for treating raw sewage to get the desired treated sewage parameters as given in the addendum. AMC reserves the right to use higher figure for power consumptions for bid evaluation in case of any discrepancy.

The list of equipment and the power consumption is final and guaranteed."

The above table along with the guarantee mentioned above shall be submitted on the letter of the bidder.

8.3.3. Transformer Sizing

Particulars		Value	Unit	Formula
Total working load as per list furnished load list	=		kW	A
Loading of all motors	=		%	B
Total running load	=		kW	C= A x B /100
Efficiency	=		%	D
Operating corrected power factor (0.98)	=			E
Total kVA drawn from the system	=		kVA	F= Cx100/ (DxE)
Add lighting load of the plant	=		kVA	G
Total load on the transformer	=		kVA	H= F+G
Add allowance as contingency	=		%	(I)
Total max. load on transformer	=		kVA	J= H x (1+I/100)
Considering the operating loading of transformer	=		%	K
Minimum transformer capacity required	=		kVA	L= (J x 100) /K
Selected Transformer Size	=		kVA	

8.3.4. Power Transformer

Sr.	Item	Unit	Description	Remarks/ make
A	General			
(i)	Application/Designation			
(ii)	Manufacturer			
(iii)	Quantity			
(iv)	Installation Indoor / Outdoor			
B	Ratings			
(i)	Rating	kVA		
(ii)	No. Load voltage :			
	- LV Winding	kV		
	- LV Winding	kV		
(iii)	Quantity supplied	Nos.		
(iv)	Rated Frequency	Hz		
(v)	Rated Percentage Impedance at 75°C			
C	Winding Connections			
(i)	HV			
	LV			
	Vector Group			
(ii)	Application/Direction of Power Flow			
(iii)	Cooling Method			
D	Transformer Protection provided - Buchholz relay, winding & oil temp. indicators, OLTC, surge relay, PRD, MOG			
E	System Data			
(i)	System Voltages			
	- HV Nominal/Highest	kV		
	- LV Nominal/Highest	kV		
(ii)	Fault Levels			
	- HV System	MVA		
	- LV System	MVA		
(iii)	System neutral earthing			
	- HV system			
	- LV system			

Sr.	Item	Unit	Description	Remarks/ make
(iv)	Efficiency at 75°C at unity PF at full load	%		
(v)	Full load regulation at 75°C			
F	Losses			
(i)	No load loss on principal tap at 100% rated voltage & frequency subject to +10% tolerance as per IS	kW		
(ii)	Load loss on principal tap & rated current at 75°C winding temp. (guaranteed subject to +10% tolerance as per IS & excluding copper losses)	kW		
G	Winding Insulation Whether fully insulated/material of insulation			
H	Guaranteed maximum temperature rise over 40°C			
(i)	Ref. Ambient Temp.	°C		
(ii)	Temp. rise of oil by Thermometer	°C		
(iii)	Temp. rise of winding by resistance	°C		
I	Tappings			
(i)	Tapping on winding			
(ii)	Whether on load/off Load			
(iii)	Total Tapping Range			
(iv)	Step			
(v)	Capacity full/reduced			
(vi)	On HV/LV Winding			
(vii)	If on load taps specify details of OLTC gear			
	- Manual/Automatic			
	- Remote/Local Control			
	- Voltage class of OLTC			
	- Current rating of OLTC			
J	Terminal Bushings			

Sr.	Item	Unit	Description	Remarks/ make
(i)	Rated Voltage Class	kV		
(ii)	Minimum clearance in air			
	- Phase to phase	mm		
	- Phase to ground	mm		
(iii)	Minimum creepage distances (Total)	Mm		
(iv)	One minute power frequency withstand dry & wet			
(v)	1.2/50 impulse withstand			
K	Terminal Connections			
(i)	HV winding			
(ii)	LV winding			
(iii)	Mounting			
(iv)	Class of Insulation			
(v)	Busbar size in secondary			
(vi)	LV wdg neutral end			
(vii)	Disconnecting chamber /cable box			
L	Magnetizing current at rated voltage & frequency			
(i)	When excited from LV side			
(ii)	When excited from LV side at 110% rated voltage			
M	Maximum Flux Density			
(i)	At rated voltage			
(ii)	At 110% rated voltage			
N	Current Density			
(i)	HV			
(ii)	LV			
O	Miscellaneous			
(i)	Final painting Color shade as per IS:5			
P	Weight			
(i)	Core & windings	kg		
(ii)	Oil	kg		
(iii)	Tank, coolers & fittings	kg		
(iv)	Total	kg		

Sr.	Item	Unit	Description	Remarks/ make
(v)	Un tanking weight	kg		
Q	Dimensions			
(i)	Width	mm		
(ii)	Height	mm		
(iii)	Depth	mm		
R	Details of Fittings & Accessories			
a)	Inspection Cover			
b)	Rating Plate			
c)	Terminal marking plate			
d)	Two earthing terminals			
e)	Lifting lugs			
f)	Drain valve			
g)	Dehydrating breather			
h)	Oil level prismatic			
i)	Thermometer pocket			
j)	Oil filling hole with cover			
k)	Conservator			
l)	Air release plug			
m)	Jacking pads			
n)	Filter valves			
o)	Weatherproof marshalling box with internal connecting cabling			
p)	Cable box air insulated on HV Side with disconnecting chambers with suitable lugs & glands			
q)	Winding temp. indicator with Mercury switches for alarm and trip			
r)	Oil temperature indicator with mercury switches for alarm and trip			
s)	Magnetic oil level gauge with mercury switch for Alarm Dial Size of magnetic oil level gauge			
t)	Pressure relief valve with alarm contacts			
u)	Buchholz Relay with Alarm			

Sr.	Item	Unit	Description	Remarks/ make
	and Trip contacts			
v)	Neutral CT - 2 Nos. Mounted on Tank /L.V Bus Box			
w)	Wheels Flat/flanged Unidirectional/Bidirectional Quantity Gauge			

8.3.5. Medium Voltage Switchgear (not exceeding 1000V)

Sr. No.	Item	Unit	Description	Remarks/ make
A	General Construction of Switchgear			
a)	Manufacturer/Assembler			
b)	Quantity offered	No.		
c)	Switchgear designation			
d)	Applicable Standards			
e)	Installation Indoor/Outdoor			
f)	Single front or double front			
g)	Module Construction			
h)	Degree of Protection (As per IS:2147)			
i)	Cable Entry - for incoming cables - for outgoing cables			
j)	Sheet Steel Construction			
	- Cold rolled/Hot rolled			
	- Thickness Frames Door Rear cover Side and top covers Panel partitions	mm		
	Has the sheet metal been treated in accordance with the specifications			
	One minute power frequency with stand voltage Main circuit Control circuit			

Sr. No.	Item	Unit	Description	Remarks/ make
	Aux. Circuits connected to CTs/PTs			
k)	Painting/Powder Coating			
l)	Paint Shade			
m)	Acceptable temp rise inside the panel above amb. Temp.			
n)	Socket / Space heater / internal cubicle lighting			
o)	Control Supply			
p)	Total Dimensions of each switchgear Length x Width x Depth			
q)	Fully drawout/semi drawout/ Fixed			
B	Busbars			
(i)	Material			
	- Phase			
	- Earth			
(ii)	Size Phase Earth	 mm mm		
(iii)	Voltage Rating	V		
(iv)	System Frequency	Hz		
(v)	HV Power Frequency withstand test voltage			
(vi)	Rated Current			
	- Continuous	A		
	- Short time	A		
(vii)	Maximum limit of temperature	°C		
(viii)	Whether busbars have been insulated			
(ix)	Type of insulation			
(x)	Temperature rise over the reference ambient when carrying rated current	°C		
(xi)	Material of busbar supports			
(xii)	Clearances in air in mm			
	- Between phases			
	- Between phases & earth			
(xiii)	Short time rating in kA (One sec)			

Sr. No.	Item	Unit	Description	Remarks/ make
(xiv)	Momentary rating (peak			
C	Air Circuit Breakers			
(i)	Make			
(ii)	Applicable standard			
(iii)	Type designation			
(iv)	Rated Voltage	V		
(v)	Rated Current	A		
(vi)	Number of Poles			
(vii)	Short circuit withstand capacity (RMS)			
(viii)	Type of Operating mechanism			
(ix)	Insulation level (1 minute power frequency withstand) voltage)			
(x)	Details of Releases provided			
(xi)	Type of Releases			
	Moulded Case Circuit Breaker (MCCB)			
(i)	Make			
(ii)	Applicable standard			
(iii)	Type designation			
(iv)	Rated Voltage	V		
(v)	Rated Current	A		
(vi)	Protections			
	Fuse Switch Units			
(i)	Make			
(ii)	Applicable standard			
(iii)	Type designation			
(iv)	Rated Voltage	V		
(v)	Rated Current	A		
(vi)	Maximum prospective fault current withstand of composite unit of switch & fuse			
D	Fuses			
(i)	Make			
(ii)	Type			
(iii)	Applicable standard			

Sr. No.	Item	Unit	Description	Remarks/ make
(iv)	Rated voltage	V		
(v)	Rated current for individual circuits to be provided as per requirements of protection & coordination	A		
(vi)	Reputuring capacity at rated voltage (prospective current)			
E	Control/Selector switch			
(i)	Make			
(ii)	Type designation			
(iii)	Number of positions			
(iv)	Number of poles			
(v)	Contact rating	A		
(vi)	Rated Voltage	V		
F	Starters			
(i)	Applicable Standard			
(ii)	Starter Type			
(iii)	Class of duty			
(iv)	Rated Voltage	V		
(v)	Quantity of each type	nos.		
G	Contactor			
(i)	Make			
(ii)	Type			
(iii)	Applicable standards			
(iv)	Rated duty			
(v)	Rated Utilization Category			
(vi)	No. of auxiliary contacts required			
(vii)	Rated voltage of main contacts	V		
(viii)	Rated (thermal) current	A		
(ix)	Rated voltage of auxiliary contacts	V		
(x)	Rated voltage of coil	V		
(xi)	Rated breaking capacity Factor of rated Current			
(xii)	Rated making capacity Factor of rated current			
(xiii)	Insulation class for winding of electromagnet			

Sr. No.	Item	Unit	Description	Remarks/ make
(xiv)	Limits of operation Supply voltage variation Supply frequency variation for closing Drop out voltage			
(xv)	Number of auxiliary contacts			
	- Normally open			
	- Normally closed			
(xvi)	Current rating of auxiliary contacts at Control Voltage Make and carry Break	 A A		
H	Single Phasing Reventers			
(i)	Make			
(ii)	Type designation			
(iii)	Rated voltage	V		
(iv)	Setting (voltage unbalance as percentage of rated voltage)			
(v)	Operating time	Sec		
(vi)	Number of contacts			
	- Normally open			
	- Normally closed			
(vii)	Contact rating	A		
I	Current Transformers			
(i)	Make			
(ii)	Applicable standards			
(iii)	Type			
(iv)	CT Ratio			
(v)	VA Burdon	VA		
(vi)	Accuracy class			
(vii)	Instrument security factor			
(viii)	Short time current for 1 Sec			
(ix)	Momentary current			
(x)	Class of insulation			
J	Voltage Transformers			
(i)	Make			
(ii)	Applicable standards			
(iii)	Ratio			
(iv)	VA Burdon per phase			
(v)	Accuracy class			

Sr. No.	Item	Unit	Description	Remarks/ make
(vi)	Over voltage factor			
(vii)	Class of insulation			
K	Control Transformer			
(i)	Make			
(ii)	Type			
(iii)	Applicable standards			
(iv)	Ratio			
(v)	Class of insulation			
(vi)	VA Rating			
L	Instantaneous Over current Relay (External)			
(i)	Application (phase fault or earth fault)			
(ii)	Make			
(iii)	Type designation			
(iv)	Setting range			
M	Inverse Time & Thermal Over current relay			
(i)	Application			
(ii)	Make			
(iii)	Type			
(iv)	Current setting range			
(v)	Time setting range at 10 times the current setting			
N	Under voltage Relay			
(i)	Make			
(ii)	Type			
(iii)	Voltage rating			
(iv)	Setting range			
O	Auxiliary Relays and Timers			
(i)	Make			
(ii)	Type			
(iii)	Coil voltage	V		
(iv)	Time delay range (for timers)	Sec		
(v)	Resetting features			
(vi)	No. of contacts Normally open/Normally closed			
(vii)	Contact rating	A		

Sr. No.	Item	Unit	Description	Remarks/ make
(viii)	Whether operation indicator is provided			
P	Voltmeter			
(i)	Make			
(ii)	Type			
(iii)	Applicable standard			
(iv)	Accuracy class			
Q	Ammeter			
(i)	Make			
(ii)	Type			
(iii)	Applicable standard			
(iv)	Accuracy class			
R	Wattmeter			
(i)	Make			
(ii)	Type			
(iii)	Applicable standard			
(iv)	Accuracy class			
S	Space Heater			
(i)	Make			
(ii)	Type			
(iii)	Rated voltage	V		
(iv)	Heater output for each vertical panel	W		
(v)	Thermostat setting range	°C		
T	Control Wiring			
(i)	Size			
(ii)	Type			
(iii)	Insulation			
(iv)	Voltage grade	V		
(v)	Colour Code			
(vi)	Minimum size of conductor for			
	- Power wiring	mm		
	- Control wiring	mm		
U	Control Terminal Blocks			
(i)	Make			
(ii)	Type of terminal blocks			

Sr. No.	Item	Unit	Description	Remarks/ make
	- For with draw able type			
	- For Fixed Type			
(iii)	Voltage grade	V		
(iv)	Current rating	A		
(v)	10%spare terminal to be furnished			
(vi)	Whether terminals for CT's have been provided with short circuiting facilities			
V	Push Button			
(i)	Make			
(ii)	Type designation			
(iii)	Rating	A		
(iv)	Number of contacts			
	- Normally open			
	- Normally closed			
(v)	Emergency Push Button			
W	Indicating Lamps			
(i)	Make			
(ii)	Type			
(iii)	Voltage	V		
(iv)	Lamp Watts	W		
(v)	Colour			
(vi)	Series resistor			
X	Indicating Meters			
(i)	Type			
(ii)	Dial Size			
(iii)	Accuracy Class			
Y	Relays			
(i)	Type of State			
	- Solid state			
	- Electromagnetic			
	- Microprocessor based			
(ii)	Type of Relay			
	Over current Short Circuit Under Voltage CT Ratio Class of Accuracy			

Sr. No.	Item	Unit	Description	Remarks/ make
(ii)	Type of Relay			
	- Over current			
	- Short Circuit			
	- Under Voltage			
	- CT Ratio			
	- Class of Accuracy			
Z	Annunciation			
(i)	Make			
(ii)	Make			
(iii)	Number of windows			
(iv)	Voltage			

8.3.6. Shunt Capacitor Sizing

Total Working load	Present P.F (ϕ1)	New P.F.	TAN (ϕ1)	TAN (ϕ2)	KVAR Required
A			B	C	D = Ax (B-C)

Configuration of the Capacitor Bank selected

Rating of the Capacitor Bank selected

8.3.7. Shunt Capacitor

Sr.	Item	Unit	Description	Remarks/ make
(i)	Name of manufacturer			
(ii)	Manufacturer's type and designation			
(iii)	Reference Standards			
(iv)	Rated VAR capacity of the capacitor bank			
(v)	Rated voltage			
(vi)	Rated frequency			
(vii)	Output of the capacitor bank at rated voltage	KVAr		
(viii)	Temperature rise over the specified ambient temperature as mentioned	°C		
(ix)	Hot spot temperature at rated current	°C		
(x)	Maximum operating	°C		

Sr.	Item	Unit	Description	Remarks/ make
	Temperature			
(xi)	Capacity of Bank	Micro farads		
(xii)	Rated line current Maximum permissible overload current	A A		
(xiii)	Capacitor Losses			
	- For complete Bank	Watts		
	- For individual units	Watts		
(xiv)	Electrical clearance in the capacitor bank			
	- Phase to phase min	mm		
	- Phase to earth min	mm		
(xv)	Permissible Harmonics	%		
2	Unit Capacitors			
(i)	Rated Voltage	V		
(ii)	Rated Output	kVAr		
(iii)	Number of phases			
(iv)	Whether single bushing or multibushing type			
(v)	Maximum overvoltage the unit capacitor is capable of with standing continuously	%		
(vi)	Insulation strength to earth			
(vii)	Number of capacitor elements per capacitor			
(viii)	Mode of internal connection of the capacitor element			
(ix)	Type of active element			
	- Watt loss of paper at various dielectric temperature enclosed	Yes / No		
	- Thickness	Mm		
	- Alternating nominal r.m.s. voltage stress on the dielectric paper	Volts / mm		
(x)	Type of impregnant used Pressure at which the impregnant is kept within the	kg/mm^2		
	unit			
3	Capacitor Fuses			

Sr.	Item	Unit	Description	Remarks/ make
3.1	Rating of the fuse element Current Voltage	 A V		
3.2	Strength of the fuse elements in Amp Sec at which it melts	Amp Sec.		
3.3	Type of the fuse			
3.5	Discharge device used			
3.6	No. of stages			
4	General			
4.1	Overall dimensions of bank and units	mm		
4.2	Layout and dimension drawings attached	Yes / No		
4.3	Type test certificates enclosed	Yes / No		

8.3.8. Capacitor Control Panel

Sr.	Item	Unit	Description	Remarks/ make
(i)	Manufacturer/Assemble			
(ii)	Quantity			
(iii)	Dimensions of capacitor control panel			
	- Width	mm		
	- Depth	mm		
	- Height	mm		
(iv)	Enclosure Protection			
(v)	Auto Power factor relay			
	- Manufacturer			
	- Type			
	- Number of stages			

8.3.9. Push Button Station

Sr.	Item	Unit	Description	Remarks/ make
(i)	Manufacturer			
(ii)	Enclosure thickness			
(iii)	Number of contacts			
(iv)	Contact rating at 240V AC			

8.3.10. Cables

Sr.	Item	Unit	Description	Remarks/ make
1.1	11 kV XLPE UNEARTHED POWER CABLE			
a	Manufacturer			
b	Permissible voltage, frequency & combined Variation			
c	Continuous current rating	A		
d	De-rating factors for -Variation in ambient temp. in steps of 5deg.Cent. Grouping of cables incovered trenches			
e	Short circuit capacityCurrent & duration Maximum conductortemp	kA/sec °C		

Sr.	Item	Unit	Description	Remarks/ make
f	Loss tangent at normal frequency			
g	Conductor Composition - Cross section	sq.mm.		
h.	Type of conductor screening			
i	Insulation Composition - Thickness	Mm		
j	Type of insulation screening			
k	Inner sheath Material Calculated dia. Over stranded cores	Mm		
l	Outer sheath Material Thickness	mm		
m	Armour Type Nominal diameter of cable over inner sheath Armour thickness/wire diameter	Mm mm		
n	Overall diameter of cable	mm		
o	Recommended minimum bending radius	mm		
p	Safe pulling force when pulled by pulling eye			
q	Standard length of cable in drum	m		
1.2	650/1100V grade PVC INSULATED POWER CABLES			
a	Manufacturer & cable type			
b	Rated Voltage			
c	Permissible voltage, frequency Variation			
d	Continuous current rating	A		

Sr.	Item	Unit	Description	Remarks/ make
e	De-rating factors forVariation in ambient temp. in steps of 5deg.CentGrouping of cables in covered trenches			
f	Short circuit capacity Current & duration Maximum conductor temp	 kA/sec °C		
g	Conductor Composition Cross section	 sq.mm.		
h	Insulation Composition Thickness	 Mm		
i	Inner sheath Material Calculated dia. Over stranded cores	 Mm		
j	Outer sheath Material - Thickness	 mm		
k	Armour Type Nominal diameter of cable over inner sheath Armour thickness/wire diameter	 mm mm		
l	Overall diameter of cable	mm		
m	Recommended minimum bending radius	mm		
n	Standard length of cable in drum	m		
1.3	650/1100V grade PVC INSULATED CONTROL			
	CABLES			
a	Manufacturer & cable type			
b	Rated Voltage			
c	Conductor Composition Cross section	 sq.mm.		
d	Insulation Composition	 Mm		

Sr.	Item	Unit	Description	Remarks/ make
	Thickness			
e	Inner sheath Material	mm		
f	Outer sheath Material - Thickness	mm		
g	Armour Type Nominal diameter of cable over inner sheath Armour thickness/wire daimeter	mm mm		
h	Overall diameter of cable	mm		
i	Standard length of cable in drum	Mtr.		

8.3.11. Lighting System

Sr.	Item	Unit	Description	Remarks/ make
A	Lighting Fittings			
(i)	Manufacturer			
(ii)	Nominal working voltage	V		
(iii)	Maximum permissible supply voltage variation	%		
(iv)	Power factor at normal working voltage & frequency			
(v)	Power loss per ballast at normal working voltage & frequency	W		
B	Emergency Lighting Fittings			
(i)	Manufacturer			
(ii)	Rated voltage	V		
(iii)	Light output duration			
(iv)	Lamp rating (AC/DC)	W		
(v)	Catalogue containing technical literature enclosed			
	Yes/No			
C	Lighting Installation			
(i)	Earthing conductor			
	- Size			
	- Material			
(ii)	Conduit			

Sr.	Item	Unit	Description	Remarks/ make
	- Size			
	- Material			
(iii)	Wire/cables			
	- Conductor			
	- Material			
	- Size			

8.3.12. Terminations

Sr.	Item	Unit	Description	Remarks/ make
(i)	Gland type			
(ii)	Lugs			
(iii)	Application Indoor/Outdoor			

8.3.13. Cable Tray

Sr.	Item	Unit	Description	Remarks/ make
a	Manufacturer			
b	Type			
c	Material			
d	Finish			
e	Tray width			
f	Cable tray supports and fixing			
	- Type			
	- Material			
	- Finish			

8.3.14. Earthing System

Sr.	Item	Unit	Description	Remarks/ make
(i)	Earthing conductor buried in			
	Ground			
	- Material			
	- Size			
(ii)	Earthing conductor above			
	ground upto equipmentterminal			
	- Material			
	- Size			

Sr.	Item	Unit	Description	Remarks/ make
(iii)	Earth Electrode test pits			
	- Material			
	- Size			
	- Type of Electrode			

8.4. PERFORMANCE GUARANTEE

The Tenderer shall provide requirement of electrical energy and chemical usage for the qualities of raw sewage and effluent standards to be met as detailed in Volume IIIA: Scope of Work.

Note: The values provided in this schedule will be used to determine a typical annual running cost for the Works. These costs shall be used in calculations of NPV for the bid.

8.4.1. Functional Guarantees

The Tenderer Guarantee the performance of the Plant namely 100 MLD capacity STP at Kalwa in the performance and in O & M period as per following format:

8.4.2. Plant Effluent

The characteristics of treated sewage achieved is guaranteed to be

1. BOD_5 20°C, mg/l :
2. Suspended Solids, mg/l :
3. pH :
4. Oil & Grease, mg/l :

8.4.3. Electrical Energy Usage per Unit Volume of Treated Sewage

The energy usage for the Plants during the Performance and O & M period is guaranteed to be not more than _____ kWh per m3 of treated sewage

The energy costs detailed above shall be for the whole plant.

8.4.4. Chlorine usage per Unit of Treated Sewage

The consumption of chlorine during Performance and O & M period is guaranteed to be not more than _____ kg per m3 of treated sewage.

8.5. MISCELLANEOUS INFORMATION

The Tenderer shall provide other supporting data, which he considers necessary to complete his proposal.

VOLUME II-B
CIVIL SPECIFICATIONS

TABLE OF CONTENTS - VOLUME II B,

CIVIL SPECIFICATIONS

LIST OF TABLES

PREAMBLE

1.0 The “Volume IIB: Civil Specifications” are to be read for the purpose of pricing in conjunction with "Volume-I: Conditions of Contract" of the Tender Documents containing instructions to Tenderer and General Conditions of Contract; “Volume IIA: Scope of Work” under this tender; “Volume IIC: Mechanical Specifications”, “Volume IID: Electrical Specifications”, “Volume IIE: Automation and control panel specification”,and “Volume-III: Financial Bid” of this tender.

2.0 The prices quoted in the Volume III: Financial Bid shall be all inclusive value for the work described including all costs and expenses which may be required in and for the execution of the work described together with all general risks, liabilities and obligations set forth or implied in the document on which the tender is based.

3.0 All works shall be carried out strictly as per detailed specifications whether actually specified or not. If not specified work shall be carried out as per directions of Owner/Engineer In Charge.

4.0 The total amount entered in the Volume III: Financial Bid shall be written in ink and shall be entered both in figures and words.

5.0 Specifications of items of work described in Section D for each item shall read this in conjunction with other technical specifications and specific technical requirements and quote accordingly.

6.0 No separate payment whatsoever shall be made for dewatering if required to be done during excavation, laying of PCC and RCC laying and jointing of pipes, construction of manholes, testing and backfilling etc. and Contractor should quote accordingly.

7.0 If the Tenderer needs any clarification, they shall obtain the same in writing from Owner/Engineer. No notice will be taken of any verbal discussions in such matters.

8.0 Abbreviations used in this Volume IIB : Civil Specifications document have the meanings shown below:

mm	Millimetre	CI	Cast Iron
cm	Centimetre	GI	Galvanized Iron
m	Metre	GSW	Glazed Stone Ware
km	Kilometre	BBCC	Burnt Brick Cement Concrete
sq.m	Square Metre	RCC	Reinforced Cement Concrete
cum.	Cubic Metre	PCC	Plain Cement Concrete
M.T.	Metric Ton	wt	Weight
SWG	Standard Wire Gauge	kg	Kilogram
R.M.	Running Metre	I.D.	Internal Diameter
nos.	Numbers	C.M.	Cement Mortar
MS	Mild Steel	IS	Indian Standards
M.D	Metre Depth of Manhole	SS	Stainless Steel
HDPE	High Density Polyethylene	DWC	Double Wall Corrugated

1. GENERAL

1.1. SPECIFICATION DRAWINGS

The site plan, schematic flow diagram and layout plan drawings of the proposed work(s)/plant(s) are incorporated in tender documents. These drawings are made for Tenderer's guidance only.

The Contractor will have to submit detailed design as well as General Arrangement drawings as well as structural drawings to the Engineer-in-Charge and obtain prior approval to start the construction, erection and commissioning of civil, electrical and mechanical components of the treatment plant, Pumping stations, Sewer collection networks and works mentioned in scope of work clause.

Work shall be carried out by Contractor exactly in accordance with the Drawings marked as RELEASED FOR CONSTRUCTION and approved by Engineer-in-Charge and as per the instructions of the Engineer-in-Charge in writing.

1.2. GEO-TECHNICAL STUDIES

The bidders are free to visit and inspect the sites till the submission date for the purpose of quoting and estimation. The Contractor shall carry out geo-technical studies at their cost at the site and with prior permission of Engineer-in-Charge, from AMC approved soil consultant and the report should be furnished to the AMC/Consultant and should approved by AMC/Consultant prior to start of structural design & drawings. AMC accepts no responsibility, whatsoever for inferences drawn from this data and the Contractor is to satisfy AMC on his own responsibility as to the extent to which this information represents the conditions to be encountered.

1.3. MATERIALS

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 new and of the kinds and qualities described in the Contract and shall be approved by the Engineer in- charge.

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.

1.3.1. Samples and Tests of Materials

1. The Contractor should submit test certificates of the materials at the time of material unloading on the site.
2. The Contractor shall submit samples of such materials as may be required by the Engineer-in-Charge and shall carry out the specified tests directed by the Engineer- in-Charge at the site, at the supplier's premises and at a laboratory approved by the Engineer-in-Charge.
3. The Contractor should give Engineer-in-Charge seven days notice in writing about the date on which any of the materials will be ready for testing or inspection at the supplier's premises or at a laboratory as approved by the Engineer-in-Charge. The Engineer shall attend the test at the appointed place within 7 days of the said date on which the materials are expected to be ready for testing or inspection according to Contractor, failing to which the test may proceed in his absence unless instructed by

Engineer-in-Charge to carry out such a test on a mutually agreed upon date in his presence. The Contractor shall in any case submit to the Engineer-in-Charge within seven days of every test such number of certified copies (not exceeding six) of the test readings as the Engineer-in-Charge in charge may require.

4. Approval by the Engineer-in-Charge as to the placing of orders for materials or as to samples or tests shall not prejudice any of the Engineer-in-Charge's powers under the contract particularly as to the provisions under the conditions of contract.
5. The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.
6. In any case the Contractor shall not use any material without prior testing and clearance by the Engineer-in-Charge. In case such material is used, this will be liable for rejection either partly or fully.
7. If required rejected material shall be marked and stockpiled separately; and such rejected material shall be taken out within a week from construction site. The cost of the material testing at the supplier premises and as on the site shall be borne by the Contractor and without prior testing and clearance of the Engineer-in-Charge, the materials should not be used for the work.

1.4. DESIGN STANDARDS

All components of the work shall be in accordance with the provision of the relevant Codes of practice and Specifications. In particular the following codes in the order mentioned shall take precedence.

1. The special attention of the Contractor is drawn to the relevant sections and clauses of the National Building Code of India 1984 & Maharashtra PWD specifications, MORTH Codes and Specification, IRC codes, CPHEEO manual guidelines, MJP guidelines and latest BIS Codes (Latest editions along with amendments) and should follow them strictly in addition to the specifications & conditions stipulated in this volume.
2. Materials and workmanship shall comply with the relevant Indian Standards (with amendments) current at the Tenth day of August, 2001, unless a more recent amendment is specified hereinafter, or with the requirements of any other authoritative standard approved by the Engineer-in-Charge which shall be no less exacting in the opinion of the Engineer-in-Charge than the corresponding standard quoted here in.
3. Where the relevant standard provides for the furnishing of a certificate to the AMC on request, stating that the materials supplied comply in all respects with the standard, the Contractor shall obtain the certificate and forward it to the Engineer-in-Charge.
4. The specifications, standards and codes listed below are made a part of this specification. All standards, tentative specifications, specifications, codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions.
5. If no standard is indicated, the relevant Indian Standard, if any, shall apply. Indian standards are published by BIS.
6. HandBook (1990) shall be followed, wherever not specified in this “Volume II: Technical Specifications”, Maharashtra PWD specifications (1990) and IS specifications shall be applicable in case of discrepancy Engineer-in-Charge’s decision will be final & binding. Specifications for different Materials as per IS codes

1.5. LIST OF IMPORTANT INDIAN STANDARDS

The following list includes various Indian Standards which are IMPORTANT and are referred to in the general specifications and used in construction works. These standards are to be strictly adhered to unless otherwise is applicable in the relevant context. These standards are to be followed both in respect of materials and construction of civil engineering works included in the

tenders.

Though the list of Indian Standards includes the year of Publication of the standard, it may not in all cases be the latest. It is obligatory that only the latest edition of the standard is referred to and followed, along with all amendments and revisions issued with respect to the standard under consideration. This list is not exhaustive but contains only the standards that are very frequently used on the construction works. If a standard exists for a particular item of material or equipment or code of practice the same shall be followed whether the same is included in this list, specifications, other parts of the tender documents or not. Some Indian Standards are referred to in the specifications/ drawings/ other parts of the tender documents and they are supplementing this list if they do not find a place in the list.

Table 1: List of IS

Sr.No	IS Code No. / Year	Title
1	153-1950	Ready mixed paint, spraying, stoving, lead free, for general purposes
2	171-1985	Cotton and cotton regenerated cellulosic fibre blended grey yarn
3	2062-1984	Specification for Structural Steel (Fusion Welding Quality)
4	269-1976	Ordinary and low heat Portland cement
5	383-1970	Coarse and fine aggregates from natural sources for concrete
6	432(part1)-1982	Mild steel and medium tensile steel bars
7	455-1976	Portland slag cement
8	456	Code of practice for plain and reinforced cement concrete
9	458-1971	Concrete pipes
10	516-1959	Methods of test for strength of concrete
11	651-1981	Salt-glazed stoneware pipes and fittings
12	783-1985	Code of practice for laying of concrete pipes
13	784-1978	Pre-stressed concrete pipes
14	800-1984	Code of practice for general construction in steel
15	816-1969	Code of practice for use of metal arc welding for general construction in mild steel
16	1038-1983	Steel-doors, windows and ventilators
17	1077-1986	Common burnt clay building bricks
18	1199-1959	Methods of sampling and analysis of concrete
19	1200 (part1-26)	Method of measurement of building and civil engineering works
20	1363 (part 1-3)	Hexagon head bolts, screws and nuts of product grade C
21	1367	Technical supply conditions for threaded steel fasteners
22	1477 (part 1-2)	Code of practice for painting of ferrous metals in buildings
23	1542-1977	Sand of plaster
24	1726 (part 1,2 & 4)	Cast iron manhole covers and frames
25	1786-1985	High strength deformed steel bars and wires for concrete reinforcement
26	2074-1979	Ready mixed paint, air drying red oxide zinc chrome priming
27	2116-1980	Sand for masonry mortars
28	2212-1962	Code of practice for brickwork
29	2250-1981	Code of practice for preparation and use of masonry mortars
30	2339-1963	Aluminum paint for general purpose in dual container
31	2386 (part I-VIII)	Methods of tests for aggregate for concrete

Sr.No	IS Code No. / Year	Title
32	2502-1963	Code of practice for bending and fixing of bars for reinforced concrete
33	2720 (part IV,VIII)	Methods of test for soil
34	3006-1979	Chemically resistant glazed stoneware pipes and fittings
35	3370 (part I-IV)	Code of practice for concrete structures for the storage of liquids
36	3696	Safety code for scaffolds and ladders
37	3764-1966 (part 1-2)	Safety code for excavation work
38	4082-1977	Recommendations on stacking and storage of construction materials at site
39	4111 (part 1-4)	Code of practice for ancillary structures in sewerage systems
40	4127-1983	Code of practice for laying of glazed stone ware pipes
41	6248-1979	Metal rolling shutters and rolling grills
42	6909-1973	Super sulphated cement
43	7293-1974	Safety code for working with construction machinery
44	7969-1975	Safety code for handling and storage of building materials
45	Code	National Building Code of India
46	4014	Code of practice for steel tubular scaffolding.
47	5121	Code of practice for deep foundation
48	2911-1980 Part III & IV	Code of practice for design and construction of pile foundation
49	3764	Safety code for excavation work
50	4082	Recommendations on stocking & storage material at site.
51	7293	Safety code of working with construction machinery.
52	3114	Code of practice for laying CI pipes
53	5822	Code of practice for laying of welded steel for pipes
54	7364	Plastic pipe work for potable water supply (part I-III)
55	21138	ISO Code for HDPE pipes
56	7634	HDPE pipe laying

2. SPECIFIC CIVIL REQUIREMENTS

2.1. DESIGN SUBMISSIONS

The Contractor shall submit complete detailed design calculations of foundations and superstructure together with general arrangement drawings and explanatory sketches to the AMC. Separate calculations for foundations or superstructures submitted independent of each other should be deemed to be incomplete and will not be accepted by the AMC.

The design considerations described herewith establish the minimum basic requirements of plain and reinforcement 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 take care to check the stability of structure partly constructed to comply with design loads.

2.2. DESIGN STANDARDS

All designs shall be based on the latest International or 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 AMC. In case of any variation or contradiction between the provision of the IS Standards or Code and the specifications given with the submitted tender document, the provision given in the Specification shall The following minimum loads shall be considered in design of structures.

2.3. DESIGN LOADINGS

All building 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, wind load, seismic load, stresses due to temperature changes, shrinkage and creep in materials, dynamic loads and uplift pressure.

2.3.1. Dead Load

This shall comprise all permanent construction including walls, floors, roofs, 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 loads shall be considered in design of structures:

Sr.	Parameter	Load
(i)	Weight of water	10.0 kN/cu.m
(ii)	Weight of 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	20.0 kN/cu.m
(iii)	Weight of plain concrete	24.0 kN/cu.m
(iv)	Weight of reinforced concrete	25.0 kN/cu.m
(v)	Weight of brickwork (exclusive of plaster)	22.0 kN/cu.m per mm thickness of brickwork
(vi)	Weight of plaster to masonry surface	18.0 kN/cu.m per mm thickness

Sr.	Parameter	Load
(vii)	Weight of granolithic terrazzo finish or rendering screed, etc	24.0 kN/cu.m per mm thickness
(viii)	Weight of sand (filter media)	24.0 kN/cu.m

2.3.2. Live Load

Live loads shall be in general as per IS 875. However, the following minimum loads shall be considered in the design of structures.

Sr.No.	Location	Live Loads
1	Office, Conference Hall	400 kg/sq.m
2	Floor supporting Pumping Machinery	1,000 kg/sq.m
3	Storage	750 kg/sq.m
4	Platform, Staircase, Corridors, Walkways	500 kg/sq.m
5	Administration Building - Hall, Toilet	200 kg/sq.m
6	Laboratory	400 kg/sq.m
7	Roof Slab	150 kg/sq.m

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

2.3.3. Wind Load

Wind loads shall be as per IS:875

2.3.4. Earthquake Load

This shall be computed as per IS:1893 considering in Zone-III.

2.3.5. Dynamic Load

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

2.3.6. Other Loads

In addition to earth pressure and water pressure etc., the surcharge of 1 Ton/sq.m shall be taken into account in the design for channels, tanks, pit, sludge settler, etc.

2.4. JOINTS

Movement joints such as expansion joints, complete contraction joints, partial contraction joints and sliding joints shall be designed to suit the structure as per relevant IS code provisions. Expansion joints of suitable gap at intervals not more than 30 m shall be provided in walls, floors and roof slabs of Liquid Retaining Structures.

Construction joints shall be provided at right angles to the general direction of the member. The locations of construction joints shall be decided on convenience of construction. To avoid segregation of concrete in walls, horizontal construction joints are normally to be provided at every 2 m height, PVC waterstops of suitable type and approved make, minimum 230 mm width, 6 m thick shall be used for walls and base slabs.

2.5. 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:

1. Liquid depth up to full height of wall : no relief due to soil pressure from outside to be considered.
2. Structure empty (i.e. empty of liquid, any material, etc) full earth pressure including saturated condition and surcharge pressure wherever applicable to be considered.
3. Partition wall between dry sump and wet sump to be designed for full liquid depth up to full height of wall
4. Partition wall between two compartments to be designed as one compartment empty and other compartment full
5. Structures shall be designed for uplift in empty conditions with the water table indicated in the geotechnical report or high flood level, whichever is maximum. No reduction factor for the uplift force shall be considered.
6. The dead weight of the empty structures should provide a safety factor of not less than 1.2 against uplift pressures during construction and in service.
7. Wall shall be designed under operating conditions to resist earthquake forces from earth pressure mobilisation and dynamic water loads;
8. Underground or partially underground structures shall be checked against stresses developed due to any combination of full and empty compartments with appropriate ground/uplift pressures from below to base slab
9. The walls and base slabs shall be designed for saturated earth/water pressure corresponding to high flood level.

2.6. FOUNDATION

1. The minimum depth of foundations for all structures, equipment's building sand frame foundations and load bearing walls shall be as per IS:1094.
2. The earthfill above virgin ground level till formation level shall be taken as a surcharge load and shall be added in the loads coming on foundations appropriately
3. Maximum safe bearing capacity of soil strata shall be taken as indicated in geotechnical reports.
4. Care shall be taken to avoid 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.
5. Special attention is drawn to danger of uplift being caused by the ground water table
6. Plinth level of all structures/top of tanks shall be atleast 500 mm above high flood level.

2.7. DESIGN REQUIREMENTS

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

1. All blinding and levelling concrete shall be minimum 100 mm thick in concrete grade M15 for Building & minimum 150 mm thick for Water Retaining Structure.
2. All structural reinforced concrete shall be with a maximum 40 mm aggregate size for footings and base slabs and with a maximum 20 mm aggregate size for all the Water Retaining Structures & other structural members.
3. All liquid retaining structures shall be designed as per IS:3370 as Uncracked Section. The minimum grade of concrete shall be M 30.
4. All new liquid retaining structures shall be form finished.
5. For all old liquid retaining structures inside finish shall be provided in CM 1:3 smooth cement plaster 20 mm thick and outside finish shall be 20 mm thick sand face plaster CM 1:3. Snowcem shall also be applied for finishing the outer surfaces.
6. Minimum Cement Content shall be 320 kg/cu.m for M 30 for liquid retaining structures.

7. The maximum free water cement ratio shall not exceed 0.42 for all liquid retaining structures.
8. The amount of reinforcement in each of the two directions at right angles within each surface zone should not be less than the minimum specified as IS:3370 or IS:456 which ever is applicable for the type of structure.
9. Use of pressure relief valves to reduce uplift pressure due to ground water table shall not be allowed.
10. All pipes and ducts laid below the structural plinth and road works shall be surrounded with concrete of grade M15.

The following minimum thickness shall be used for different reinforced concrete members irrespective of design thickness.

Sr.	Civil Member	Width (mm)
(i)	Walls for liquid retaining structures	200
(ii)	Bottom slabs for liquid retaining structures	200
(iii)	Wall foundation for wall of liquid retaining structures	250
(iv)	Walls of Launders	150
(v)	Base slab of Launders	150
(vi)	Roof slabs/Domes for liquid retaining structures	125
(vii)	Floor slabs including roof slabs, walkways canopy slabs	125
(viii)	Walls of cables/pipe trenches, underground pits, etc	125
(ix)	Column footings - Edge Thickness	200
(x)	Column footings - at Face of Column	300
(xi)	Parapets, chajja	100
(xii)	Precast trench cover	75
(xiii)	Beam	230 (width) and 300 (depth)

2.8. MINIMUM COVER TO MAIN REINFORCEMENT

Sr.	Member	Details	Cover (mm)
1	Slab	Free Face	20
		Face in contact with earth	30
2	Beam	Top/Bottom	40
		Side	30
		Face in contact with earth	40
3	Column and pedestal	Super Structure	40
		Face in contact with earth	40
4	Retaining wall, Basement & Pit wall	Face in contact with earth	30
		Free face	30
5	Liquid Retaining Structure	Face in contact with liquid	40
		Face in contact with earth	40
		Free face	40
6	Foundation	Bottom	60
		Top	60
		Sides	50

2.9. MINIMUM BAR DIAMETER

Sr.	Member	Diameter (mm)
1	Major Foundation	10
2	Block Foundation - Main Bars	10
3	Block Foundation - Tie Bars	8
4	Minor Foundation (Local Foundation etc.)	8
5	Column, Pedestal - Main Bars	12
6	Column, Pedestal - Ties	8
7	Beam - Main Bars	12
8	Beam - Anchor Bars	10
9	Beam - Stirrups	8
10	Slab - Main Bars	8
11	Slab - Distribution Bars	8
12	Wall - Main Bars	8
13	Wall - Distribution Bars	8
14	Minor elements such as chajjas, Lintel Beams etc.	8

2.10. BAR SPACING

The bar spacing shall be as per design and conform to IS: 456 - 2000.

Sr.No.	Member	Minimum (mm)	Maximum (mm)
(i)	Foundations	125	200
(ii)	Slabs	100	250
(iii)	Stirrups for Beams	100	250
(iv)	Ties for Columns, Pedestals	100	250
(v)	Walls	100	250

** Bar spacing shall be provided in multiple of 25 mm*.

2.11. MATERIALS

2.11.1. 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.

Expect 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 new and of the kinds and qualities described in the Contract and shall be at least equal to approved samples.

As soon as practicable after receiving the order to commence the works, the Contractor shall inform the AMC of the names of the suppliers from whom he proposes to obtain any materials but he shall not place any order without the approval of the AMC which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the AMC informed of orders for and 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.

2.11.2. Cement

The Cement shall be Ordinary Portland Cement grade-43 / 53, confirming to the relevant BIS codes and approved by the AMC. Manufacturers Test Certificate shall have to be furnished.

2.11.3. Reinforcement Steel

Reinforcement Steel shall confirm to BIS Specification 432-1966 (with up to date revision) and B.I.S. Specification 1786-1985 (with up to date revision). All reinforcement steel shall be Fe 415 TMT grade with preferable make of TATA Tiscon/RINL/SAIL or approved by Engineer In charge will be permitted.

2.11.4. Minimum Cement Content

The minimum cement content for each grade of concrete shall be as per table below.

Sr.	Grade of Concrete	Minimum Cement Content in Concrete (kg/cum of finished Concrete)
(i)	M 20	280
(ii)	M 25	300
(iii)	M 30	320
(iv)	M 35	350

2.12. SAMPLES AND TESTS OF MATERIALS

The Contractor shall submit samples of such materials as may be required by the AMC and shall carry out the specified tests directed by the AMC at the site and at the Site at the supplier's premises or at the laboratory approved by the AMC. All testing charges shall be borne by the contractor.
Samples shall be submitted and tests carried out sufficiently early to enable further samples to be submitted and tested if required by the AMC.

The Contractor shall give the AMC 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 AMC. The AMC 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 AMC to carry out such a test on a mutually agreed date in his presence. The Contractor shall in any case submit to AMC within seven days of every test such number of certified copies (not exceeding six) of the test results as the AMC may require.

Approval by the AMC as to the placing of orders for materials or as to samples or tests shall not prejudice any of the AMC powers under the Contract.
The provisions of this clause shall also apply to materials supplied under any nominated sub-contract.

2.13. ORIENTATION

The works shall be laid out within the confines of the site in order to be compatible with the existing infrastructure facilities, inlet and outlet pipe work /channels and nearby water bodies. Underground services requiring being relocated in order to accommodate the proposed site layout shall be relocated by the Contractor to alignments approved by the Employers Representative.

2.14. ROADWAYS, PATHWAYS & HARDSTANDINGS

A comprehensive network of roadways shall be provided around the treatment plant to link in with the existing approach road and permit access to the plant for necessary maintenance, delivery of consumables and personnel access. All roads shall be of Water Bound Macadam (WBM) with BM + AC of 4 m wide. Vehicular access shall be provided for all Plant structures and buildings. All roads shall be provided with drainage and shall be constructed to prevent standing water.

Paved pedestrian access ways shall be constructed to provide a network of logical routes inter-linking plant areas. Damage to any existing roads, on account of their use by the Contractor shall be made good to the satisfaction of the AMC.

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.

2.15. SITE DRAINAGE

The Contractor shall provide a site drainage system. The system shall comprise of the following:

- Storm Water Drainage
- Foul Drainage

2.15.1. Storm Water Drainage

Storm water drains adjacent to the existing and proposed roads (under this Contract) shall be sized for a rainfall intensity of 50 mm/hr, allowing for 100% runoff. Drains adjacent to roads shall be in stone/brick masonry (1:5) of appropriate thickness topped with 75 mm thick M10 concrete and internally flush pointed plastered in cement mortar (1:4) mm thick.
The storm water drainage system shall be designed to cater for the run-off from the existing plot areas and structures, if necessary.

2.15.2. Foul Drainage

The foul drainage system shall accept discharge from toilets, washrooms, offices and the laboratory. The foul drainage system shall be conveyed to the nearby sewer manhole.

2.16. CABLES AND PIPEWORK TRENCHES

Cables and pipe work trenches shall generally be constructed in reinforced concrete. However, 500mm x 500mm size or small trenches, not on fill may be constructed in 350 mm thick brick masonry (1:4). The trenches will be plastered internally with cement mortar (1:4) and externally in cement mortar (1:3).

Trenches within the buildings or Plant areas shall be covered with GI chequered plates, suitably painted and that outside the buildings shall be covered with M20 premoulded/branded precast RCC covers. The trenches shall be suitably sloped to drain rainwater.

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 AMC while planning the works.

2.17. PIPES AND DUCTS

RCC ducts for drainage shall have adequate cover while laid under roads. Access shafts, where required shall not be of size less than not less than 600 mm x 1000 mm.

All drains (except storm water drains adjacent to roads) shall be covered and designed structurally for appropriate loads.

2.18. SOIL DATA & GROUND WATER TABLE

The contractor shall visit the site and should carry soil investigation and confirm the data at his own cost.

2.19. 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 reinforced concrete framework with concrete floors and roofs.
2. All internal partition walls except for toilet shall be in 230 mm thick brick masonry built in cement mortar 1:5 with transomes and mullions as in (2) above. Toilet partition walls shall be in 115 mm thick brick masonry built in cement mortar 1:4 and shall have transomes and mullions similar to (2) above and shall form panels not exceeding 1200 mm x 1200 mm in size.
3. Toilet floor slab shall be filled with brick bat cobs (broken bricks in lime) and provided with waterproofing as per the specifications of an approved specialist waterproofing company.
4. The finished floor level in toilet areas shall be 25 mm below general finished floor level elsewhere in the building.
5. The toilet facilities shall be provided in Administration-cum-Laboratory building separately for men and women which include at least :
   i) 2 Nos. Toilet (1 no. for men and 1 no. for women) with white porcelain Orissa pan minimum 580 mm long with flushing cistern of 10 litres capacity.
   ii) 2 Nos. wash basins (1 no. for men and 1 no. for women) of size 510 mm x 400 mm in white porcelain with inlet, outlet and overflow arrangements.
   iii) 2 Nos. mirrors (1 no. for men and 1 no. for women) of size 400 mm x 600 mm wall mounted type fitted over wash basins.
   iv) 2 Nos. plastic liquid soap bottles (1 no. for men and 1 no. for women)
   v) 2 Nos. chromium plated brass towel rails (1 no. for mean and 1 no. For women) minimum 750 mm long.
   vi) All stopcocks, valves and pillar cocks shall be heavy-duty chromium plated brass.
   vii) All fittings such as "P" or "S" traps, floor traps, pipes, downtake pipes etc.
   viii) The sewage from toilet blocks shall be led to the nearest AMC sewerage network sewer line.
6. All staircase shall have 25 mm thick chequered mosaic tiles for treads and 25 mm thick plain mosaic tiles of approved shade for risers set in cement mortar or lime mortar to give an overall thickness of 50 mm.
7. All floor cut-outs and cable ducts, etc. shall be covered with precast concrete covers in outdoors areas and mild steel chequered plates of 6 mm thickness in indoor areas. All uncovered openings shall be protected with galvanised MS hand railing.
8. All staircases shall be provided with Stainless Steel hand railing for protection.
9. For the entire finished roof surface shall have adequate slope to drain quickly the rainwater to rainwater down take inlet points.
10. For roofing drainage, CI rainwater down takes with CI bell mouth and MS grating at

top shall be provided. 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 diameter down take pipe shall be provided.

11. 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.
12. All doors, windows, rolling shutters shall have lintels above. Chaija protection to lintels on external walls shall be such as to prevent the rainwater splashing into the building. The minimum width of chajja for doors, windows, and rolling shutter shall be 750 mm, 600 mm, and 900 mm respectively.
13. All windows and ventilators shall have 25 mm thick Tandoor/Kota stone stills bedded in cement mortar (1:3)
14. All concrete channels and ducts use for conveying liquid shall have inside width not be less than 500 mm. All open channels shall be provided with hand railings. Also all such channels, which are more than 1000 mm above finished plot level, shall be provided with walkways for access.
15. Kerbs to be provided below the hand railing on the catwalks/pathways should be as per relevant sections of Factor Act.
16. Wherever equipment and machinery are to be moved for inspection, servicing, replacement etc., suitable movable gantry of minimum capacity of 2 tons or more as required shall be provided with monorail and operating equipment.
17. The design of buildings shall reflect the climatic conditions existing on site. Process buildings shall be as far as is possible permit the entry of natural light.
18. The Laboratory, Chlorine House and office building shall be provided with a sink with two drinking water taps of 20 mm size with adequate inlet and outlet connections.
19. The sidewalls of buildings shall, except those used for storage and handling of Chlorine gas comprise at least 15% ventilation areas. Ventilated brickwork or louvres shall not be used where the ingress of driven rain could affect plant or stored materials.
20. All walkways, staircase, platforms etc, shall be minimum 1200 mm wide and will be provided with hand railing on one or both sides as required.
21. The floor shall generally be made of 150mm thick concrete slab on grade with 230 mm thick rubble soling and polyethylene sheet. The grade slab shall be provided with TOR 8 mm reinforcement Bars at 200 mm c/c bothways.
22. All hardware fittings and fixtures for doors, windows and louvers (e.g. Hinges, bolts, locks, latches, stay doorstops, door closers, floor springs) shall be heavy type matching to the size and weight of the door/window/ventilator shutters. These shall operate easily without hindrance secure properly without jamming; require nominal maintenance durable under prevailing site/weather conditions.
23. Suitable steps and/or ramp with overhead RCC Canopy shall be provided as per requirement, at the entrances of the buildings.
24. 1,000 mm wide Plinth Protection (Apron) shall be provided all around the Building/Sheds.

2.20. ANTICORROSIVE TREATMENT

All the water retaining RCC structures shall be given anticorrosive treatment. The wall from inside shall be coated with polymer anticorrosive paint. It shall be elastomeric (450% elongation), thermoplastic, fire retardant. The coating skin shall have tensile strength of 18 to 21 kg/cm2. It shall be antifungal and antibacterial. The polymer paint shall be of Meta-chem or equivalent make as approved by Engineer-in-charge.

2.21. PRESSURE GROUTING

2.21.1. Products

All components used for grouting repair system are to be from one of the approved makes of polymers. All components are to be of the same make. No components of different makes can be used in conjunction with each other. Only be MC Bauchemie product shall be used.

The product shall only be from the approved list of companies.

Proper care is to be taken when using the material to maintain the required consistency and purity.

Only polymer latexes based on Styrene butadiene (SBR), acrylics, polyvinyl acetate or expoxies can be used. The latex should have solid to a maximum of 50% and minimum of 40%. The physical chemical and structural properties of the material used are to be submitted and specific approval to be seek for the material/system, to be used.

2.21.2. Surface Inspection and Preparation

All surfaces to be treated are to be exposed to the base level with removal of all claddings, plasters, facaders, waterproof layers etc. The surface is to be examined for surface cracks, crevices and spalls and honey combing.

Concrete surface to which treatment is to be applied shall be freshly exposed parent concrete free of loose and unsound materials. Prepare surfaces by mechanical abrasion unless prohibited by environmental limitations in which case acid etching may be used.

Mechanical abrasion - Use sandblasting or scarifying or water blasting or other approved means.

ACID ETCHING - Etch surface with a commercial grade (22 deg. Baume) of hydrochloric acid diluted at a ratio of 10:90 to 20:80. After this application, scrub surface with a stiff bristled broom, or similar implement. Immediately after foaming action of acid has subsided, flush surface with water jets until all residue is removed. Repeat procedure until laitance is completely removed. Wash such areas with water at least three times and allow to air dry prior to further treatment. This method of cleaning is to be used only in exceptional cases and under normal cases permission will not be given for use of this method.

Inspection of concrete surfaces prior to mortar application.

Inspect all concrete surfaces prior to application of mortar to ensure that requirements of this Article are met.

Surfaces shall be free of any deleterious materials such as laitance, curing compounds, dust, dirt and oil. Materials resulting, from surface preparation specified shall be removed.

All concrete surfaces shall be dry as defined in tender below unless a water insensitive coating is used. Surface temperature shall be at least 40F to permit wetting of concrete surface by polymer coating.

Valuate moisture content for concrete by determining if moisture will collect at surfaces. This may be accomplished by taping a 4 x 4ft polyethylene sheet of concrete surface. If moisture colelcts on underside of polyethylene sheet before polymer would cure, then all concrete to dry sufficiently. Drying of the surfaces can be accomplished by either heating the surfaces by blow lamps or by use of sawdust, sand or any other means so that the surface is bone-dry.

2.21.3. Identification of Methods of Grouting

2.21.3.1. For All Surfaces having Cracks / Crevices:

Locate the cracks by either surface inspection or by scrubbing the surface. In case the cracks are not visible to naked eye use compressed air to clear marks. Having identified the cracks use light chisel or mechanical/electrical saw to clear the crack upto the depth of the crack. In case widening of the crack is necessary to reach the depth of the crack it is advisable to do so at this juncture.

After cleaning/widening the crack use compressed air/water jet to clean the opened crack surface. Ensure that the surface is dried in case water jet is used.

A method of grouting thorough rows of grout nipple is to be adopted for all such cases.

2.21.4. Grouting for Honey Combed Surfaces

For surface, which exhibits honeycombed concrete, the surface has to maintained in its dry state and a method of grouting through triangular grout nipples is to be adopted.

The opposite side to the grouting surface has to be sealed for flowing grout by either impervious cement plaster or by use of proper sealant as specified in the material to be used for grouting.

2.21.5. Size and Spacing of Nipples

To determine the size of nipples use a standard caliper or a metric scale and measure the width of the opened crack. The size of the nipple to be fixed within the crack has got to be minimum half the surface width of the crack measured above, but should not exceed s15 mm in dia.

The nipples to be used should be of metal with one end tapered and thickness should be sufficient to withstand 5 m head of water. The spacing for the crack depends inversely to the width of the crack and will not exceed more than 300 mm c/c and will not be less than 125 mm c/c. The member of nipples along the crack will always be a less than two rows of nipples that needs to be fixed parallel to the crack at the same distance as the nipples spacing in the crack so as to form equilateral triangle with the apexes in the crack.

3. EARTHWORK AND EXCAVATION

3.1. RELAVENT IS CODE

IS: 1200 : Method of Measurement for Building Works
IS: 3764 : Safety code for Excavation Work
IS: 3385 : Code of practice for measurement of civil engineering works
IS: 2720 : Part II - Determination of Moisture Content
: Part VII - Determination of Moisture content dry density relation using light compaction
: Part VIII - Determination of Moisture Content Dry Density using heavy compaction
: Part XXVIII - Determination of Dry Density of soils, in place, by the sand replacement method
: Part XXIX - Determination of Dry Density of soils, in place, by the core cutter method.

3.2. EXCAVATION

3.2.1. Definitions

The following terms shall have the meanings hereby assigned to them:

- Top Soil means any surface material, including turf, suitable for use in soiling areas to be grassed or cultivated.
- Excavation means excavation in open cut (excluding trench excavation) down to levels required as per approved Drawings or otherwise as being the general levels after completion of excavation.

3.2.2. Site Clearance

All area of the Site, marked in the Specification Drawings shall be cleared to the extent required by the Engineer-in-Charge of all buildings, walls, gates, fence and other structure and obstructions of all bushes, hedges, trees, stumps, roots and other vegetation except for trees marked for preservation. Material so cleared shall so far as suitable be preserved and stacked will be the property of AMC for further use but shall otherwise be burnt to ash or disposed off the Site as directed by the Engineer-in-Charge.
Before starting the work the site shall be cleared of

1. All shrubs, grass, and other vegetation including large and small bushes, all stumps, removal of roots, cutting and disposal of small trees up to 300 mm girth etc.
2. All the tress having girth above 300 mm. (the girth shall be measured at a height of 1.5 m above the ground level) by felling, logging, fashioning of timber and billeting of all branches, trunks etc. including removal of all roots etc. complete as directed.
3. All serviceable reclaimed material shall be stacked separately at the site shown by the Engineer In Charge near the site of excavation and/or transported as directed by Engineer In Charge. All the existing utilities passing through or along the plant and station site has be shifted by contractor before commencing of works. All the Liaoning work and expenditure required to shift utility shall be done by contractor.
4. After the tree is cut and roots taken out the potholes formed shall be filled with good earth in 250mm layers and consolidated unless directed by the Engineer in Charge otherwise. The trees shall be cut in suitable piece as instructed by the Engineer In Charge

3.2.3. General Excavation

1. General excavation means excavation in all types of soild like dry soil, wet soil, murum, boulders, hard strata, rock of any type at different depth and lift required for structures and from borrow areas, and shall not include trench excavation. General excavation may also include miscellaneous isolated lengths of trenches beneath or

adjacent to other structures, trial pits along the structural layout or otherwise.

2. The ground shall be excavated by such methods and to such dimensions and depths as shall allow for the proper construction of the works and safety of personnel and equipment used on excavation. Slopes required for stable formation of sides shall be provided.
3. The excavation in earth, murum, boulders, soft and hard rock shall be carried out to the correct levels required and specified and no tolerance, plus or minus, shall be permitted. However, if any depressions/Loose pockets are formed due to removal of boulders, they shall be made good by filling with 1:5:10 concrete up to the bottom layer of the footing/raft.
4. Payment for all types of excavation shall be made by detailed measurement supported by ground levels recorded prior to and after completion of excavation, subject to the limit for payment indicated by the slopes of excavation indicated in the specification drawing. Any additional excavation will be at the Contractor's expense, unless specifically approved by the Engineer-in-Charge. Measurement for excavation shall be done all as per dimensions of P.C.C. given in design drawings & specifications. For concrete foundations same shall be paid on least dimensions at bottom and Contractor shall cover any extra excavation required for workspace, supports etc while quoting.
5. As far as possible excavation should be done by means of mechanical equipment. The bidder should quote accordingly and nothing extra will be paid for mechanical excavation and deployment of extra staff.
6. It will be the responsibility of the Contractor to obtain prior permissions from the competent authority to use blasting device, if at all to be resorted to and the license are to be obtained for the same.
7. The chance of blasting required shall be well decided with the expert, to avoid any damage to the surrounding property. However for any such damage to the surrounding property or public or additional excavation shall be the Contractor's responsibility and the risks what so ever arising from the same will have to be borne by the Contractor.

3.2.4. Lift and Lead

Lead for deposition of the excavated materials should be 5000 m. For the purpose of measurement of lead, the area to be excavated or filled or area in which excavated material is to be deposited /disposed off shall be divided into suitable blocks and for each of the blocks, the distance between centrelines shall be taken as the lead which shall be measured by the shortest straight line route on plan and not the actual route taken by Contractor. No extra compensation is admissible on the grounds that the lead including that for borrowed material had to be transported over marshy or kaccha land route.

3.2.5. Excavation in Hard Rock

Excavation in hard rock may be done either by blasting or chiseling or by mechanical means depending upon the site conditions. When excavation has reached within 300 mm of the required formation level, further excavation shall be carried out carefully either by blasting (if as directed by the Engineer-in-Charge) or chiseling. Where blasting is resorted to, small charges shall be used to minimize occurrence of heavy over-cuts. The Contractor shall make every effort to carry out the excavation to correct formation level as far as practicable. In order to minimize the over break and loosening of materials at the finished surfaces, final cutting for the last 450 mm to 600 mm in rock shall be carried out by controlled blasting and trimming with the help of pneumatic or other power tools. Unless otherwise specified, the over break shall not exceed 75 mm. The over breakage of 75 mm shall not be measured for payment and therefore the Contractor while quoting his rates for rock excavation has to take this into account. Deduction of 40% or higher percentage as may be decided by the Engineer-in-Charge shall be made to allow for the

voids. Stacks shall not be of width greater than 1.5 m wide or of height less than one meter

1. Blasting shall be carried out by the licensed person only if permitted by the Engineer-in-charge for which contractor shall obtain the required permission from police commissioner.
2. The Contractor shall provide a method statement and shall comply fully with the requirements of this clause, or any direction, order, requirement or instruction given by the police department or any other relevant authorities as required by the law.
3. Contractor shall submit Blasting plan to the Engineer-in-charge and take approval for the same on daily basis
4. Contractor shall plan the blasting activities in well advance and convey same to the Project In-charge so as to co-ordinate with all the work groups at site.
5. If blasting is not permitted then contractor shall excavate the rock by manual methods or by mechanical mean like needle breaker, poclain, rock splitter etc without any extra cost.

This includes rock, which is easily excavated by blasting, but due to close proximity of structures or any other reason that the Engineer-in-Charge may consider, will have to be excavated by chiseling.
Hard rock excavation means excavation in all types of rock at any depth or lead required as per design and drawings. The contractor shall ascertain the level and type of rock by inspecting site, trial pits or trial bore at his cost before quoting the tender.

It should be noted that this clause does not override the Contractor's obligation to satisfy the requirement of the relevant authorities but sets out the extent to which the engineer in charge will exercise his control in approving the Contractor's use of explosive to ensure that explosive are always used in a safe manner. It is the Contractor's sole responsibility to ensure that his method of blasting is safe, that all statutory and imposed limitation are adhered to, and to obtain a permit to use explosive from the relevant authorities and to comply with the condition of issue of the permit.

The Contractor shall be solely responsible for obtaining the necessary licenses for the procurement, possession, transport, storage and handling of explosive and for ensuring the validity of such licenses at all times. Before starting work, the Contractor shall satisfy the engineer that all the requirement permits are in order and that this category of work is adequately covered in the policies of insurance.

Explosives shall be used in the quantities and manner recommended by the manufacturers. All necessary precautions shall be taken to preserve the materials below in the soundest possible condition and also beyond the lines of all excavations.
Blasting by means of drill holes, tunnels or any other similar method shall be the responsibility of the Contractor.
The Contractor shall take all necessary precautions during blasting operations to ensure that no injure is caused to persons or damage to property or to the finished works. Shots shall be properly loaded and capped and only appropriate charges shall be used in each hole.

3.2.5.1. Storage and Transport

Proper building or magazine, with separate compartment for detonators in suitable positions for the storage of explosive in the manner and quantities to be approved, shall be provided. Separate vehicles or vessels for detonators shall also be used for the transportation of explosives. The prevention of any unauthorised issue or improper use of any explosive brought on to the site shall be the responsibility of the Contractor and only experienced licensed short

firers shall be employed to handle the explosive for the purpose of the work the relevant security regulations dealing with the storage, handling and transport of explosives shall be complied with.

3.2.5.2. Safety

The Contractor shall provide an approved system of warning and preparing the general public and all site personnel of an impending blast by both audible & visual means and shall ensure that the blasting area is cleared of all personnel immediately prior to blasting. This system shall comply with all statutory requirements. The Contractor's attention I drawn to the need to devise adequate system for warning and clearing the public from specified areas during blasting operations and to prevent persons entering the blasting area.

When blasting is near to the proximity of existing public and private thoroughfares, traffic is to be stopped just prior to firing. The operation is to be carried out I close cooperation with the police department and in such a way as to cause minimum traffic delay.

All operations involving explosives shall be suspended on the approach of a thunderstorm and shall not be resumed until the storm has clearly passed.
Blasting screens shall be erected to conform with the permit conditions. Public roads, private roads and property adjacent to the site and services within the site area shall be protected by rock fall fences which will be subjected to the engineer's approval.

The Contractor shall take all necessary precautions to avoid damage to permanent and temporary works already completed. In all cases, delay blasting techniques will be mandatory with the quantity of explosives restricted to ensure that the peak particle velocity generated does not exceed the peak particle velocity of each component of the safe limits of the nearest structure subject to vibration damage. All operations shall stop when these limits are exceeded until reports are made available to the engineer that no damage has occurred and will not occur or corrective action has been taken to lower the vibration. The sound level limit in areas where site personnel or public can access during blasting operation must not exceed 110 dB.
The Contractor may not be permitted to use explosives in areas of the site immediately adjacent to pylon positions. Particular limitations may apply in such areas depending on the Contractor's proposed method of working and a detailed method statement will therefore be required from the Contractor. The method statement shall cover the methods of excavation and protection systems proposed, all of which shall be subjected to the approval of the relevant authorities and the Engineer.

In all such cases particular attention should be paid to the requirements stated above and effects on these structures and installations shall be closely monitored and the quantities of explosives limited accordingly.
Drilling rigs for shot hole shall be of the hydraulic type fitted with efficient silencers and with means of dust separation.
The Contractor may report to any of the following methods to excavate rock by chiseling:

- Wedging by means of crowbars, pick axes or pneumatic drills
- Heating and quenching
- Controlled blasting with a small charge just sufficient to make a crack in rock which will be subsequently removed by wedging
- No extra payment shall be made for removal of rock by chiseling and controlled blasting.

3.2.6. Excess excavation to be made good

The Contractor, at his own expense, shall, if directed, remove from the Site all excess material resulting from excess excavation and shall make good the same with such kind of fill material or in such class of concrete as may be reasonably required by the Engineer-in-Charge having regard to the circumstances.

3.2.7. Stripping Top Soil

Where ordered by the Engineer-in-Charge, top soil shall be stripped to such depths and over such areas as he may direct, as a separate operation prior to any further excavation, which may be required.

3.2.8. Supporting Excavations

1. The Contractor shall properly support the sides and ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation. Any excavation necessary to provide space for such support or other working space shall be carried out. If, for any reason, any portion of the bottoms, sides or ends of any excavations shall give way, the Contractor shall at his own expense take all necessary remedial measures including the extra necessary excavation and removal of excess material.
2. Where the Contractor proposes and is permitted by the Engineer-in-Charge to perform excavations with sloping faces (other than sloping excavations shown on the Drawings or required as permanent features of the Works) and without shoring, the excavated faces shall be to stable slopes and heights.

3.2.9. Trimming Excavations

1. When excavating to specified or required levels for the foundation of any structure or to specified or required limits for the face of any structure required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing the constructional work, except where the Engineer-in-Charge shall permit otherwise. After getting the permission for the commencement of the construction, if the Contractor delays on any account & the formation level gets damaged he will have to do further excavation upto 150mm or as per Engineer-in-Charge's instructions at his own account.
2. Before commencement of any constructional work all shattered and loose materials shall be removed from the excavations by hand so as to ensure that the work rests on a solid and perfectly clean foundation or abuts against solid ground.

3.2.10. Inspection by the Engineer-in-Charge

1. When the specified levels or limits of excavation are reached the Engineer-in-Charge will inspect the ground exposed, and if he considers that any part of the ground is by its nature unsuitable he may direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with concrete, selected excavated material or selected imported material as directed by the Engineer-in-Charge.
2. Should the material forming the bottom of any excavation, while acceptable to the Engineer-in-Charge at the time of his inspection, subsequently become unacceptable to him due to exposure to weather conditions or due to flooding or have puddles, soft or loss during the progress of the works, the Contractor shall remove such damaged, softened or loosened material and excavate without any extra cost.

3.2.11. Disposing Excavated Material

All excavated material shall remain the property of the Employer. The Contractor shall ensure that no excavated material which is suitable for and is required for re-use in the Works is transported unless so ordered by the Engineer-in-Charge.

3.2.12. Back-Filling General Site Grading and Sand Filling

3.2.12.1. Fill Material

1. All fill material whether such material is brought from outside borrow areas or excavation within the site, will be subject to Engineer-in-Charge's approval after carrying required tests at Contractor's Soil testing laboratory. Notwithstanding any approval given to the fill material or borrow areas from which fill material is proposed to be brought, the Engineer-in-Charge reserves the right to reject such material which does not meet the specification requirements or unsuitable for the purpose for which it is intended.
2. Roads, of a temporary nature, required to be constructed for access and for movement of men, materials, equipment, transport vehicles, vehicles carrying fill material, etc. to or over borrow areas and or to or over areas on which fill has to be deposited shall be constructed by the Contractor. Such access roads shall be maintained in good condition during all seasons to ensure completion of the work according to the time schedule. No separate payment shall be made for such items of work.

3.2.12.2. Backfilling

1. Excavated material used as back filling to excavations or completed structures shall be free from rubbish, vegetation, clods and lumps and shall be approved by the Engineer-in-Charge. The approved materials shall be placed in layers, not exceeding 150 mm in depth before compaction and shall be compacted with watering, consolidating and ramming. The maximum boulder size shall be of 150 mm for filling material
2. Soft material shall not be used as back filling around structures in rock. The Contractor shall backfill such excess excavation with concrete; rubble, stone or rock fills as directed by the Engineer-in-Charge. Filling other than concrete shall be placed in layers not exceeding 150 mm in thickness, shall be thoroughly compacted and have adequate fined content to fill the voids.
3. Should the material being placed as back filling, while acceptable at time of selection, become unacceptable to the Engineer-in-Charge due to exposure to weather conditions or due to flooding or have become puddles, soft or segregated during the progress of the works, the Contractor shall remove such damaged, softened or segregated material and replace it with fresh approved material at his expense.
4. The Contractor shall while placing the back filling make due allowance for any settlement that may occur before the end of the Defects Liability Period, remove any excess material or make up any deficiency by back filling to the specified levels. As a rule material to be back filled shall be stacked temporarily at a suitable place.
5. General Site Grading: Site grading shall be carried out as directed by the Engineer-in-Charge. Excavation shall be carried out as specified in the specification. Filling and compaction shall be carried out as specified under (6) of this Clause unless otherwise indicated below.
6. The approved material shall be placed in layers not exceeding 150 mm in depth before compaction and shall be compacted to 90% of Proctor Density with water contain at OMC.
7. The Contractor shall protect the earth fill from being washed away by rain or

damaged in any other way. Should any slip occur, the Contractor shall remove the affected materials and make good the slip without any extra cost.

8. The fill shall be carried out to such dimensions and levels as directed by the Engineer-in-Charge, after the compaction.
9. Sand filling below Plinth and other places

   Back filling shall be carried out with sand at places as directed by the Engineer-in-Charge. 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 conditions shall be to the Contractor's account. The surface of the Consolidated sand shall be dressed to the required level or slope. Construction of floors or other structures on sand fill shall not be started until the Engineer-in-Charge has inspected and approved the fill.

   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.

   A smaller weight roller may be used only if permitted by Engineer-in-Charge. 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 upto 300 mm. Engineering-Charge will determine the thickness of layers in which fill has to be consolidated depending on the fill material and equipment used.

   Rolling shall commence from outer edge and progress towards the centre and continue until compaction is to the satisfaction of the Engineer-in-Charge, 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. Contractor shall then be permitted to use pneumatic tampers, rammers etc and he shall ensure proper compaction.

3.2.13. Fill Density

The compaction, only where so called for, in the schedule of quantities /items shall comply with the specified (proctor/modified proctor) density at moisture content differing not more than 4 percent from optimum moisture content. Contractor shall demonstrate adequately at his cost, by field and laboratory tests that the specified density
had been obtained.

3.2.14. Local Rules and Regulations

1. The Contractor shall familiarize himself with the local rules and regulations governing the excavation, quarrying operations, etc. and the work shall be carried out strictly in accordance with rules and regulations, if any. Whenever a quarry is required to be opened in connection with the execution of work covered under this Contract, the Contractor shall investigate that it shall yield stones and other materials such as sand, murum, soil etc. of approved quality and shall satisfy himself as to the availability in desired quantity. He shall supply necessary quantity of sand, stone, metal aggregate etc. to the Engineer-in-Charge for carrying out tests as desired by the Engineer-in-Charge and well in advance of its use so as to carry out tests and to get approval. The cost of opening and operating the quarry & royalties and ant other charges shall be borne entirely by the Contractor.
2. The Contractor shall obtain necessary permission from the concerned authorities before opening the quarry. In case of quarries in private land on payment of whatever charges as may be due to the owner.

3.3. DEWATERING

a. All excavations shall be kept free of water. Grading in the vicinity of excavations shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove by pumping or other means approved by Engineer-in-Charge any water inclusive of rain water and sub-soil water accumulated in excavation and keep all excavations de-watered until the foundation work is completed and back filled. Sumps made for dewatering must be kept clear of the excavations/trenches required for further work. Method of pumping shall beapproved by Engineer-in-Charge; but in any case, the pumping arrangement shall be such that there shall be no movement of sub-soil or blowing in due to differential head of water during pumping. Pumping arrangements shall be adequate to ensure no delays in construction.

b. When there is a continuous inflow of water and quantum of water to be handled is considered in the opinion of Engineer-in-Charge, as large, well point system: Single-stage or Multi-stage shall be adopted. Contractor shall submit to the Engineer-in-Charge his scheme of well pointing system including stages, the spacing, number and diameter of well points, headers etc. and the number, capacity and location of pumps for approval.

c. The rates for excavation are inclusive of dewatering by any means and no extra payment is allowed for excavation in wet condition.

3.4. TIMBER SHORING

The Timber Shoring shall be as per 3764-1966 safety code for excavation work.

a. Close timbering shall be done by completely covering the sides of the trenches and pits generally with short, upright members called 'polling boards'. The boards shall generally be placed in position vertically side by side without any gap on each side of the Excavation and shall be secured by horizontal walings of strong wood at maximum 1.2 m spacing and suitably strutted. If the soil is very soft and loose, the boards shall be placed horizontally against each side of the excavation and supported
by vertical walings, which in turn shall be suitably strutted. The lowest boards supporting the sides shall be taken into the ground and no portion of the vertical side of the trench or pit shall remain exposed, so as to render the earth liable to slip out.

b. The shoring material shall not be sizes less than those specified below unless steel
sheet piling is used or unless otherwise approved by the Engineer-in-Charge in writing:

- Planks - 5 cm x 25 cm
- Waling pieces - 10 cm x 20 cm
- Struts - 15 cm x 20 cm

c. Timber shoring shall be 'close' or 'open' type, depending on the nature of soil and
the depth of pit or trench. The type of timbering shall be as approved by Engineer-
in-Charge. It shall be the responsibility of the Contractor to take all necessary steps
to prevent the sides of excavations, trenches, pits, etc., from collapsing.

d. Timber shoring may be required to keep the sides of excavations vertical to ensure safety of adjoining structures or to limit the slope of excavations, or due to space restrictions or for other reasons. Such shoring shall be carried out, except in an emergency, only under instructions from the Engineer-in-Charge.

e. The withdrawal of the timber shall be done very carefully to prevent the collapse of the pit or trench. It shall be started at one end and proceeded systematically to the
other end. Concrete or masonry shall not be damaged during the removal of the timber. No claim shall be entertained for any timber, which cannot be retrieved.

f. In the case of open timbering, the entire surface of the side of trench or pit is not required to be covered. The vertical boards of minimum 25 cm X 5 cm sections shall be spaced sufficiently apart to leave unsupported strips of maximum 50 cm average width. The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of the Engineer-in-Charge. In all other respects, the specification for close timbering shall apply to open timbering.

g. In case of large pits and open excavations, where shoring is required for securing safety of adjoining structures or for any other reasons and where the planking across
sides of excavations/pits cannot be strutted against, suitable inclined struts supported
on the excavated bed shall be provided. Load from such struts shall be suitably distributed on the bed to ensure no yielding of the strut.

3.5. RAIN WATER DISCHARGE

3.5.1. Scope

The scope covers the drainage of the rainwater in excavated areas.

Grading in the vicinity of excavation shall be such as to exclude rain/surface water draining into excavated areas. Excavation shall be kept clean of rain and such water as the Contractor may be using for his work by suitably pumping out the same at no extra cost to the Owner. The scheme for pumping and discharge of such water shall be approved by the Engineer-in-Charge.

4. ANTI TERMITE TREATMENT

4.1. RELAVENT IS CODE

IS: 6313 - 1981	: Code of Practice for Anti Termite Measure in Buildings
IS: 6313 (Part I) - 1981	: Construction Measures
IS: 6313 (Part II) - 1981	: Pre-Construction Chemical Treatment Measures
IS: 6313 (Part III) - 1981	: Treatment for existing Buildings

4.2. DELIVERY, STORAGE AND HANDLING

Deliver pesticides to the project site in sealed and labeled containers in good condition as supplied by the manufacturer or formulator. Store, handle, and use pesticides in accordance with manufacturer's labels. Labels shall bear evidence of registration as per the IS or appropriate regulations.

4.3. SAFETY REQUIREMENTS

Formulate, treat, and dispose of termiticides and their containers in accordance with label directions. Draw water for formulating only from sites designated by the Contracting Officer, and fit the filling hose with a backflow preventer meeting local plumbing codes or standards. The filling operation shall be under the direct and continuous observation of a Contractor's representative to prevent overflow. Secure pesticides and related materials under lock and key when unattended. Ensure that proper protective clothing and equipment are worn and used during all phases of termiticide application. Dispose of used pesticide containers off Government property.

4.4. WARRANTY

Furnish an three-year written warranty against infestations or reinfestations by subterranean termites of the buildings or building additions constructed under this contract. Perform annual inspections of the building(s) or building addition(s). If live subterranean termite infestation of subterranean termite damage is discovered during the warranty period, and the soil and building conditions have not been altered in the interim, the Contract shall :

1. Retreat the soil and perform other treatment as may be necessary for elimination of subterranean termite infestation;
2. Repair damage caused by termite infestation; and
3. Reinspect the building approximately 180 days after the pretreatment.

4.5. QUALITY ASSURANCE

4.5.1. Application Report

Upon completion of this work, submit Pest Management Report, Identifying target pest, type of operation, brand name and manufacturer of pesticide, formulation, concentration or rate of application used. Maintain daily records using Pest Management Maintenance Record, and submit copies of records when requested by the Engineer-in-Charge.

4.6. PRODUCTS

4.6.1. Pesticides

Termiticides bearing current registration or approved for such use by the appropriate agency of the host country. The Contractor shall comply with the requirements on Contractor's licensing, certification, and record keeping.

4.6.2. Execution

4.6.2.1. Verification of Conditions

At the time of application, the soil shall have sufficiently low moisture content to allow uniform distribution of the treatment solution throughout the soil. Do not make applications during or immediately following heavy rains or when conditions may cause runoff and create an environmental hazard.

4.6.3. Application

4.6.3.1. Treatment Area

Apply termiticide to soil material which will be covered by or lie immediately adjacent to the buildings and structures so as to provide a protective barrier against subterranean termites.

4.6.3.2. Treatment Application

Apply termiticide as a coarse spray and in such matter as to provide uniform distribution onto the soil surface. Apply treatment prior to placement of a vapor barrier or waterproof membrane and prior to concrete pouring. Where treated soil or fill material is not to be covered with a vapor barrier or waterproof membrane, exercise adequate precautions to prevent its disturbance. If soil or fill material has been disturbed after treatment, retreat as specified above before placement of slabs or other covering structures. Coordinate treatment of the soil on the exterior sides of foundation walls, grade beams, and similar structures with final grading and planting operations so as to avoid disturbance of the treated barriers by such operations. Observe manufacturer's warnings and precautions in the handling and use of such materials. Exercise precaution that these chemicals do not enter water supply systems or potable water supplies or aquifers, and that they do not endanger plants and animals as well. Notify the Contracting Officer at least 48 hours prior to beginning of treatment and perform formulating, mixing, and application in the presence of the AMC.

4.6.4. Rates and Methods of Application

Apply in accordance with the pesticide label. Provide maximum application or dosage rates. Resolve conflict between this specification and label direction in favor of the label.

5. CONCRETE AND ALLIED WORKS

5.1. GENERAL

a. The quality of materials and method and control of manufacture and transportation of all concrete work irrespective of mix, whether reinforced or otherwise shall conform to the applicable portions of this specification.

b. The Engineer-in-Charge shall have the right to inspect the source/s of material/s, the layout and operation of procurement and storage of materials, the concrete batching and mixing equipment, and the quality control system. Such an inspection shall be arranged and Engineer-in-Charge's approval obtained, prior to starting of concrete work. However, this shall not relieve the Contractor with any of his responsibilities and all the materials, which do not conform to the specifications, will be rejected.

c. The minimum wall thickness for all RCC wall shall be 225 mm thick.

d. The liquid retaining structures will be in M 30 grade.

e. The Contractor will maintain all registers and formats for quantity qualitative and quantitative measures of all concrete works on daily basis of steel consumed and concreting done updated on daily basis.

f. As per site conditions, if required, contractor may use ready mix concrete of approved mix design from approved ready mix plant without any extra cost.

5.2. APPLICABLE CODES

The following specifications, standards and codes, including all official amendments/revisions and other specifications & codes referred to therein 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 this bid document, this specification shall govern.

MATERIALS

1. IS:269	-	Specification for 33 grade ordinary Portland cement
2. IS:455	-	Specification for Portland slag cement.
3. IS:1489	-	Specification for Portlandpozzolana cement.
4. IS: 8112	-	Specification for 43grade ordinary Portland cement.
5. IS: 12330	-	Specification for sulphate resisting Portland cement.
6. IS: 383	-	Specification for coarse and fine aggregates from natural sources for concrete
7. IS: 432	-	Specification for mild steel and medium tensile steel (Parts-I & II) bars and harddrawn steel wires for concrete reinforcement.
8. IS: 1786	-	Specification for high strength deformed steel bars and wires for concrete reinforcement.
9. IS: 1566	-	Specification for harddrawn steel wire fabric for (Part-I) concrete reinforcement.
10. IS: 9103	-	Specification for admixtures for concrete.
11. IS: 2645	-	Specification for integral cement waterproofing compounds.
12. IS: 4990	-	Specification for plywood for concrete shuttering work.

MATERIAL TESTING

1. IS: 4021	-	Methods of physical tests for hydraulic cement. (Parts-1 to 13)
2. IS: 4032	-	Method of chemical analysis of hydraulic cement.
3. IS: 650	-	Specification for standard sand for testing of cement.
4. IS: 2430	-	Methods for sampling of aggregates for concrete.
5. IS: 2386	-	Methods of test for aggregates for concrete. (parts-I to VIII)
6. IS: 3025	-	Methods of sampling and test (physical and chemical) water used in industry.

7. IS: 6925	-	Methods of test for determination of watersoluble chlorides in concrete admixtures.

MATERIALS STORAGE

1. IS: 4082	-	Recommendations on stacking and storing of construction materials at site

CONCRETE MIX DESIGN

1. IS: 10262	-	Recommended guidelines for concrete mix design.
2. SP: 23	-	Handbook on Concrete Mixes. (S & T)

CONCRETE TESTING

1. IS: 1199	-	Method of sampling and analysis of concrete.
2. IS:516	-	Method of test for strength of concrete
3. IS: 9013	-	Method of making, curing and determining compressive strength of accelerated cured concrete test specimens.
4. IS: 8142	-	Method of test for determining setting time of concrete by penetration resistance.
5. IS: 9284	-	Method of test for abrasion resistance of concrete.
6. IS: 2770	-	Methods of testing bond in reinforced concrete.

EQUIPMENT

1. IS: 1791	-	Specification for batch type concrete mixers.
2. IS: 2438	-	Specification for roller pan mixer.
3. IS: 4925	-	Specification for concrete batching and mixing plant.
4. IS: 5892	-	Specification for concrete transit mixer and agitator.
5. IS: 7242	-	Specification for concrete spreaders.
6. IS: 2505	-	General Requirements for concrete vibrators: Immersion type.
7. IS: 2506	-	General Requirements for screed board concrete vibrators.
8. IS: 2514	-	Specification for concrete vibrating tables.
9. IS: 3366	-	Specification for pan vibrators.
10. IS: 4656	-	Specification for form vibrators for concrete.
11. IS: 11993	-	Code of practice for use of screed board concrete vibrators.
12. IS: 7251	-	Specification for concrete finishers.
13. IS: 2722	-	Specification for portable swing weigh batchers for concrete (single and double bucket type).
14. IS: 2750	-	Specification for steel scaffoldings.

CODES OF PRACTICE

1. IS: 456	-	Code of practice for plain and reinforced concrete.
2. IS: 457	-	Code of practice for general construction of plain and reinforced concrete for dams and other massive structures.
3. IS:3370	-	Code of practice for concrete structures for storage of liquids.(parts-I to IV)
4. IS: 3935	-	Code of practice for composite construction.
5. IS: 2204	-	Code of practice for construction of reinforced concrete shell roof.
6. IS: 2210	-	Criteria for the design of reinforced concrete shell structures and folded plates.

7. IS: 2502	-	Code of practice for bending and fixing of bars for concrete reinforcement.
8. IS: 5525	-	Recommend ation for detailing of reinforcement in reinforced concrete works.
9. IS: 2751	-	Code of practice for welding of mild steel plain and deformed bars used for reinforced concrete construction.
10. IS: 9417	-	Specification for welding cold worked bars for reinforced concrete construction.
11. IS: 3558	-	Code of practice for use of immersion vibrators for consolidating concrete.
12. IS: 3414	-	Code of practice for design and installation of joints in building.
13. IS: 4326	-	Code of practice for earthquake resistant construction of building.
14. IS:4014	-	Code of practice for steel tubular scaffolding.(parts-I & II)
15. IS: 2571	-	Code of practice for laying insitu cement concrete flooring.
16. IS: 7861	-	Code of practice for extreme weather concreting.
		Part-I: Recommended practice for hot weather concreting.
		Part-II: Recommended practice for cold weather concreting.
17. IS: 13920	-	Ductile Detailing of Reinforced Concrete Structure subjected to 1993 seismic forces.
18. SP-16	-	Design Aids for Reinforcement Concrete to IS:4561978 (S&T) 1980
19. SP-24	-	Explanatory Handbook on IS:4561978
20. SP-34	-	Handbook on Concrete Reinforcement and Detailing (S&T) 1987

CONSTRUCTION SAFETY

1. IS:3696	-	Safety code for scaffolds and ladders.(Parts-I & II)
2. IS:7969	-	Safety code for handling and storage of building materials
3. IS: 8989	-	Safety code for erection of concrete framed structures.

MEASUREMENT

1. IS: 1200	-	Method of measurement of building and engineering works.
2. IS: 3385	-	Code of practice for measurement of civil engineering works.

5.3. MATERIALS FOR STANDARD CONCRETE

a. The ingredients to be used in the manufacture of concrete shall consist solely of Ordinary Portland Cement or Sulphate Resistant Cement of approved make clean sand, natural coarse aggregate, clean water, and admixtures.

b. Cement

1. The Contractor will have to make own arrangements for procuring cement and steel. Cement remaining in bulk storage at the mill, prior to shipment for more than 6 months or cement in bags in local storage in the hands of vendor for more than 3 months after completion of tests may be retested before use and may be rejected if it fails to conform to any of the requirement of IS 269-1976.
2. The Contractor will have to make his own arrangements for transport from supplier godown and storage of adequate quantity of cement. Contractor will construct cement godown at site as per AMC rules. Cement in bulk may be stored in bins or silos, in batches of 10x10, which will provide complete protection from dampness, contamination and minimize caking and false set. Cement bags shall be stored in a dry enclosed shed (storage under tarpaulins will not be permitted), well away from the outer walls and insulated from the floor to avoid contact with moisture from the ground and so arranged as to provide ready

access. Damaged or reclaimed or partly set cement will not be permitted to be used and shall be removed from the site. The storage bins and storage arrangement shall be approved by the Engineer-in-Charge. Consignments of cement shall be stored as received and shall be consumed in the order of their delivery. Stacking of cement shall be done as per IS and in such a way that first come cement shall be used first.

3. Cement held in storage for a period of ninety (90) days or longer shall be tested. Should at any time the Engineer-in-Charge have reasons to consider that any cement is defective, then irrespective of its origin, date of manufacture and or manufacturer's test certificate, such cement shall be tested immediately at the Contractor's cost at an approved laboratory and until the results of such tests are found satisfactory, it shall not be used in any work. Testing certificates for each batch of cement should be submitted by the Contractor to the Engineer-in-Charge, before starting the concreting work. The Contractor shall not be entitled to any claim of any nature on this account.
4. Aggregates
   i) General

   "Aggregate" in general designates both fine and coarse inert materials used in the manufacture of concrete (Vide BIS 456 & BIS 383) and confirming to tests as per BIS 2386 (Part I to VI)

   "Coarse Aggregate" is aggregate most of which is retained when passed through on 4.75 mm BIS sieve.

   All fine and coarse aggregates proposed for use in the works shall be subject to the AMC Quality Control Department approval and after specific materials have been accepted, the source of supply of such materials shall not be changed without prior approval of the AMC Quality Control Department.

   Aggregates shall consist of natural sands, stone (crushed or uncrushed) and gravel from a source known to produce satisfactory aggregate for concrete and shall be chemically inert, non-flaky, strong, hard, durable against weathering, of limited porosity and free from deleterious materials that may cause corrosion of the reinforcement or may impair the strength and or durability of concrete. The grading of aggregates shall be such as to produce a dense concrete of specified strength and consistency that will work readily into position without segregation and shall be based on the "mix design" and preliminary tests on concrete specified later.

   ii) Sampling and testing

   Samples of the aggregates for mixed design and determination of suitability shall be taken under the supervision of the Engineer-in-Charge and delivered to the laboratory, well in advance of the scheduled placing of concrete. Records of tests, which have been made on proposed aggregates and on concrete made from this source of aggregates, shall be furnished to Engineer-in-Charge in advance of the work, for use in determining aggregate suitability. The costs of all such tests, sampling etc. shall be borne by the Contractor.

   iii) Storage of aggregates

   All coarse and fine aggregates shall be stacked separately in stock piles in the material yard near the work site in bins properly constructed to avoid inter mixing of different aggregates. Contamination with foreign material and earth during storage and while heaping the materials shall be avoided. The aggregates must be of specified quality not only at the time of receiving at site but more so at the time of loading into mixer. Rakers shall be piled in layers not exceeding 1.20 m in height to prevent coning or segregation. Each layer shall cover the entire area

of stockpile before succeeding layers are started. Aggregates that have become segregated shall be rejected.

iv) Specific Gravity

Aggregates having a specific gravity below 2.4 (saturated surface dry basis) shall not be used.

5.4. FINE AGGREGATE

a) Fine aggregate shall consist of natural or crushed sand conforming to BIS 383 confirming to tests as per BIS 2386 part I to VI. The sand shall be clean, sharp, hard, strong and durable and shall be free from dust, vegetable substances, adherent coating, clay, alkali, organic matter, mica, salt, or other deleterious substances, which can be injurious to the setting qualities/strength/durability of concrete.

b) Screening and Washing: Sand shall be prepared for use by such screening or washing, or both, as necessary, to remove all objectionable foreign matter while separating the sand grains to the required size fraction.

c) Foreign Material limitations : The percentage deleterious substances in sand delivered to the mixer shall not exceed the following:

Table 2: Foreign Material Limitations in Fine Aggregate

Sr.	Foreign material	Percentage by weight	
		Uncrushed	Crushed
1	Material finer than 75 micron BIS sieve	3	15
2	Shale	1	-
3	Coal & Lignite	1	1
4	Clay Lumps	-	1
	Total	5	17

d) Gradation: Unless otherwise directed or approved by the Engineer-in-Charge, the grading of sand shall be within the limits indicated hereunder:

Table 3: Grading of Sand for Fine Aggregate

BIS: Sieve Designation	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	99-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 microns	15-34	35-59	60-79	80-100
300 microns	May-20	Aug-30	Dec-40	15-50
150 microns	0-10	0-10	0-10	0-15

Where the grading falls outside the limits of any particular grading zone of sieves, other than 600 microns IS sieve, by total amount not exceeding 5%, it shall be regarded as falling within that grading zone. This tolerance shall not be applied to percentage passing the 600 micron IS sieve or to percentage passing any other sieve on the coarser

limit of grading zone I or the finer limit of grading zone IV. Fine aggregates conforming to grading zone IV shall be used. Mix designs and preliminary tests shall show its suitability for producing concrete of specified strength and workability.

e) Fineness Modulus

The sand shall have a fineness modulus of not less than 2.0 or more than 3.5. The

fineness modulus is determined by adding the cumulative percentages retained on the following IS sieve sizes (4.75 mm, 2.36 mm, 1.18 mm, 600 microns and 150 microns) and dividing the sum by 100.

5.5. COARSE AGGREGATE

a) Coarse aggregate for concrete, except as noted above, shall conform to IS 383 & IS 2386. This shall consist of crushed stone and shall be clean and free from elongated, flaky or laminated pieces, adhering coatings, clay lumps, coal residue, clinkers, slag, alkali, mica, organic matter or other deleterious matter.

b) Screening and Washing: Crushed rock shall be screened and or washed for the removal of dirt or dust coating, if so requested by the Engineer-in-Charge.

c) Grading

i) Coarse aggregate shall be either in single size or graded, in both cases the grading shall be within the following limits:

BIS Sieve Size (mm)	Percentage passing for single sized aggregate of normal size					Percentage Passing For Graded Aggregate Of Normal Size			
	40mm	20mm	16mm	12.5mm	10mm	40mm	20mm	16mm	12.5mm
63	100	-	-	-	-	100	-	-	-
40	85-100	100	-	-	-	95-100	-	-	-
20	0-20	85-100	100	-	-	30-70	95-100	100	-
16	-	-	85-100	100	-	-	-	90-100	-
12.5	-	-	-	85-100	100	-	-	-	90-100
10	0-5	0-20	0-30	0-45	85-100	10-35	25-35	30-70	40-85
4.75	-	0-5	0-5	0-10	0-20	0-5	0-10	0-10	0-10
2.36	-	-	-	-	0-5	-	-	-	-

ii) The pieces shall be angular in shape and shall have granular or crystalline surfaces. Friable, flaky and laminated pieces, mica and shale, if present, shall be only within tolerance limits which will not affect adversely the strength and or durability of concrete. The maximum size of coarse aggregate shall be 40 mm for M-7.5 and M-10 and 20mm for M-15 to M-30 concrete, or as directed by the Engineer-in-Charge or specified. The maximum size of coarse aggregate shall be the maximum size specified above but in no case greater than 1/4th 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 plain concrete the maximum size of aggregate shall be of 40 mm. For heavily reinforced concrete members, the nominal maximum size of the aggregate shall be 5 mm less than the minimum clear distance between the reinforcing main bars or 5 mm less than the minimum cover to reinforcement whichever is smaller.

d) Foreign material limitations

The percentage of deleterious materials in the aggregate delivered to the mixer shall not exceed the following:

Table 4 : Foreign Material Limitations in Coarse Aggregate

Sr.	Foreign Material	Percentage by Weight	
		Uncrushed	Crushed
1	Material finer than 75 micron BIS Sieve	3.0	3.0
2	Coal and lignite	1.0	1.0
3	Clay Lumps	1.0	1.0
4	Soft Fragments	3.0	-
	Total	8.0	5.0

5.6. WATER

a) Water used for washing, mixing and curing shall be free from injurious amounts of deleterious materials. Potable water is generally satisfactory for mixing and curing concrete. Physical and chemical analysis of the water should be submitted to the Engineer-in-Charge, before starting the work.

b) In case of doubt, the suitability of water for making concrete shall be ascertained by the compressive strength and initial setting time test specified in BIS 456. The sample of water taken for testing shall be typical of the water proposed to be used for concreting, due account being paid to seasonal variation. The sample shall not receive any treatment before testing other than that envisaged in the regular supply of water proposed for use in concrete. The sample shall be stored in a clean container previously rinsed out with similar water.

c) Average 28 days compressive strength of at least three 15 cm concrete cubes prepared with water proposed to be used shall not be less than 90% of the average strength of three similar concrete cubes prepared with distilled water. The cubes shall be prepared, cured and tested in accordance with the requirements of BIS 516.

d) The initial setting time of test block must be made with the appropriate test cement and the water proposed to be used. It shall not be less than 30 minutes and shall not differ by more than +/-30 minutes from the initial setting time of control test block prepared with the appropriate test cement and distilled water. The test block shall be prepared and tested in accordance with the requirements of BIS 4031.

e) Where water can be shown to contain an excess of acid, alkali, sugar or salt, Engineer-in-Charge may refuse to permit its use. As a guide, the following concentrations represent the maximum permissible values.

1) To neutralise 200 ml sample of water, using phenolphthalein as indicator, it should not require more than 2 ml of 0.1 normal NaOH. The details of test shall be as given in BIS 3025.

2) To neutralise 200 ml sample of water, using methyl orange as an indicator, it should not require more than 10 ml of 0.1 Normal HCl. The details of test shall be as given in BIS 3025.

3) Percentage of solids, when tested in accordance with the method indicated below shall not exceed the following:

Solids	Percent	Method of test
Ref. to col. no in IS:3025) Organic		
(organic solid = total solids minus ignited residue)	0.02	10 and 11
Inorganic	0.03	11(ignited residue)
Sulphates (as So_4)	0.05	20
Alkali Chlorides (as Cl)	0.2	24
Suspended matter	0.2	12

The pH value of water shall not generally be less than 6.

5.7. STEEL AND ALUMINIUM MEMBERS ENCASED IN CONCRETE

Structural steel and aluminum ladders etc. to be encased in concrete shall be without paint. Primer should be used for encasing purpose. The encasing shall be done in concrete with 10 mm, maximum size aggregate and a works cube strength not less than 150 kg/sq.cm. at 28 days unless otherwise specified. The member shall be wrapped with galvanized aluminum wire mesh of adequate size. The galvanized aluminum wire mesh shall be kept 20 mm from the edge or surface of the member and shall be held in position securely. The member will have a minimum cover of 50 mm unless otherwise indicated in the drawings. Where the clear cover is more than 75 mm, concrete with 20 mm coarse aggregate can be used.

5.7.1. Anchor Bolts, Anchors, Sleeves, Inserts,

The Contractor shall build in to concrete work all the items mentioned in Drawings or Engineer In Charge and shall embed them partly or fully as directed and secure the same as may be required. The materials if required to be supplied by the Contractor, shall be as specified and be of best quality available according to relevant Indian standards of approved manufacture and to the satisfaction of the engineer. Exposed surface of embedded materials is to be painted with one coat of approved anti-corrosive paint and/ or bituminous paint without any extra cost to the owner. If welding is to be done subsequently on the exposed surface of embedded material the paint shall be cleaned off the member to a minimum length of 50 mm beyond each side of the weld line.

Necessary templates, jigs, fixtures, supports etc. shall be used as may be required or directed by the Engineer In Charge.

5.8. CONTROLLED CONCRETE

All concrete in the works shall be "Controlled Concrete" as defined in IS: 456 except for M-7.5 and M-10 for which normal mix concrete shall be used. Whether reinforced or otherwise, all concrete works to be carried out under this specification shall be divided into the following classifications:

Minimum Compressive Strength Of 15 cm cubes at 7 days and 28 days after mixing, conducted in accordance with IS: 516. Any operation of concrete done at atmospheric temperature above 40 degree C or where the temperature of concrete at the time of placement is expected to be beyond 40 degree C may be categorize as hot weather concreting and should be confined to the requirement of IS 7861(Part-I) 1975 and SP-23 (S&T)-1982.

Class	Preliminary Test N/mm^2		Works Test N/mm^2		Max. Size of Aggregate in mm
M40	33.5	50	27	40	20
M35	30	44	23.5	35	20
M30	25	38	20	30	40 or 20
M25	22	32	17	25	40 or 20
M20	17.5	26	13.5	20	40 or 20
M15	13.5	20	10	15	40 or 20
	At 7 Days	At 28 days	At 7 days	At 28 days	As indicate in the specification or as required

Note: It shall be very clearly understood that whenever the grade of concrete such as M-20, etc. is specified it shall be Contractor's responsibility to ensure the minimum crushing strength stipulated for the respective grade of concrete is obtained at works.

5.9. MIX DESIGN

5.9.1. General

i) This is essential for investigating the grading of aggregates, water-cement ratio, workability and the quality of cement required to give preliminary and works cubes of the minimum strength specified. The proportions of the mix shall be determined by weight. Adjustment of aggregate proportions due to moisture present in the aggregate shall be made. Determination of mix proportions shall be carried out according to "Recommended guidelines for Concrete Mix Design" conforming to IS: 10262.

ii) Whenever there is a change either in required strength of concrete, or water-cement ratio or workability or the source of aggregates and/or cement, preliminary tests shall be repeated to determine the revised proportions of the mix to suit the altered conditions. While designing proportions, over-wet mixes shall always be avoided.

iii) Mix Design may be done without changing its minimum cement content mentioned in NIT

iv) While fixing the value for water/cement ratio for preliminary mixes, assistance may be derived from the graph (Appendix A, BIS 456 showing the relationship between the 28 day compressive strengths of concrete mixes with different water/cement ratios and the 7-day compressive strength of cement tested in accordance with IS: 269.

5.9.2. Preliminary Tests

Test specimens shall be prepared with at-least two different water/cement ratios for each class of concrete, consistent with work ability required for the nature of the work. The materials and proportions used in making preliminary tests shall be similar in all respects to those to be actually employed in the works as the object of these tests is to determine the properties of cement, aggregates and water necessary to produce concrete of required consistency and to give the specified strength, it will be Contractor's sole responsibility to carry out these tests and he shall therefore furnish to Engineer-in-Charge a statement of proportions proposed to be used for the various concrete mixes. For preliminary tests, the following procedure shall be followed.

Materials shall be brought to the room temperature and all materials shall be in a dry condition. The quantities of water cement and aggregates for each batch shall be determined by weight to an accuracy of 1 part in 100 parts.

Mixing concrete shall be done by hand (for small quantities, as directed by Engineer-in-Charge) or in a small batch mixer as per IS: 516 in such a manner as to avoid loss of water. The cement and fine aggregate shall first be mixed dry until the mixture is uniform in color. The coarse aggregate shall then be added, mixed and water added and the whole batch mixed thoroughly for a period of not less than two minutes until the resulting concrete is uniform in appearance. Each batch of concrete shall be such a size as to leave about 10% excess concrete, after moulding the desired number of test specimens.

The consistency of each batch of concrete shall be measured immediately after mixing, by the slump test in accordance with IS: 1199. If in the slump test, care is taken to ensure that no water or other material is lost, the material used for the slump test may be re-mixed with the remainder of the concrete for making the specimen test cubes. The period of re-mixing shall be as short as possible yet sufficient to produce a homogeneous mass.

The samples for compression tests of concrete shall be made as per IS: 516 on 15 cm cubes. Each mould shall be provided with a metal base plate having a plate surface so as to support the mould during filling without leakage. The base plate shall be preferably attached to the mould by springs or screws. The parts of the mould when assembled shall be positively and rigidly held together. Before placing concrete, the mould and base plate shall be cleaned and oiled. The dimensions and internal faces of the mould shall be accurate within the following limits. Height and distance between the opposite faces of the mould shall be of specified size +0.2 mm. The angle between the adjacent internal faces and between internal faces and top and bottom faces of mould shall be 90-degree +0.5 degree. The interior faces of the mould shall be plane surfaces with a permissible variation of 0.03 mm.

Concrete test cubes shall be moulded by placing fresh concrete in the mould and compacted as specified in IS 516.

Curing shall be as specified in IS 516. The cubes shall be kept in moist air of at least 90% relative humidity at a temperature of 27 degree C + 2 degree C for 24 hours +2 hours from the time of adding water to the dry ingredients. Thereafter they shall be removed from the moulds and kept immersed in clean, fresh water and kept at 27 degree C +2 degree C temperature until required for test. Curing water shall be renewed every seven days. A record of maximum and minimum temperatures at the place of storage of the cubes shall be maintained during the period they remain in storage.

The strength shall be determined based on not less than five cube test specimens for each age and each water cement ratio. All these laboratory test results shall be tabulated and furnished to the Engineer-in-Charge. The test results shall be accepted by the Engineer-in-Charge if the average compressive strengths of the specimens tested is not less than the compressive strength specified for the age at which specimens are tested subject to the condition that only one out of the five consecutive tests may give a value less than the specified strength for that age. The Engineer-in-Charge may direct the Contractor to repeat the tests if the results are not satisfactory and also make such changes as he considers necessary to meet the requirements specified. All these preliminary tests shall be conducted by the Contractor at his own cost in an approved laboratory of AMC.

5.10. PROPORTIONING, CONSISTENCY, BATCHING AND MIXING OF CONCRETE

The determination of the water cement ratio and proportion of aggregates to obtain the required strength shall be made from preliminary tests by designing the concrete mix. Controlled concrete shall be used on all concrete work complying with all the requirements of IS: 456. Cube tests shall be carried out by the Contractor on the trial mixes before the actual concreting operation starts. Based on the strength of the concrete mix sanction for the use has to be obtained from Engineer-in-Charge.

If during the execution of the works it is found necessary to revise the mix because of the cube tests showing lower strengths than the required one due to inconsistency of quality of material or otherwise, The Engineer-in-Charge shall ask for fresh trial mixes to be made by the Contractor. No claim to alter the rates of concrete work shall be entertained due to such change in mix variations, as it is the Contractor's responsibility to produce the concrete of the required grade.

Great care shall be exercised when mixing the actual works concrete using the proportions of the selected trial mix. The final concrete mix shall have the same proportions and same source of cement, fine and coarse aggregates and water as that of the approved selected mix.

A reasonable number of bags should be weighed separately to check the Net weight, where the weight of cement is determined by accepting the manufacturer's weight per bag at the site. Proper control of mixing water is deemed to be of paramount importance. If mixers with automatic addition of water are used, water should be either measured by volume in calibrated buckets, tins or weighed. All measuring equipment shall be maintained in a clean serviceable condition and their accuracy periodically checked and certified and the Engineer-in-Charge's approval obtained.

The Engineer-in-Charge may require the Contractor to carry out moisture content tests in both fine and coarse aggregates. The amount of the added water shall then be adjusted to compensate for any observed variations in the moisture contents. BIS: 2386 shall be referred to for determination of moisture content.

No substitution in material, used on the work or alteration in the established proportions shall be made without additional tests to show that the quality and strength of concrete are satisfactory. No alterations shall be permitted without the prior sanction of the Engineer-in-Charge.

5.10.1. Mixing of Concrete

The mixing of concrete shall be strictly carried out in an approved type of mechanical Concrete mixer. The mixing equipment shall be capable of combining the aggregates. Cement and water within the specified time into a thoroughly mixed and uniform mass, and of discharging the mixture without segregation. The entire batch shall be discharged before recharging. Mixing periods shall be measured from the time when all of the solid materials are in the mixing drum, provided that all of the mixing water shall be introduced before one fourth of the mixing time has elapsed. The mixing time in no case shall be less than two minutes. The mixer speed shall not be less than 14 nor more than 20 revolutions per minute.

Mixing shall be continued until there is a uniform distribution of the materials and the mass is uniform in color and consistency. Hand mixing of concrete shall not be permitted at all.

For quantities less than 1 cum of concrete, hand mixing may be permitted at the discretion of the Engineer-in-Charge with 10% excess cement quantity.

5.10.2. Grade of Concrete

The different grades of concrete specified shall conform to the strengths as required by IS: 456-1987.Standard deviation shall be calculated as stated in 14.5 of IS: 456-1978. The acceptable criteria for concrete shall be as stated in clause 15 of IS: 456 -1978.The assumed standard deviations as given in table 6 of IS: 456-1978 has to be followed and are given here under. However, the minimum cement content shall be as per Table no. 7: Minimum Cement Content in Concrete in this tender document.

Table 5: Grade of Concrete

Grade of Concrete	Assumed Standard Deviation N/sq.mm
M 10	2.3
M 15	3.5
M 20	4.6
M 25	5.3

In order to get a quick idea of quality of concrete the optional tests are conducted as stipulated in 14.1.1 of IS: 456-1978 and the results are analyzed according to table 5 on page 41 of IS: 456-1978.

5.10.2.1. Controlled Concrete

Controlled concrete shall be used on all concreting works except where specified otherwise the mix proportions for all grades of concrete shall be designed to obtain strengths corresponding to the values specified in table below for respective grades of concrete.

Table 6: Compressive Strengths at 28 days

Grade	Specified Characteristic Compressive Strength at 28 days (N/sq.mm)
M15	15
M20	20
M25	25
M30	30

The maximum Water : Cement ratio for all controlled concrete works shall be as specified in IS: 456-1978 as Preliminary tests as specified in the BIS code and required by the Engineer-in-Charge shall be carried out sufficiently ahead of the actual commencement of the work with different grades of concrete made from representative samples of aggregates and cement expected to be used on the job to ascertain the ratios by weight of cement of total quantity of fine and coarse aggregates and the water cement ratio required to produce a concrete of specified strength and desired workability.
The minimum cement content for each grade of concrete shall be as per table below.

Table 7: Minimum Cement Content in Concrete

Grade of Concrete	Minimum Cement Content in Concrete (kg/cum of finished Concrete)
M 20	280
M 25	300
M 30	320
M 35	350

At least 4 (four) trial batches are to be made and 7 test cubes should be taken for each batch noting the slump on each mix. These cubes shall then be properly cured and two cubes from each mix shall be tested in a testing laboratory approved by the Engineer-in-Charge at 7 days and others at 28 days for obtaining the ultimate compressive strength. The test reports shall be submitted to the Engineer in charge. The cost of mix design and testing shall be borne by the Contractor. On the basis of the preliminary test reports for trial mix, a proportion of mix by weight and water cement ratio will be approved by the Engineer-in-Charge, which will be expected to give the required strength. Consistency and workability and the proportions so decided for different grades of concrete shall be adhered to during all concreting operations. If however at any time the Engineer-in-Charge feels that the quality of material, being used has been changed from those used for preliminary mix design, the Contractor shall have to run similar trial mixes to ascertain the mix proportions and consistency.

The mix once approved must not be varied without prior approval of the Engineer-in-Charge. However should the Contractor anticipate any change in the quality of future supply of materials than that used for preliminary mix design, he shall inform the same to the Engineer-in-Charge and bring fresh samples sufficiently ahead to carry out fresh trial mixes. The Engineer-in-Charge shall have access to all places and laboratory where design mix is prepared. Design mix will indicate by means of graphs and curves etc. the extent of variation in the grading of aggregates which can be allowed.

In designing the mix proportions of concrete, the quantity of both cement and aggregate shall be determined by weight. All measuring equipment shall be maintained in clean and serviceable condition and their accuracy periodically checked.

To keep the water cement ratio to the designed value, allowance shall be made for the moisture contents in both fine and course aggregates and determination of the same shall be made as frequently as directed by the Engineer-in-Charge. The determination of moisture contents shall be according to IS: 2386 (Part III). Absorption of water by dry aggregates shall not be more than 5%.

5.10.2.2. Strength Requirements

Where ordinary Portland cement conforming to IS: 269 or Portland blast furnace slag cement conforming to IS: 455 is used the compressive strength requirements for various grades of concrete shall be as shown in table below. Where rapid hardening Portland cement is used the 28 days compressive strength requirements specified in Tablehereunder shall be met in 7 days. The strength requirements specified in table shall apply to both controlled concrete and

ordinary concrete.

Strength Requirements of Concrete

Grade of Concrete	Minimum Compressive Strength Concrete in accordance with IS: 516 (in Kg/Cm2) As per IS 456-2000 for 15 cm Cube Specimens		
	at 3 days	at 7 days	at 28 days
M 15	100	200	150
M 20	135	260	200
M 25	170	320	250
M 30	200	380	300

Other requirements of concrete strength as may be desired by the Engineer-in-Charge shall be in accordance with Indian Standard IS: 456 (latest revision). The acceptance of strength of concrete shall be as per clause 5.4 “Sample size and Acceptance Criteria” of IS: 456 (latest revision) subject to stipulation and/or modifications stated elsewhere in this specification if any.

Concrete work found unacceptable shall have to be dismantled and replaced to the satisfaction of the Engineer-in-Charge by the Contractor free of cost to the Owner. No payment will be made for the dismantled concrete, the relevant formwork and reinforcement, embedded mixtures etc. wasted in the dismantled portion shall be made. In the course of dismantling if any damage is done to the embedded items or adjacent structures, the same shall also be made good free of charge by the Contractor to the satisfaction of the Engineer in charge. If the water quantity has to be increased in special cases, cement also has to be increased proportionately to keep the ratio of water to cement same as adopted in trial mix design for each grade of concrete.

5.10.2.3. Workability

The workability of concrete shall be checked at frequent intervals by slump test. Where facilities exist and if required by the Engineer-in-Charge, alternatively the compacting factor test in accordance with IS: 1199 shall be carried out. The degree of workability necessary to allow the concrete to be well consolidated and to be worked into the corners of form work and round the reinforcement to give the required surface finish shall depend on the type and nature of the structure and shall be based on experience and tests. The limits of consistency for structures are as specified in the table below:

Table 8: Limits of Consistency

Concreting of shallow Sections with vibration	Very low	20-10 seconds Veebee time or 0.75-0.80 compacting factor
Concreting of lightly Reinforced sections With vibration	Low	10-5 seconds or 0.80-0.85 compacting factor
Concreting of lightly Reinforced sections Without Vibration or Heavily reinforced Section with Vibration	Medium	5-2 seconds Veebee time or 0.85-0.92 compacting factor or 25-75mm slump for 20 mm Aggregate
Concreting of heavily Reinforced sections compacting Without vibration factor	High	Above 0.92 compacting factor or 75-125 mm slumps for 20 mm aggregate

5.10.3. Workmanship

All workmanship shall be according to the latest relevant standards. Before starting a pour the Contractor shall obtain the approval of the Engineer-in-Charge and all other concerned department including safety dept, in a “Pour Card” maintained for this purpose. He shall

obtain complete instructions about the material and proportion to be used, slump, workability of water per unit of cement, number of test cubes to be taken, finishing to be done and any admixture to be added etc.

5.11. SAMPLING AND TESTING OF CONCRETE IN THE FIELD

Sampling and Testing of Concrete shall conform to IS: 456 2000.

a) Facilities required for sampling materials and concrete including whether proof buildings to house the facilities in the field, shall be provided by the Contractor at no extra cost.
The following equipment with operator shall be made available in serviceable conditions.

i.	Concrete cube-testing machine suitable for 15 cm cubes of 100 tonnes capacity with proving calibration ring	1 no.
ii.	Cast iron cube moulds 15 cm size	24 nos.
iii.	Slump cone complete with tamping rod	2 set
iv.	Laboratory balance to weigh upto 5 kg with sensitivity of 10 gm	1 no.
v.	BIS sieves for coarse and fine aggregates	1 set
vi.	Set of measures from 5 litres to 0.1 litre	1 set
vii.	Electric oven with thermostat upto 120° C	1 no.
viii.	Flakiness gauge	1 no.
ix.	Elongation index gauge	1 no.
x.	Sedimentation pipette	1 no.
xi.	Calibrated glass jar 1.0 litre capacity	2 nos.
xii.	Glass flasks and metal containers	As required
xiii.	Chemical reagents like sodium hydroxide, tannic acid, litmus paper etc. -	As required
xiv.	Laboratory balance of 2 kg capacity and sensitivity of 1 gm -	1 no.
xv.	Weighing Machine for cement bags of 6 Nos.:	2 no.
xvi.	Vernier Calipers	As required.
xvii.	Thermometer for concrete	1 no.

b) No concrete of any kind may be placed until the field concrete testing laboratory as specified is provided to the satisfaction of the Engineer. The Contractor shall notify the Engineer in advance of all concrete and concrete material testing as provided in the clause to provide the Engineer/his representative with an opportunity to witness all prescribed tests.

c) At least 12 test cubes of each class of concrete shall be made of every 50cum concrete or part thereof or from different batches as directed by Engineer-in-Charge. Such samples shall be drawn on each day for each type of concrete. Of each set of 12 cubes, six shall be tested at 7 days age and six at 28 days age. The cubes must be casted from various batches to arrive at an average strength. The laboratory test results shall be tabulated and furnished to the Engineer. The Engineer will pass the concrete if average strength of the specimens tested is not less than the strength specified, subject to the condition that only one out of three consecutive tests may give a value less than the specified strength but this shall not be less than 90% of the specified strength.

d) Consistency: Slump tests shall be carried out as often as requested by the Engineer and invariably from the same batch of concrete from which the test cubes are made. Slump tests shall be done immediately after sampling.

5.12. CONCRETE TESTS

The Engineer-in-Charge, may order tests to be carried out on cement, sand, coarse aggregate, water in accordance with the relevant Indian standards.
Tests on Cement shall include:

- Fineness test

- Test for normal consistency
- Test for setting time
- Test for soundness
- Test for tensile strength
- Test for compressive strength
- Test for heat of hydration (by experiment and by calculations) in accordance with BIS 269
- Tests on Sand shall include:
- Sieve test
- Test for organic impurities
- Decantation test for determining clay and silt content
- Specific gravity test
- Test for unit weight and bulkage factor
- Test for sieve analysis and fineness modulus
- Tests on Coarse Aggregate shall include:
- Sieve analysis
- Specific gravity and unit weight of dry, loose and rodded aggregate
- Soundness and alkali aggregate reactivity
- Petrography examination
- Deleterious materials and organic impurities
- Test for aggregate crushing value

Any or all these tests would normally be ordered to be carried out only if the Engineer feels the materials are not obtained and shall be performed by the Contractor at a test laboratory approved by AMC. The Contractor shall bear the charges of these optional tests.

Concrete not made to the requirements of specification in all respects may be rejected by the Engineer-in-Charge in which case it shall be removed and reconstructed entirely at the expense of the Contractor.

Failure to meet Specified Requirements

If from the cube test results it appears that some portion of the work has not attained the required strength, the Engineer may order that portion of the structure be subjected to further testing of any kind whatsoever as desired by the Engineer, including if so desired by him, full load testing of the suspected as well as adjacent portions of the structure as specified in the contractors cost. The engineer may also reject the work and order its demolition and reconstruction at the contractors cost.

If the Strength of concrete in any portion of the structure is lower than the required strength, but is considered nevertheless adequate by the Engineer So that demolition is not necessary, the contractor shall be paid a lower rate for such lower strength concrete as determined by Engineer.

If the concrete is not able to meet the prescribed acceptance standard the effect of such deficiency on structure shall be investigated by the contractor as directed by the Engineer. The engineer may accept the work as sub standard work. Any additional work required by the Engineer for such acceptance shall be carried out by the contractor at his cost. In case the concrete is not found to be acceptable after investigation, the contractor shall remove the rejected work.

5.12.1. Load Test on Members or Any Other Tests

i) In the event of any work being suspected of material or workmanship or both, the Engineer-in-Charge requiring its removal and reconstruction may order, or the Contractor may request that it should be load tested in accordance with the following

provisions.

ii) The test load shall be 125% of the maximum superimposed load for which the structure was designed. Such test load shall not be applied before 56 days after the effective hardening of concrete. During the test, struts strong enough to take the whole load shall be placed in position leaving a gap under the members. The test load shall be maintained for 24 hours before removal.

iii) If within 24 hours of the removal of the load, the structure does not show a recovery of at least 75% of the maximum deflection shown during the 24 hours under load, the test loading shall be repeated after a lapse of at least 72 hours. The structure shall be considered to have failed to pass the test if the recovery after the second test is not at least 75% of the maximum deflection shown during the second test. If the structure is certified as failed by the Engineer-in-Charge, the cost of all the new construction and the load tests shall be borne by the Contractor.

iv) Any other tests, e.g. taking out in an approved manner concrete cores, examination and tests on such cores removed from such parts of the structure as directed by the Engineer-in-Charge, sonic testing etc. shall be carried out by the Contractor, if so directed, at no extra cost.

5.12.2. Unsatisfactory tests

Should the results of any test prove unsatisfactory, or the structure shows signs of weakness, undue deflection or faulty construction, the Contractor shall remove and rebuild the member or members involved or carry out such other remedial measures as may be required by the Engineer-in-Charge.

5.12.3. Non Destructive Test (NDT)

Frequency of Non Destructive test
up to 15 m^3 : 1 sample
15 to 30 m^3 : 2 samples
30 to 50 m^3 : 3 samples
or 1.5 % of the surface area of concrete which is greater
The Indian Standard 13311 (both part-I and Part-II), Part- I deals with Ultrasonic Pulse Velocity and part-II deals with Hammer Testing
The Calibartion of the
Type more here

5.13. ADMIXTURES

5.13.1. General

Admixtures may be used in concrete where required, only with the approval of the Engineer-in-Charge. How ever it should be seen that, with the passage of time, neither the compressive strength nor its durability is reduced. Calcium chloride shall not be used for accelerating set of the cement for any concrete containing reinforcement or embedded steel parts. When calcium chloride is permitted to be used, such as in mass concrete works, it shall be dissolved in water and added to the mixing water in an amount not to exceed 1.5% of the weight of the cement in each batch of concrete. When admixtures are used, the designed concrete mix shall be corrected accordingly. Admixtures shall be used as per manufacturer's instruction and in the manner and with the control specified by the Engineer-in-Charge.

5.13.2. Air Entraining Agents

Neutralized Vinson resin or other approved air in the concrete mix agents shall conform to the requirements of ASTM standard 6.260; Air Entraining Admixtures for Concrete. The recommended total air content of the concrete is 4% + 1%. The method of measuring air content shall be as per IS: 1199.

5.13.3. Water Reducing Admixtures

Water reducing lignosulfonate admixture may be added in quantities approved by the Engineer-in-Charge. The admixtures shall be added in the form of a solution.

5.13.4. Retarding Admixtures

Retarding agents may be added to the concrete mix in quantities approved by the Engineer-in-Charge.

5.13.5. Water Proofing Agent

Water proofing agents shall conform to IS: 2645.

5.13.6. Other Admixtures

The Engineer-in-Charge may at his discretion allow the Contractor to use any other admixture in the concrete.

5.14. PREPARATION PRIOR TO CONCRETE PLACEMENT, FINAL INSPECTION AND APPROVAL

a. Before the concrete is actually placed in position, the insides of the formwork shall be inspected to see that they have been cleaned and oiled. Temporary openings shall be provided to facilitate inspection, especially at bottoms of columns and wall forms, to permit removal of sawdust, wood shavings, binding wire, dirt etc. Openings shall be placed or holes drilled so that these materials and water can be removed easily. Such openings/holes shall be suitably plugged later.

b. The various agencies shall be permitted ample time to install drainage and plumbing lines, floor and trench drains, conduits, hangers, anchors, inserts, sleeves, bolts, frames and other miscellaneous embedment to be cast in the concrete as specified or required or as is necessary for the proper execution of the work as specified in the drawings.

c. All embedded parts, inserts, etc. supplied by the AMC or the Contractor shall be correctly positioned and securely held in the forms to prevent displacement during depositing and vibrating of concrete.

d. All anchor bolts shall be positioned and kept in place with the help of properly manufactured templates unless specifically waived in writing by the Engineer-in-Charge.

e. Slots, openings, holes, pockets etc. shall be provided in the concrete work in the position specified in drawing or required or as directed by the Engineer-in-Charge.

f. Reinforcement and other items to be cast in concrete shall have clean surfaces that will not impair bond.

g. Prior to concrete placement, all work shall be inspected and approved by the Engineer-in-Charge and if found unsatisfactory, concrete shall not be poured until after all defects have been corrected.

h. Approval by the Engineer-in-Charge of any and all materials and work as required herein shall not relieve the Contractor from his obligation to produce finished concrete in accordance with the requirements of the specifications.

i. Rain or wash water

No concrete shall be placed in wet weather or on a water-covered surface. Any concrete that has been washed by heavy rains shall be entirely removed, if there is any sign of cement and sand having been washed away from the concrete mixture. To guard against damage, which may be caused by rains, the works shall be covered with tarpaulins immediately after the concrete has been placed and compacted before leaving the work unattended. Any water accumulating on the surface of the newly placed concrete shall be removed by approved means and no further concrete shall be placed thereon until such water is removed. To avoid flow of water over/around freshly placed concrete, suitable drains and sumps shall be provided. During summer season, temperature of water should be maintained, as per the criteria and for the same, icing should be done for concreting work.

j. Bonding Mortar
Immediately before concrete placement begins, prepared surfaces except formwork, which will come in contact with the concrete to be placed, shall be covered with abonding mortar as specified.

k. The corrosive matters on the reinforcement should be removed by means of wire brush.

l. Laitance should be removed by means of chiseling from top concrete layer which was earlier concreted

5.15. TRANSPORTATION

5.15.1. General

All buckets, containers or conveyors used for transporting concrete shall be mortar-tight, leak proof irrespective of the method of transportation adopted, concrete shall be delivered with the required consistency and plasticity without segregation or loss of slump. However, chutes shall not be used for transport of concrete without the written permission of the Engineer-in-Charge and concrete shall not be re-handled before placing.

5.15.2. Retempered or Contaminated Concrete

Concrete must be placed in its final position before it becomes too stiff to work. On no account, water shall be added after the initial mixing. Concrete, which has become stiff or has been contaminated with foreign materials shall be rejected and disposed off as directed by the Engineer-in-Charge.

5.15.3. Avoiding Segregation

Concrete shall, in all cases, be deposited as nearly as practicable directly, in its final position and shall not be re-handled to flow in a manner which will cause segregation, loss of materials, displacement of reinforcement, shuttering or embedded insets, or impair its strength. For locations where direct placement is not possible, and in narrow forms, the Contractor shall provide suitable drop and “Elephant Trunks” to confine the movement of concrete. Special care shall be taken when concrete is dropped from a height, especially if reinforcement is in the way, particularly in column and the walls.

5.15.4. Placing by Manual Labour

Except when otherwise approved by the Engineer-in-Charge, concrete shall be placed in the shuttering by shovels or other approved implements, and shall not be dropped from a height more than 1.0 m or handled in a manner, which will cause segregation.

5.15.5. Placing by Mechanical Equipment

The following specification shall apply when placing concrete by use of mechanical equipment is warranted considering the nature of work involved. The control of placing shall begin at the mixer discharge. Concrete shall be discharged by a vertical drop into the middle of the bucket or hopper and this principle of a vertical discharge of concrete shall be adhered to throughout all stages of delivery until the concrete comes to rest in its final position.

5.15.5.1. Types of Buckets

Central-bottom-dump buckets of a type that provides for positive regulation of the amount and rate of deposition of concrete in all dumping positions, shall be employed.

5.15.5.2. Operation of Bucket

In placing concrete in large open areas, the bucket shall be spotted directly over the position designated and then lowered for dumping. The open bucket shall clear the concrete already in place and the height of drop shall not exceed 1.0 m. The bucket shall be opened slowly to avoid high vertical bounce. Dumping of buckets on the swing or in any manner, which results

in separation of ingredients or disturbance of previously placed concrete, will not be permitted.

5.15.6. Placement of Restricted Forms

Concrete placed in restricted forms by barrows, buggles, cars, short chutes or hand shoveling shall be subject to the requirement for vertical delivery of limited height to avoid segregation and shall be deposited as nearly as practicable in its final position.

5.15.7. Chuting

Where it is necessary to use transfer chutes, specific approval of Engineer-in-Charge must be obtained to type, length slopes, baffles, vertical terminals and timing of operations. These shall be so arranged that an almost continuous flow of concrete is obtained at the discharge and without segregation. Concrete should flow smoothly in the chute and there should not be any obstruction to the flow. To allow for the loss of mortar against the sides of the chutes, the first mixes shall have less coarse aggregate. During cleaning of chutes, the wastewater shall be kept clear of the forms. Concrete shall not be permitted to fall from the end of the chutes by more than 1.0 m. Chutes, when approved for use shall have slopes not flatter than 1 vertical, 3 horizontal and not steeper than 1 vertical, 2 horizontal. Chutes shall be of metal or metal lines end of rounded cross section. The slopes of all chute sections shall be approximately the same. The slopes of all chute sections shall be approximately the same. The discharge end of the chutes shall be maintained above the surface of the concrete in the forms.

5.15.8. Placing by Pumping/Pneumatic Placers

Concrete may be conveyed and placed by mechanically operated equipment e.g., pumps or pneumatic placers only with the written permission of the Engineer-in-Charge at no extra cost. The slump shall be held to the minimum necessary for conveying concrete by this method.

When pumping is adopted, before pumping of concrete is started, the pipeline shall be lubricated with one or two batches of mortar composed of one part cement and two parts sand. Care shall be taken to avoid stoppages in work once pumping has started.

When a pneumatic placer is used, the manufacturer's advice on layout of the pipeline shall be followed to avoid blockages and excessive wear. Restraint shall be provided at the discharge box to cater for the reaction at this end. Manufacturer's recommendations shall be followed regarding concrete quality and all other related matters when pumping/ pneumatic placing equipment is used. It should be noted that no extra payment is made for these items, if required and directed by Engineer-in-Charge.

5.15.9. Concrete in Layers

Concreting, once started, shall be continuous until the pour is completed. Concrete shall be placed in successive horizontal layers of uniform thickness ranging from 15 cm to 45 cm directed by Engineer-in-Charge. These shall be placed as rapidly practicable to prevent the formation of cold joints or planes of weakness between each succeeding layer within the pour. The thickness of each layer shall be such that it can be deposited before the previous layer has stiffened. The bucket loads or other units of deposit, shall be spotted progressively along the face of the layer with such overlap as will facilitate spreading the layer to uniform depth and texture with a minimum shoveling. Any tendency to segregation shall be corrected by shoveling stones into mortar rather than mortar on to stones. Such a condition shall be corrected by redesign of mix or other means, as directed by the Engineer-in-Charge.

5.15.10. Cover Blocks

Cover blocks of required size depending on the cover of the reinforcement as mentioned in the drawings shall be prepared in 1:3 cement mortar with fine aggregates and minimum compressive strength of 300 kg/sq.cm.

5.15.11. Bedding of Layers

The top surface of each pour and bedding planes shall be approximately horizontal unless otherwise instructed. Top layer should be rough and with key for further extension

of work.

5.15.12. Compaction

Concrete shall be compacted during placing with approved vibrating equipment until the concrete has been consolidated to the maximum practicable density, as specified in the IS, is free of pockets of coarse aggregate and fits tightly against all form surfaces, reinforcement and embedded fixtures. Particular care shall be taken to ensure that all concrete placed against the form faces and into corners of forms against hardened concrete at joints is free from voids or cavities. The use of vibrators shall be consistent with the concrete mix and caution exercised not to over vibrate the concrete to the point that segregation results.

5.15.12.1. Type of Vibrators

Vibrators shall conform to BIS specifications. Type of vibrator to be used shall depend on the structures where concrete is to be placed. Shutter vibrators to be effective, shall be firmly secured to the formwork which must be sufficiently rigid to transmit the vibration and strong enough not to be damaged by it. Immersion vibrators in sufficient numbers and each of adequate size shall be used to properly consolidate all concrete. Tapping or external vibrating of forms by hand tools or immersion vibrators will not be permitted.

5.15.12.2. Use of Vibrators

The exact manner of application and the most suitable machines for the purpose must be carefully considered and operated by experienced men. Immersion vibrators shall be inserted vertically at points not more than 450 mm apart and withdrawn when air bubbles cease to come to the surface. Immersion vibrators shall be withdrawn very slowly. In no case shall immersion vibrators be used to transport concrete inside the forms. Particular attention be paid to vibration at the top of a lift e.g. in a column or wall.

5.15.12.3. Melding Successive Batches

When placing concrete in layers, which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration blending and melding of the concrete between the succeeding layers.

5.15.12.4. Penetration of Vibrators

The immersion vibrator shall penetrate the layer being placed and also penetrate the layer below while the under layer is still plastic to ensure good bond and homogeneity between the two layers and prevent the formation of cold joints.

5.15.12.5. Vibrating against Reinforcement/Formwork

Care shall be taken to prevent contact of immersion vibrators against reinforcement steel. Immersion vibrators shall not be allowed to come in contact with reinforcement steel after start of initial set. They shall also not be allowed to come in contact with forms or finished surfaces.

5.15.12.6. Use of Form Attached Vibrators

Form attached vibrators shall be used only with specific authorization of the Engineer-in-Charge.

5.15.12.7. Use of Surface Vibrators

The use of surface vibrators will not be permitted under normal conditions. However, for thin slabs, surface vibrating by specially designed vibrators may be permitted, upon approval of Engineer-in-Charge.

5.15.12.8. Stone Pockets And Mortar Pondages

The formation of stone pockets and mortar pondages in corners and against faces of forms shall not be permitted. Should these occur, they shall be dug out, reformed and

refilled to sufficient depth and shape for thorough bonding, as directed by the Engineer-in-Charge.

5.15.13. Placement Interval

Except when placing with slip forms, each placement of concrete in multiple lift work, shall be allowed to set for atleast 24 hours after the final set of concrete and before the start of a subsequent placement

5.15.14. Special Provision in Placing

When placing concrete in walls with openings, in floors of integral slabs and beam construction and other similar conditions, the placing shall stop when the concrete reaches the top of the opening in walls or bottom horizontal surface of the slab, as the case may be.

Placing shall be resumed before the concrete in place takes initial set, but not until it has had time to settle as determined by the Engineer-in-Charge.

5.15.15. Placing Concrete Through Reinforcing Steel

When placing concrete through reinforcing steel, care shall be taken to prevent segregation of the coarse aggregate. Where the congestion of steel makes placing difficult, it may be necessary to obtain Engineer in-Charge's permission for temporarily moving the top steel aside for proper placement & for restoring reinforcement as per drawing.

5.15.16. Bleeding

Bleeding or free water on top of concrete being deposited into the forms, shall be the cause to stop the concrete pour and the conditions causing this defect corrected before any further Concreting is resumed.

5.16. APPLICATION OF ARALDITE FOR BONDING OF NEW AND OLD CONCRETE

5.16.1. General

Araldite epoxy resins will be used to bond fresh concrete to concrete that is fully cured, to give a monolithic bond capable of transmitting high stresses when traditional bonding agents such as cement slurry cannot always be relied upon to provide good adhesion which is particularly the case when large areas are involved.

a. The Araldite based formulation shall be applied to a suitably prepared concrete sub-strata and the fresh concrete poured as soon as possible, but always during the 'open time' of the adhesive.
b. Materials used shall be of best quality like CIBA, FOSROC or ROFF and approved by the Engineer-in-Charge.
c. Manufacturer's instructions shall be followed in all respects.
d. No separate payment shall be paid for this item of work.

5.16.2. Formulation

ARALDITE	GY250	100	Parts by weight
Hardener	HY825	20	Parts by weight
Hardener	HY830	20	Parts by weight
Hardener	HY850	20	Parts by weight
Silica Flour	20	Parts by weight	

5.16.3. Application

The application of the adhesives shall be as per manufacturer standards.

5.16.3.1. Preparation of the Substrata

To obtain good adhesion, it is necessary to have clean and sound substrata. Preparation can be carried out using a variety of techniques including chemical treatment and mechanical methods such as grinding, milling, abrading, planing and sand blasting. Dust and loose particles resulting from the pretreatment should be removed by vacuum cleaning or oil-free or blast.

5.16.3.2. Mixing

The resin and hardener should be thoroughly mixed in the dry filler. The mixed, ready to use adhesive should not contain lumps of unwetted filler and should be of uniform color. For a total weight of 1 kg or less hand mixing should be sufficient. For quantities in excess of 1 kg, the use of a mechanical mixer is recommended.

5.16.3.3. Pot life and 'Open time'

The pot life is the period during which the ready to use ARALDITE based formulation must be applied. After this period, the mix can no longer be worked and will have begun to set in its container. The table below indicates the pot life at different temperatures:

Mix Temperature	Pot life in minutes
25° C	90 Minutes
30° C	60 Minutes
35° C	45 Minutes

(The figures in this table are for batches less than 1 kilogram).

The 'Open time' is the maximum period of time allowable between application of the ARALDITE adhesive and pouring the fresh concrete. Exceeding the 'Open time' would result in considerably reduced adhesion. The adhesive should be applied to the pre-treated substrata as soon as the components have been mixed and fresh concrete poured immediately afterwards.

Accurate knowledge of the 'Open time' is essential in case the work is interrupted.

Table gives the 'Open time' of ARALDITE based formulations as a function of substrata temperature. In all cases, the adhesives shall be applied immediately after mixing. Any delay between mixing and application will reduce the 'Open time'. Fresh concrete must be poured before the adhesive begins to gel. New to old concrete bonding is not recommended at temperatures below 5-Degree Centigrade, as curing cannot be assured under these circumstances.

5.16.3.4. Methods of Application

The shape and size of the concrete structure will determine the method of application used. The ARALDITE based adhesive may be applied by hand using brushed, brooms or any other suitable applicator.

5.16.3.5. Suitability of Fresh Concrete

Best results are obtained when the water/ cement ratio of the new concrete is low as is practicable.

5.16.3.6. Coverage

One kilogram of the mixed ARALDITE adhesive including hardeners and filler covers an area of 2 to 3 sq.m. when applied with a stiff nylon bristle brush. However, the coverage is very much dependent on the finish in the concrete.

5.17. HANDLING PRECAUTIONS

Epoxy resins can cause irritation of the skin in sensitive person if incorrectly handled. Certain safety precautions must therefore be observed and those handling the resins and hardeners should be given suitable instructions. Those working with epoxy resins should, above all, be instructed that personal cleanliness at the place of work is essential. The resin and hardener should not be allowed to come into direct contact with the skin. The most effective protection is achieved by wearing rubber or polythene gloves, the latter having the advantage that they can be replaced when dirty. They are more pleasant to wear if cotton gloves are worn underneath. Parts of the skins, which have come into contact with the resin or hardener, should be washed with lukewarm water and a mild soap. Special cleaning creams may be used as they have proved to be highly suitable.

5.18. CONSTRUCTION JOINTS

a. A construction joint is defined as a joint in the concrete introduced for convenience

in construction at which special measures are taken to achieve subsequent continuity without provision for further relative movement.

b. No concreting shall be started until the Engineer-in-Charge has approved the method of placing the positions and form of the construction joints and lifts. The construction joints shall be so located as not to impair the strength of the structure. Water stops shall be inserted as per clause 3.20

c. Concrete placed to form the face of a construction joint shall have all Laitance removed and the aggregate exposed prior to the placing of fresh concrete. The Laitance shall wherever practicable be removed by spraying the concrete where it is still green. The whole of the concrete surface forming part of the joint shall be hacked to expose the aggregate to the 1/3rd size of maximum size of aggregate. Where aggregate is damaged during hacking, it shall be removed from the concrete face by further hacking. All loose matter shall be removed and the exposed surface thoroughly cleaned by wire brushing, air blasting or washing, leaving the surface clean and damp. Immediately before fresh concrete is placed, a 12 mm thick layer of sand/cement mortar mixed in the same proportions as in the concrete shall be spread in the horizontal face of the construction joint. A drier mix shall be used for the top lift of horizontal face of the construction joint. A drier mix shall be used for the top lift of horizontal pours to avoid Laitance. The new concrete shall be well worked against the prepared face before the mortar sets. Special care shall be taken to obtain thorough compaction and to avoid segregation of the concrete along the joint plane.

5.19. MOVEMENT JOINTS

a. Movement joints are defined as all joints intended to accommodate relative movement between adjoining parts of a structure, special provision being made where necessary for maintaining the water tightness of the joint. The Contractor shall comply with the instructions of manufacturers of proprietary jointing materials and shall, if required by the Engineer-in-Charge, demonstrate that the jointing materials can be applied satisfactorily.

b. The surface of set concrete in a movement joint shall, as shown on the drawings, be painted with two coats of bituminous paint and new concrete shall be placed against it only when the paint is dry. Expansion joints shall be formed by a separating strip of approved preformed joint filler.

c. Caulking grooves shall be provided. At all joints where a caulking groove is formed, immediately prior to caulking, the groove shall be wire brushed and loose material removed and blown out by compressed air. After the groove has dried, it shall be primed and caulked with approved sealing compound applied in accordance with the manufacturer's instructions. At all caulked joints, the face of the caulking strip and a width of concrete on either side shall be painted with two coats of paint having the same base as the sealing compound.

5.20. WATER STOPS AND JOINT FILLERS

5.20.1. Water stops

a. At all construction, contraction and expansion joints in the water retaining structures and wherever specified or directed by the Engineer-in-Charge, water stops shall be provided. The water stops shall be PVC type or of any other equivalent material as approved by the Engineer-in-Charge. PVC water stops shall have a tensile strength of not less than 14 MN/m2 and elongation at break of not less than 300%. Water stops shall not be exposed to direct sunlight for long periods. Before being concreted in water stops shall be cleaned of all foreign materials. Wherever provided, water stops shall be placed in such a manner that they are embedded in the adjacent sections of the panels for equal width.

b. As far as possible, jointing on site shall be confined to the making of butt joints in straight runs of water stops and all the joints should be monolithic. Where it is agreed with the Engineer-in-Charge that it is necessary to make an intersection or change of direction of any joint, other than a butt joint in a straight run on site, a

preliminary joint, intersection or change of direction piece shall be made and submitted to such tests as the Engineer-in-Charge may require.

c. Flexible water stops shall be fully supported in the form work, free of nails and clear of reinforcement and other fixtures. Damaged water stops shall be replaced and during concreting care shall be taken to place the concrete so that water stops do not bend or distort or displace.

d. The different types of water stops to be used in liquid retaining structures will be as follows:

Table 9: Types of water Stops

Sr.	Type of Joint	Type of water stops
1	Partial/complete Contraction joint in walls and slabs	230 mm wide, ribbed with hollow centre bulb & 6 mm minimum thickness
2	Expansion joints in walls and slabs	230 mm wide, ribbed with hollow centre bulb & 9 mm minimum thickness
3	Construction joint in raft	230 mm wide, ribbed with hollow centre bulb & 9 mm minimum thickness
4	Construction joint in wall	230 mm wide, ribbed with hollow centre bulb & 6 mm minimum thickness
5	Expansion joint raft	230 mm wide, ribbed with hollow centre bulb & 9 mm minimum thickness
6	Partial/complete Contraction joint in raft	230 mm wide, ribbed with hollow centre bulb & 9 mm minimum thickness

5.20.2. Jointing fillers

Joint fillers shall be of durable, compressible and non-extruding material.

Details of jointing material required here. Type of joint, size or width of joint and joint filler material to be used with preferred brands if any.

5.21. SEALING COMPOUNDS

Horizontal joints shall, where used in water-retaining structures be sealed with a cold pouring polysulphide rubber sealing compound of quality equal to, or better than serviced “Paraseal”. Horizontal joints in roofs, floors and other non-water retaining structures shall be sealed with an approved sealant with properties equal to or better than serviced “Paraplastic 41”. Vertical joints and joints in the soffits of slabs in both water retaining as well as non-water retaining structures shall be sealed with a trowel or gun applied polysulphide rubber sealing compound such as serviced “Vertiseal” or equivalent. Sealing compounds shall be fully cured before water is permitted to come in contact. At 40° C, the curing time would be approximately 7 weeks for polysulphide compounds like CIBA, FOSROC or ROFF as approved by Engineer-in-Charge.

5.22. TOLERANCES IN CONCRETE SURFACES

- Concrete surfaces for the various classes of unformed and formed finishes specified in various clauses shall comply with the tolerances shown in Table hereunder, except where different tolerances are expressly required by the specification.
- In the table ‘line and level’ and ‘dimension’ shall mean the lines, levels and cross-sectional dimensions as specified and required.
- Surface irregularities shall be classified as ‘abrupt’ or ‘gradual’. Abrupt irregularities include by shall not be limited to offsets and fins caused by displaced or misplaced formwork, loose knots and other defects in formwork materials, and

shall be tested by direct measurement. Gradual irregularities shall be tested by means of a straight template for plane surfaces and 1.5 m long formed surfaces.

Maximum tolerance (mm) in:				
Class of finish	Line & level	Abrupt irregularity	Gradual irregularity	Dimension
U 1	12	6	6	-
U 2	6	3	3	-
U 3	6	3	3	-
F 1	12	6	6	6
F 2	6	6	6	6
F 3	3	3	3	+6-

5.23. CURING, PROTECTING, REPAIRING AND FINISHING

5.23.1. Curing

All concrete shall be kept continuously in a damp or wet condition by ponding or by covering with a layer of sacking, canvas, hessian or similar materials and kept constantly wet for atleast seven days from the date of placing concrete in case of OPC and 10 days in case of mineral admixture or blended cements are used. The period of curing shall be not less than 10 days for concrete exposed to dry and hot weather condition

5.23.2. Curing with Water

Fresh concrete shall be kept continuously wet for a minimum period of 10 days from the date of placing of concrete, following a lapse of 12 to 14 hours after laying of concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin as soon as the concrete has hardened. Water shall be applied to formed surfaces immediately upon removal of forms. Quantity of water applied shall be controlled so as to prevent erosion of freshly placed concrete.

5.23.3. Continuous Spraying

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances of hose, sprinklers and spraying devices. Continuous fine mist spraying or sprinkling shall be used, unless otherwise specified or approved by the Engineer-in-Charge.

5.23.4. Alternate Curing Methods

Whenever in the judgement of the Engineer-in-Charge, it is necessary to omit the continuous spray method, a covering of clean sand or other approved means such as wet gunny bags, which will prevent loss of moisture from the concrete, may be used. No type of covering will be approved which would stain or damage the concrete during or after the curing period. Covering shall be kept continuously wet during curing period. For curing of concrete in sidewalks, floors, flat roofs of other level surfaces, the ponding method of curing is preferred. The method of containing the ponded water shall be approved by the Engineer-in-Charge. Special attention shall be given to edges and corners of the slabs to ensure proper protection to these areas. The ponded areas shall be kept continuously filled with water during the curing period.

5.23.5. Curing Compound

Surface coating type-curing compounds shall be used only by special permission of Engineer-in-Charge. Curing compounds shall be liquid type white pigmented, conforming to US Bureau of Reclamation specification. No curing compound shall be used on surfaces where future blending with concrete, water of acid proof membrane or painting is specified. Curing compound shall be used only after getting sufficient/satisfactory test results at site.

5.23.6. Curing Equipment

All equipment and materials required for curing shall be on hand and ready for use before concrete is placed.

5.23.7. Protecting Fresh Concrete

Fresh concrete shall be protected from defacements and damage due to construction operations by leaving forms in place for an ample period as specified in section D3 of this specification. Newly placed concrete shall be protected by approved means such as tarpaulins from rain, sun and winds. Steps as approved by the Engineer-in-Charge shall also be taken to protect immature concrete from damage by debris, excessive lading, vibration, abrasion or contact with other materials, etc. that may impair the strength and/or durability of the concrete. Workmen shall be warned against and prevented from disturbing green concrete during its setting period. If it is necessary that the workmen enter the area of freshly placed concrete, the Engineer-in-Charge may require that bridges be placed over the area.

5.23.8. Repair and Replacement of Unsatisfactory Concrete

5.23.8.1. General

Immediately after the shuttering is removed, the surface of concrete shall be very carefully gone over and all defective areas called to the attention of the Engineer-in-Charge who may permit patching of the defective areas or also reject the concrete unit either partially or in its entirety. Rejected concrete shall be removed and replaced by the Contractor. Holes shall be filled with mortar composed of one part of cement to one and half parts of sand passing 2.36 mm I.S sieve after removing any loose stones adhering to the concrete. Concrete surfaces shall be finished as described in specifications or as directed by the Engineer-in-Charge. Superficial honey combed surfaces and rough patches shall be similarly made good immediately after removal of shuttering, in the presence of the Engineer-in-Charge and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with a wooden float. Excess water shall be avoided. Unless instructed otherwise by the Engineer-in-Charge, the surface of the exposed concrete placed against shuttering shall be rubbed down immediately on removal of shuttering to remove fine or other irregularities, care being taken to avoid damaging the surface. Surface irregularities shall be removed by grinding. If reinforcement is exposed or the honeycombing occurs at vulnerable positions e.g. ends of beams or columns, it may be necessary to cut out the member completely or in part and reconstruct. The decision of the Engineer-in-Charge shall be final in this regard. If only patching is necessary, the edges being cut perpendicular to the affected surface or with a small under cut if possible. Anchors, tees or dovetail slots shall be provided whenever necessary to attach the new concrete securely in place. An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.

For small repairs concerned Engineer-in-Charge shall permit to repair the same and shall be repaired at his directions. For major repairs Contractor shall submit the method of statement and on approval of same shall carry such repairs with strict compliance to the method of statement.

5.23.8.2. Use of Epoxy

The use of epoxy for bonding fresh concrete used for repairs will be permitted upon written approval of the Engineer-in-Charge. Epoxies shall be applied in strict accordance with the instructions of the manufacturer.

5.23.8.3. Method of Repair

Small size holes having surface dimensions about equal to the depth of the hole, holes left after removal of form bolts, grout insert holes and slots cut for repair of cracks shall be repaired as follows.

The hole to be patched shall be roughened and thoroughly soaked with clean water until absorption stops. A 5 mm thick layer of grout of equal parts of cement and sand shall be

well brushed into the surface to be patched, followed immediately by the patching concrete which shall be well consolidated with a wooden float and left slightly protrude of the surrounding surface. The concrete patch shall be built up in 10 mm thick layers, after an hour or more, depending upon weather conditions, it shall be worked off flush with a wooden float and a smooth finish obtained by wiping with hessian. A steel trowel shall be used for this purpose. The mix for patching shall be of the same materials and in the same proportion as that used in the concrete being repaired, although some reduction in the maximum size of the coarse aggregates may be necessary and the mix shall be kept as dry as possible. Mortar filling by air pressure (gunniting) shall be used for repair of areas too large and/or too shallow for patching with mortar. Patched surfaces shall be given a final treatment to match the colour and texture of the surrounding concrete. White cement shall be substituted for ordinary cement, if so directed by the Engineer-in-Charge, to match the shade of the patch with the original concrete.

5.23.8.4. Curing of Patched Work

The patched area shall be covered immediately with an approved non-staining, watersaturated material such as gunny bags which shall be kept continuously wet and protected against sun and wind for a period of 24 hours. Thereafter, the patched area shall be kept wet continuously by a fine spray, or sprinkling for not less than 10 days. All fillings shall be tightly bounded to the concrete and shall be sound, free from shrinkage cracks after the fillings have been cured and dried.

5.23.8.5. Approval by the Engineer-in-Charge

All materials, procedures and operations used in the repair work shall be subject to the approval of the Engineer-in-Charge.

5.23.9. Finishing

5.23.8.6. General

The type of finish for formed concrete surfaces shall be as follows, unless varied by the design/architectural drawings and specifications.

When the structure is in service all the surfaces shall receive no special finish, except repair of damaged or defective concrete, removal of fine and abrupt irregularities, filling defective concrete, filling of holes left by form ties and rods and clean up of loose or adhering debris. Surfaces which will be exposed to the weather and which would normally be level, shall be sloped for drainage. Unless a horizontal surface or the slope required is specified, the tops of narrow surfaces such as stair treads, walls, curbs and parapets shall be sloped across the width approximately 1 in 30. Broader surfaces such as walkways, and platforms shall be sloped about 1 in 50. Surfaces that will be covered by backfill or concrete, subfloors to be covered with concrete topping, terrazzo or quarry tiles and similar surfaces shall be smooth ascended and leveled to produce even surfaces. Surface irregularities shall not exceed 6 mm. Surfaces which will not be covered by backfill, concrete or tile toppings such as outside decks, floors of galleries and sumps, parapets, gutters, side-walks, floors and slabs, shall be consolidated, screened and floated. Excess water and laitance shall be removed before final finishing. Floating may be done with hand or power tools and started as soon as the screened surface has attained a stiffness to permit finishing operations and these shall be the minimum required to produce a surface uniform in texture and free from screened marks or other imperfections. Joints and edges shall be tooled as specified or as directed by the Engineer-in-Charge.

5.23.8.7. Standard Finish For Exposed Concrete

Exposed concrete shall mean any concrete, other than floors or slabs, exposed to view upon completion of the works. Unless otherwise specified, the standard finish for exposed concrete shall be a smooth finish. A smooth finish shall be obtained with the use of lined or plywood forms having smooth and even surfaces and edges. Panels of forms shall

be of uniform size and be as large as practicable and installed with closed joints. Upon removal of forms the joint marks shall be smoothed off and all blemishes, protections etc., removed leaving the surfaces smooth.

5.23.8.8. Integral Cement Concrete Finish

When specified, an integral cement concrete finish of specified thickness for floors and slabs shall be applied either monolithic or bonded, as specified or directed by the Engineer-in-Charge. The surface shall be tested with a straight edge and any high and low spots eliminated. Floating or trowelling of the finish shall be permitted only after all surface water has evaporated. Dry cement or a mixture of dry cement and sand shall not be sprinkled directly on the surface of the cement finish to absorb moisture or to stiffen the mix.

5.23.8.9. Rubbed Finish

A rubbed finish shall be provided only on exposed concrete surfaces. Upon removal of forms, all fins and other projections on the surfaces shall be carefully removed, offsets leveled and voids and/or damaged sections immediately saturated with water and repaired by filling with a concrete or mortar of the same composition as was used in the surface. The surfaces shall then be thoroughly wetted and rubbed with carborundun or other abrasive. Cement mortar may be used in the rubbing, but the finished surfaces shall not be brush coated with either cement or grout after rubbing. The finished surfaces shall present a uniform and smooth appearance.

5.23.8.10. Protection

All concrete shall be protected against damage until final acceptance by the Engineer-in-Charge.

5.24. HOT WEATHER REQUIREMENT

a. All Concrete work performed in hot weather shall be in accordance with IS:456, except as herein modified.
b. Admixtures may be used only when approved by the Engineer-in-Charge.
c. Adequate provisions shall be made to lower give limit concrete temperatures by cool ingredients, eliminating excessive mixing, preventing exposure of mixers and conveyors to direct sunlight and the use of reflective paint on mixers, etc. The temperature of the freshly placed concrete shall not be permitted to exceed 38 degrees centigrade.
d. Consideration shall be given to shading aggregate stockpiles from direct rays of the sun and spraying stockpiles with water, use of cold water when available, and burying, insulating, shading and/or painting white the pipelines and water storage tanks and conveyance.
e. In order to reduce loss of mixing water, the aggregate, wooden forms, subgrade, adjacent concrete and other moisture absorbing surfaces shall be well wetted prior to concreting, placement and finishing shall be done as quickly as possible.
f. Extra precautions shall be taken for the protection and curing of concrete.

Consideration shall be given to continuous water curing and protection against high temperatures and drying hot winds for a period of at least 7 days immediately after concrete has set and after which normal curing procedures may be resumed.

5.25. PLACING CONCRETE UNDERWATER

a) Under all ordinary conditions, all foundations shall be completely dewatered and concrete placed in the dry. However, when concrete placement under water is necessary, all work shall conform to IS:456 and the procedure shall be as follows:
   - Method of Placement
     Concrete shall be deposited underwater by means of tremises, or drop bottom buckets of approved type.
   - Direction, Inspection and Approval

All work requiring placement of concrete underwater shall be designed, directed and inspected with due regard to local circumstances and purposes. All underwater concrete shall be placed according to specifications approved by the Engineer-in-Charge.

b) Special precautions shall be taken for prevention of lifting of concrete due to uplift pressure of subsoil water.

5.26. PRECAST CONCRETE

5.26.1. General

Precast concrete units, whether manufactured on or off site, shall comply in every way with the provisions of the contract for in situ concrete. Wherever possible, precast units shall be hydraulically pressed. When ready for incorporation in the works, precast units shall be responsible for the accuracy of the level, shape of the bed or platform. A suitable serial number and the date of casting shall be impressed or painted on each unit.

5.26.2. Striking Forms

Side shutters shall not be struck in less than 24 hours after depositing concrete and no precast unit shall be lifted until the concrete reaches strength of at least twice the stress to which the concrete may be subjected to at the time of lifting.

5.26.3. Precast Units

The lifting and removal of precast units shall be undertaken without causing shock, vibration or undue bending stresses to or in the units. Before lifting and removal takes place, Contractor shall satisfy the Engineer-in-Charge or his representative that the methods he proposes to adopt for these operations will not over-stress or otherwise effect seriously the strength of the precast units. The reinforced side of the units shall be distinctly marked.

5.26.4. Curing

All precast work shall be protected from the direct rays of the sun for at least 7 days after casting and during that period each unit shall be kept constantly watered or preferably be completely immersed in water if the size of the unit so permits.

5.27. SLOTS, OPENINGS, ETC.

5.27.1. General

Slots, openings or holes, pockets, etc., shall be provided in the concrete work in the approved positions as per design drawings and as directed by Engineer-in-Charge and extra reinforcement should be provided as per design requirement. Short pipes with puddle collar shall be fixed in the side wall of suction pipes. They shall be supplied at the appropriate time during construction. Any deviation from the approved drawings shall be made good by Contractor at his own expense, without damaging any other work. Sleeves, bolts, inserts etc., shall also be provided in concrete work where so required.

5.27.2. Grouting

5.27.2.1. Standard Grout

The proportions of grout shall be such as to produce a flowable mixture consistent with minimum water content and shrinkage. The grout proportions shall be limited as follows:

Table 10 : Proportions for Standard Grout

Sr.	Use	Grout thickness	Mix proportions	W/c ratio (max.)
1	Fluid	Under 25 mm	One part Portland cement to one part sand	0.44
2	General	25mm & over but less than 50mm	One part Portland cement to 2 parts of sand	0.53
3	Stiff Mix	50mm & over	One part Portland cement to 3	0.53

Sand shall be such as to produce a flowable grout without any tendency to segregate.

Sand for general grouting purposes, shall be graded within the following limits:

- Passing BIS 2.36 mm sieve 95 to 100%
- Passing BIS 1.18 mm sieve 65 to 95%
- Passing BIS 300 micron sieve 10 to 30%
- Passing BIS 150 micron sieve 3 to 10%

Sand for fluid grouts, shall have the fine material passing the 300 and 150 micron sieves at the upper limits specified above. Sand, for still grouts, shall meet the usual grading specifications for concrete laitance. Anchor bolts, anchor bolt holes and the bottoms of equipment and column base plates shall be cleaned of all oil, grease, dirt and loose material. The use of hot, strong caustic solution for this purpose will be permitted. Prior to grouting, the hardened concrete surfaces to be grouted shall be saturated with water. Water in anchor boltholes shall be removed before grouting is started. Forms around base plates shall be reasonably tight to prevent leakage of the grout. Adequate clearance shall be provided between forms and base plate to permit grout to be worked properly into place. Grouting, once started, shall be done quickly and continuously to prevent segregation, bleeding and breakdown of initial set. Grout shall be worked from one side of one end to the other to prevent entrapment of air. To distribute the grout and to ensure more complete contact between base plate and foundation and to help release trapped air, link chains can be used to work the grout into place. Grout throughout holes in base plates shall be by pressure grouting. Variations in grout mixes and procedures shall be permitted if approved by the Engineer-in-Charge.

5.27.2.2. Non-Shrinking Grout for Equipment Foundation

Non-shrinking grout shall be used for grouting of machine base plates, anchor bolts, other anchoring devices and at locations where ordinary grouts are ineffective due to shrinkage. It shall be composed of a type of expansive hydraulic sheeting binder and select-graded aggregates. It shall have properties as mentioned below:

Table 11 : Proportions for Non-Shrinking Grout

Sr.	Properties	Values
1	Maximum grain size	6 mm
2	Water % (for 80% flow)	15.17
3	Density of hardened grout	2.27 - 2.30 gm/m1
4	Compressive strength N/mm2	
	Minimum 3 days	23
	7 days	34
	28 days	45
5	Expansion %	
	Free	0.1- 0.2
	Restrained	0.08 - 0.12
	Restrained	0.08 - 0.12

Mixing, batching, cleaning, preparation of surface and curing of non-shrinking grout shall be done as per manufacturer's instructions. Brands like FOSROC / BUILDMASTER etc or equivalent brand as approved by Engineer-in-charge shall be used as per manufacturer specifications.

5.28. INSPECTION

a. All materials, workmanship and finished construction shall be subject to continuous inspection and approval of the Engineer-in-Charge.
b. All materials supplied by the Contractor and all work or construction performed by the Contractor which is rejected as not being in conformity with the specifications and requirements, shall be immediately replaced.
c. All concrete shall be protected against damage until final acceptance by the Engineer-in-Charge.

5.29. CLEAN-UP

a. Upon completion of the concrete work, all forms, equipment, construction tools, protective coverings and any debris resulting from the work shall be removed from the premises.
b. All debris i.e. empty containers, scrap wood, etc., shall be removed to "dump" daily, or as directed by the Engineer-in-Charge.
c. The finished concrete surfaces shall be left in a clean condition satisfactory to the Engineer-in-Charge.

5.30. RECORDS OF CONCRETING

An accurate and up to date record showing times, dates, weather and temperature conditions when various positions of all the concrete structures forming the works were concreted will be kept by the Contractor and shall be countersigned by the Engineer-in-Charge. If the Contractor fails to sign the Engineer-in-Charge's record, it shall nevertheless be regarded as correct and binding on the Contractor.

The Contractor has to submit concrete pour card in duplicate duly to be signed to the Engineer-in-Charge for each type of concreting work. Contractor shall keep copy of it, after Engineer-in-Charge has checked and signed the pour card.

5.31. SUPPLY OF CEMENT

Contractor shall procure / purchase the cement and shall be sacked and well maintained as specified in the earlier sections. Contractor shall procure cement in those quantities required for maximum one month of concreting work and more than the prescribed time limit is not allowed. For any damage to cement AMC will not be responsible and the damaged cement will not be used in the work.

5.32. FOUNDATION BEDDING, BONDING AND JOINTING

In no case foundation shall rest on any loose strata or loose pockets etc. even though it has reached level shown on design drawings and referred back to design engineer / Engineer-in-Charge

a. All surfaces upon or against which concrete will be placed shall be suitably prepared by thoroughly cleaning, washing and dewatering, as specified or as the Engineer-in-Charge may direct, to meet the various situations encountered in the work.
b. Soft or spongy areas shall be cleaned out and backfilled with lean concrete or clean sand fill compacted.
c. Prior to construction of formwork for any item where soil will act as bottom form, approval shall be obtained from the Engineer-in-Charge for the suitability of the soil.

5.33. PREPARATION OF ROCK STRATA OF FOUNDATIONS

a. To provide tight bond with rock foundations, the rock surface shall be prepared and the following general requirements shall be observed.
b. Concrete shall not be deposited on large sloping rock surfaces. Where required by the Engineer-in-Charge, the rock shall be cut to form rough steps or benches

to provide roughness or a more suitable bearing surface.

c. Rock foundation stratum shall be prepared by picking, barring, wedging and similar methods which will leave the rock in an entirely sound and unshattered condition.
d. Shortly before concrete is placed, the rock surface shall be cleaned with high pressure water and air jet even though it may have been previously cleaned in that manner.
e. Prior to placing concrete, the rock surface shall be kept wet for a period of 2 to 4 hours unless otherwise directed by the Engineer-in-Charge.
f. Before placing concrete on rock surfaces all water shall be removed from depressions to permit thorough inspection and proper bonding of the concrete to the rock.

6. FORMWORK

6.1. FORMWORK, FIXING AND GENERAL

a) All formwork shall be constructed of waterproof plywood or preferably sheet metal. Plywood used for form work shall be conforming to BIS:4990 i.e. Specification for plywood for concrete shuttering works. The materials for formwork shall got approved by the Engineer-in-Charge before starting the work. Formwork shall be firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete and the effects of weather. The tolerance on line and level shall not exceed 3 mm and the soffits of beams other than pre-stressed beams shall in the absence of any specified camber, be erected with an upward camber of 6 mm for each 3 meters of span.

b) The Contractor shall be responsible for the calculations and designs for the formwork, and if required, shall submit them to the Engineer-in-Charge for approval before construction. On form work to external faces, which will be permanently, exposed, all horizontal and vertical formwork joints shall be so arranged that joint lines will form a uniform pattern on the face of the concrete. Where the Contractor proposes to make up the form work for standard sized manufactured form work panels, the size of such panels shall be approved by the Engineer-in-Charge before they are used in the construction of the Works. The finished appearance of the entire elevation of the structure and adjoining structures shall be considered when planning the pattern of joint lines caused by form work and by construction joint to ensure continuity of horizontal and vertical lines.

c) Faces of form work in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all form work shall be clean and free from standing water, dirt, shavings, chippings or other foreign matter. Joints shall be sufficiently watertight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete and no bleeding should be allowed through the joints.

d) Form work shall be provided for the top surfaces of sloping work where the slope exceeds fifteen degrees from the horizontal (except where such top surface is specified as spaded finish) and shall be anchored to enable the concrete to be properly compacted and to prevent flotation, care being taken to prevent air being trapped.

e) Openings for inspection of the inside of the form work and for the removal of water used for washing down shall be provided and so formed as to be easily closed before placing concrete. Before placing concrete, all bolts, pipes or conduits or other fixtures which are to be built in shall be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise. Holes shall not be cut in any concrete without approval of the Engineer-in-Charge.

f) All exterior angles on the finished concrete of 90 degree or less shall be given 20 mm x 20 mm chamfers unless otherwise ordered by the Engineer-in-Charge.

g) No ties or bolts or other device shall be built into the concrete for the purpose of supporting formwork without the prior approval of the Engineer-in-Charge. The whole or part of any such supports shall be capable of removal so that no part remaining embedded in the concrete shall be nearer than 50 mm from the surface in the case of reinforced concrete and 150 mm in the case of un-reinforced concrete.

h) Holes left after removal of such supports shall be neatly filled with well rammed drypack mortar.

i) Formwork in contact with the concrete shall be treated with suitable non-staining mould oil to prevent adherence of the concrete except where the surface is subsequently to be rendered. Care shall be taken to prevent the oil from coming in contact with reinforcement or with concrete at construction joints. Surface retarding

agents shall be used only where ordered by the Engineer-in-Charge.

j) No formwork shall be started or placed unless the requirement work is fully completed and checked by Engineer-in-Charge.

k) Necessary cover blocks shall be provided before starting connection.

6.2. REMOVAL OF FORMWORK

a) Formwork shall be so designed as to permit any removal without resorting to hammering or levering against the surface of the concrete.

b) The periods of time elapsing between the placing of the concrete and the striking of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown in Table below. Where soffit formwork is constructed in a manner during and after such removal of a sufficient number of adequate supporting props in an undisturbed condition, the Contractor may, with the agreement of the Engineer-in-Charge, remove the formwork at the earlier times listed below provided that the props are left in position.

Table 12 : Period for Formwork

Position of formwork	Days for striking
Walls	1
Sides of beams and columns	2
Slabs (Drops left under)	3
Props to slabs (span not exceeding 4.5m)	7
Props to slabs (span exceeding 4.5 m)	14
Beams soffits (props left under)	7
Props to beams (span not exceeding 6 m)	14
Props to beams (span exceeding 6 m)	21
Circular structures, domes ,cantilever portions etc.	21

c) Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

d) Striking shall be done slowly with utmost care to avoid damage to projections and without shock or vibration, by gently easing the wedges. If after removing the formwork it is found that timber has been embedded in the concrete. It shall be removed and made good as specified earlier.

e) Reinforced temporary openings shall be provided, as directed by the Engineer-in-Charge, to facilitate removal of formwork which otherwise may be inaccessible.

f) The rods, clamps, form bolts, etc. which must be entirely removed from walls or similar structures shall be loosened not sooner than 24 hours not later than 40 hours after the concrete has been deposited. Ties, except those required to hold forms in place, may be removed at the same time. Ties, withdrawn from walls and grade beams shall be pulled toward the inside face. Cutting ties back from the faces of the walls and grade beams will not be permitted.

g) For liquid retaining structures, no sleeves for through bolts shall be used nor shall through bolts be removed as indicated above. The bolts, in this case, shall be cut at 25 mm depth or more from the surface and then the hole shall be made good by cement sand mortar of the same proportions as the concrete just after striking the form work.

6.3. FORMED SURFACES - CLASSES OF FINISH

a) Finishes to formed surfaces of concrete shall be classified as F1, F2, or F3, or such other special finish as may be particularly specified. Where the class of finish is not specified the concrete shall be finished to Class F1.

b) Form work for Class F3 finish shall be lined with as large panels as possible of non-

staining material with a smooth unblemished surface such as sanded plywood or hard compressed fiber board, arranged in a uniform approved pattern and fixed to back form work by oval nails. Unfaced wrought boarding or standard steel panels shall not be permitted.

c) Form work for Class F2 finish shall be faced with wrought tongued and grooved boards or plywood or metal panels arranged in a uniform approved pattern free from defects likely to detract from the appearance of the surface.

d) Form work for Class F1 finish shall be constructed in sheet metal. Surfaces subsequently to be rendered, plastered or tiled shall be adequately scrabbled or hacked as soon as the form work is removed to reduce the irregularities to not more than half the thickness of such rendering, plastering or bedding for tiles and to provide a satisfactory key.

6.4. DEFECTS IN FORMED SURFACES

a. Workmanship in formwork and concreting shall be such that concrete shall normally require no making good, surfaces being perfectly compacted and smooth.

b. If any blemishes are revealed after removal of formwork, the Engineer-in-Charge's decisions concerning remedial measures shall be obtained immediately. These measures may include, but shall not be limited to the following:

- Fins, pinhole bubbles, surface discolouration and minor defects may be rubbed down with sacking immediately after the formwork is removed.
- Abrupt and gradual irregularities may be rubbed down with carborundun and water after the concrete has been fully cured. These and any other defects shall be remedied by methods approved by the Engineer-in-Charge which may include using a suitable epoxy resin or, where necessary, cutting out to a regular dovetails shape at least 75 mm deep and refilling with concrete over steel mesh reinforcement sprung into the dovetail.

c. The form work shall be checked by the Engineer-in-Charge before the form work starts and form found defective shall be rejected and the same can be used after rectifying the defects and with due approval of the Engineer-in-Charge

6.5. HOLES TO BE FILLED

1. Holes formed in concrete surfaces by form work supports or the like shall be filled with dry-pack mortar made from one part by weight of ordinary Portland cement and one part fine aggregate passing BIS sieve 1.18 mm. The mortar shall be mixed with only sufficient water to make the materials stick together when being moulded in the hands.

2. The Contractor shall thoroughly clean any hole that is to be filled with dry-pack mortar and where the surface has been damaged, the Contractor shall break out any loose, broken or cracked concrete or aggregate. The concrete surrounding the hole shall then be thoroughly soaked after which the surface shall be dried so as to leave a small amount of free water on the surface. The surface shall then be dusted lightly with ordinary Portland cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water on the surface. The surface shall then be dusted lightly with ordinary Portland cement by means of a small dry brush until the whole surface that will come into contact with the dry-pack mortar has been covered and darkened by absorption of the free water by the cement. Any dry cement in the hole shall be removed.

3. The dry-pack material shall then be placed and packed in layers having a compacted thickness not greater then 15 mm. The compaction shall be carried out by use of a hardwood stick and a hammer and shall extend over the full area of the layer, particular care being taken to compact the dry-pack against the sides of the hole. After compaction, the surface of each layer shall be scratched the dry-pack fill and striking the block several times. Steel finishing tools shall not be used and water shall not be added to facilitate finishing.

6.6. TOLERANCES

Tolerance is a specified permissible variation from lines, grade or dimensions given in approved drawings. No tolerance specified for horizontal or vertical building lines or footings shall be construed to permit encroachment beyond the legal boundaries. Unless otherwise specified, the following tolerances will be permitted:

Tolerances for RCC Structures

i. Variation from the plumb

In the lines and surfaces of columns, piers, walls 5 mm per 2.5 m or 25 mm, whichever is less.

For exposed corner columns and other conspicuous lines

In any bay or 5 m maximum	5 mm
In 10 m or more	10 mm

ii. Variation from the level or from the grades indicated on the approved drawings

In slab soffits, ceilings, beam soffit, and in arises

In 2.5 m	5 mm
In any bay or 5 m maximum	10 mm
In 10 m or more	15 mm

For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines

In any bay or 5 m maximum	5 mm
In 10 m or more	10 mm

iii. Variation of the linear building lines from established position in plan and related position of columns, wall and partitions

In any bay or 5 m maximum	10 mm
In 10 m or more	20 mm

iv. iv. Variation in the sizes and locations of sleeves, openings in walls and floors Except in the case of and for 5mm anchor bolts

v. Variation in cross sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	5 mm
Plus	10 mm

vi. Footings

Variation in dimension in plan

Minus	5 mm
Plus	10 mm

vii. Misplacement or eccentricity 2% of footing width in the direction of misplacement but not more than 50 mm Reduction in thickness: Minus 5% of specified thickness subject to a maximum of 50 mm

viii. Variation in steps

In a flight of stairs

Rise	3 mm
Tread	5 mm

In consecutive steps

Rise	1.5 mm
Tread	3 mm

Tolerances in other Concrete Structures

ix. All structures

Variation of the constructed linear outlines from established position in plan

In 5 m	10 mm
In 10 m or more	15 mm

Variations of dimensions to individual structural features from established positions

In 20 m or more	25 mm
In buried construction	50 mm

Variation from plumb, from specified batter or from curved surfaces of all structures

In 2.5 m	10 mm

In 5 m	15 mm
In 10 m or more	25 mm
In buried construction	twice the above amounts

Variation from level or grade indicated on approved drawings in slab, beams, soffits, horizontal grooves and visible arises

In 2.5 m	5 mm
In 7.5 m or more	10 mm
In buried construction	Twice the above amounts

Variation in cross-sectional dimensions of columns, beams, buttresses, piers and similar members

Minus	5 mm
Plus	10 mm

x. Footings for columns, piers, walls, buttresses and similar members

Variation of dimensions in plan

Minus	10 mm
Plus	50 mm

Misplacement or eccentricity

2% of footing width in the direction of misplacement but not more than 50 mm. Reduction in thickness

5% of specified thickness subject to a maximum of 50 mm

xi. Tolerance in other types of structures shall generally conform to those given in Clause 2.4 of Recommended Practice for Concrete Formwork (American Concrete Institute Act 347).

xii. Tolerance in fixing anchor bolts shall be as follows:

Anchor bolts without sleeves	+ 5 mm
Anchor bolts with sleeves	+ 5 mm for bolts up to 20 mm dia above 32 mm dia
3 mm for bolts	above 32 mm dia
Embedded parts	+ 5 mm in all directions

6.7. BRACING, STRUTS AND PROPS

a. Form work shall be braced, strutted, propped and so supported that it shall not deform under weight and pressure of the concrete and also due to the movement of men and other materials. Bamboo shall not be used as props or cross bearers.

b. The formwork for beams and slabs shall be so erected that the formwork on the sides of the beams and under the soffit of slabs can be removed without disturbing the beam bottoms. Repropping of beams shall not be done except when props have to be reinstated to take care of construction loads anticipated to be in excess of the design load. Vertical props shall be supported on wedges or other measures shall be taken whereby the props can be gently lowered vertically while striking the formwork.

c. If the formwork for a column is erected for the full height of the column, one side shall be left open and built up in sections as placing of the concrete proceeds, or windows may be left for pouring concrete from the sides to limit the drop of concrete to 1.0 m as directed by the Engineer-in-Charge.

Contractor shall submit the detailed design and methodology with applicable drawings if any of Formwork system for different members for approval of Engineer-in-Charge.

7. REINFORCEMENT

7.1. RELEVANT IS CODES

IS:432 : Mild steel and medium tensile steel bars & hard drawn steel wire for concrete reinforcement

IS:1786 : Cold twisted steel bars for concrete reinforcement (CTD).

IS:2502 (1963) : Code of practice for bending and fixing of bars for concrete Reinforcement

IS:55225(1969) : Recommendations for detailing of reinforcement in RCC works

IS:2751 : C.P. for welding of MS bars used for RCC

IS:9417 : Recommendations for welding cold worked steel bars for RCC

IS:10790 : Methods of sampling of reinforced steel

7.2. GENERAL

Reinforcement shall be CTD and high strength deformed corrosion resistant (CRS) bars as per IS:1786 - Fe415. Wire mesh or fabric shall be in accordance with IS:456. Substitution of reinforcement will not be permitted except upon written approval from the Engineer-in-Charge.

7.3. STORAGE

a. The reinforcement shall not be kept in direct contact with the ground but stacked on top of an arrangement of timber sleepers or the like.

b. If the reinforcing rods have to be stored for a long duration, they shall be coated with cement wash before stacking and/or be kept under cover or stored as directed by the Engineer-in-Charge.

c. Fabricated reinforcement shall be carefully stored to prevent damage, distortion, corrosion and deterioration.

d. It should be seen that the reinforcement will not be exposed to direct sunlight and preventive measures should be taken for the same.

7.4. QUALITY

All reinforcements shall be clean, free from grease, oil paint, dirt, loose mill scale, loose rust, dust bituminous material or any other substances that will destroy or reduce the bond. All rods shall be thoroughly cleaned before being fabricated. Pitted and defective rods shall not be used. No welding of rods to obtain continuity shall be allowed unless approved by the Engineer-in-Charge. If welding is approved, the work shall be carried out as per IS:1786 - Fe415 according to the best modern practices and as directed by the Engineer-in-Charge. In all cases of important connections, tests shall be made to prove that the joints are of full strength of bars welded. Special precautions, as specified by the Engineer-in-Charge, shall be taken in the welding of cold worked reinforcing bars and bars other than mild steel.

7.5. LAPS

Laps and splices for reinforcement shall be as per IS:456-2000. Splices in adjacent bars shall be staggered as mentioned in structural drawings and locations of all splices shall be approved by the Engineer-in-Charge.

Also Contractor shall submit the Bar bending schedule for approval of Engineer-in-Charge and shall follow same unless and until changed by any design changes.

7.6. BENDING

a. Reinforcement bars supplied bent or in coils, shall be straightened before they are cut to size. Straightening of bars shall be done cold and without damaging the bars.

b. All bars shall be accurately bent according to the sizes and shapes shown on the approved detailed working drawings/bar bending schedules. They shall be bent gradually by machine or other approved means. Reinforcing bars shall not be straightened and re-bent in a manner that will injure the material; bars containing cracks/splits shall be rejected. They shall be bent cold, except bars of over 25 mm in diameter, which may be bent hot if specifically, approved by the Engineer-in-Charge. Bars, which depend for their strength of cold working, shall not be bent hot.

Bars bent hot shall not be treated beyond cherry red colour (nor exceeding 845°C) and after bending shall be allowed to cool slowly without quenching. Bars incorrectly bent shall be used only if the means used for straightening and re-bending be such as shall not, in the opinion of the Engineer-in-Charge, injure the material. No reinforcement shall be bent when in position in the work without approval, whether or not it is partially embedded in hardened concrete. Bars having kinks or bends other than those required by design shall not be used.

7.7. FIXING

Reinforcement shall be accurately fixed by any approved means and maintained in the correct position shown in the approved Drawings by the use of blocks, spacers and chairs, as per IS:2502 to prevent displacement during placing and compaction of concrete. Bars intended to be in contact at crossing points shall be securely bound together at all such points with number 16 gauge GI wire. The vertical distances required between successive layers of bars in beams or similar members shall be maintained by the provision of mild steel spacer bars at such intervals that the main bars do not perceptibly sag between adjacent spacer bars. No binding wire shall protrude in cover area and shall bent inside.

7.8. COVER

Unless indicated otherwise, clear concrete cover for reinforcement (exclusive of plaster or other decorative finish) shall be as follows:

a. At each end of a reinforcement bar, not less than 25 mm nor less than twice the diameter of the bar whichever is greater
b. For a longitudinal reinforcing bar in a column, not less than 40 mm, nor less than the diameter of the bar. In case of columns of minimum dimension of 20 cm or under with reinforcing bars of 12 mm and less in diameter, a cover of 25 mm may be used.
c. For longitudinal reinforcing bars in a beam, not less than 40 mm nor less than the diameter of the bar, whichever is greater
d. For tensile, compressive, shear or other reinforcement in a slab, or wall, not less than, 20 mm, nor less than the diameter of such reinforcement.
e. For any other reinforcement, not less than 20 mm, nor less than the diameter of such reinforcement.
f. For footing and other principal structural members in which the concrete is poured on a layer of lean concrete, the bottom cover shall be reduced to 60 mm.
g. For concrete surfaces exposed to the weather or the ground after removal of forms, such as retaining walls, grade beams, footing sides and tops, etc. not less than 40 mm for bars larger than 16 mm diameter and not less than 30 mm for bars 16 mm diameter or smaller.
h. For liquid retaining structures, the minimum cover to all steel shall be 40 mm or the diameter of the main bar, whichever is greater.
i. The correct cover shall be maintained by cement mortar cubes or other approved means. Reinforcement for footings, grade beams and slabs on subgrade shall be supported on precast concrete blocks as approved by the Engineer-in-Charge. The use of pebbles or stones shall not be permitted.
j. The 28 day crushing strength of cement mortar cubes/precast concrete cover blocks shall be at least equal to the specified strength of concrete in which these cubes/blocks are embedded.
k. The minimum clear distance between reinforcing bars shall be in accordance with IS:456

7.9. INSPECTION

After final erection of reinforcement, it shall be intimated to Engineer-in-Charge in writing or through pour cards. Erected and secured reinforcement shall be inspected and approved by the Engineer-in-Charge prior to placement of concrete.

7.10. WELDING OF REINFORCEMENT

a. Reinforcement which is specified to be welded shall be welded by any process which conforms with the requirements of IS:2751 and which the Contractor can demonstrate by bend and tensile tests will ensure that the strength of the parent metal is not reduced and that the weld possesses a strength not less than that of the parent metal. The welding procedure established by successful test welds shall be maintained and no deviation from this procedure shall be permitted.

b. Welds in positions other than those shown on the approved Drawings shall not be permitted. Tack welding to lightly secure reinforcement in place will be permitted subject to approval of the Engineer-in-Charge.

7.11. SUPPLY OF REINFORCING BARS

Steel reinforcement, such as MS bars HYSD bars etc. required for the works shall be procured by Contractor. The Contractor shall arrange for transport, loading, unloading and storage at the work sites. The Contractor should plan the procurement of steel in such a way that at least required quantity of steel of specified sizes is available at site for 3 months period.

Steel brought on site shall be stored in proper manner as approved by Engineer In Charge so as to avoid distortion, deterioration and corrosion. The Contractor shall maintain proper register for the steel account, showing the steel received at site, steel used, and the balance stock on site, to the entire satisfaction of the Engineer-in-Charge

8. STRUCTURAL STEEL WORK

8.1. RELEVANT IS CODES

IS:2062 : Specification for Structural Steel (Fusion Welding Quality)
IS:800 : C.P. for general construction in steel
IS:808 : R.S. beam, channel and angel sections
IS:814 : Covered electrodes for metal arc welding of structural steel
IS:1148 : Hot rolled steel rivet bars for structural purpose
IS:1363 : Black hexagon bolts, nuts, and lock nuts (dia 6 to 39mm) & black hexagon screws (dia 6 to 24mm)
IS:2062 : Structural steel (fusion welding quality)
IS:3954 : Hot rolled steel channel sections for general engineering purposes
SP-6 (I - VII) : ISI Handbook for Structural Engineers
SP-40 : Handbook on structures with steel portal frames (without cranes)

8.2. GENERAL

Structural steel fabrication work shall include all types of steel structural work required for installation of platform for operation and installation of equipment where rolled steel sections are joined together either by bolting or riveting or welding as specified in the drawings/bill of quantities/directed by the Engineer. It shall also include fabrication and installation of air vessels/pressure vessels etc. Covers for ducts for electrical panels along with their seating arrangements are also classified under this heading unless they are provided separately under a different heading. Reaction tanks or storage vessels are also classified under this heading.

8.3. MATERIALS

The MS structural members such as MS angles, channels, flats, I sections etc. shall conform IS 2062. Structural steel that is used for fabrication shall be conforming to any of the following grades of steel as specified to each of the works:

- IS:2062 : Specification for Structural Steel (Fusion Welding Quality)
- IS:1977-1975: Structural steel (ordinary quality)
- IS:2062-1980: Weldable Structural steel (fusion quality)

Whenever the Contractor supplies steel, he shall on demand the test certificates from the manufacturer.

The welding rods used for fabrication shall conform to IS:814-1974 (parts I and II). The fasteners like bolts, nuts etc., shall conform to IS:1367. Rivets shall conform to IS:1184-1982. Plain washers shall conform to IS:2016-1967. Spring washers shall conform to IS:3063-1972.

MS rivets shall conform to IS:1148 and IS:1929-1967 bolts and nuts shall conform to IS:1363 - 1967.

If metal arc welding is to be done as per design or as ordered by the Engineer-in-Charge the electrodes used for strength welds shall conform to IS: 814 and shall be of such shape and size approved by the Engineer-in-Charge and shall be prevented from oxidation and shall be kept in clean condition.

Paints used shall be of approved manufacture and shade and shall conform to the ISI standards.

8.4. FABRICATION AND ERECTION

All the shop drawings shall be prepared by the Contractor and submitted in advance of atleast 15 days to the Engineer for his approval. The drawings shall be submitted in triplicate. The fabrication work shall not be taken in hand until the shop drawings are approved by the Engineer. Approval of the shop drawings however shall not relieve the Contractor of his responsibility of correct conformation to the designs and fabrications of the structure to meet the requirements of the contract. One copy of the approval drawings shall be given to the Contractor for going ahead with the fabrication work.

In the shop drawings to be submitted by the Contractor, standard symbols as described in the IS:813-1961 shall be followed.

Fabrication work shall be carried out as laid down in IS:800-1984 Code of practice for general construction in steel.

Welding shall be carried out in accordance with the following specifications as applicable:

IS:803 - 1976 : Code of practice for design fabrication and erection of vertical mild steel cylindrical welded oil storage tanks.

IS: 816 - 1969 : Code of practice for use of metal and welding for general construction in mild steel

IS:822 - 1970 : Code of practice for manual and welding of mild steel

IS:9595 - 1980 : Recommendations for metal are welding of carbon Radiographic tests are required to be carried out as directed by the Engineer in case of pressure vessels.

IS:818 - 1968 : Code of practice for safety and health requirements in electric and gas welding and cutting operations

IS:3016-1982 : Code of practice for fire precautions in welding and cutting operations

IS:7205 - 1973 : Safety code for erection of structural steel work

The sections shall be fixed absolutely vertical or to the specified angle as shown in the drawings/as desired/directed by the Engineer.

All connections like angle brackets, cleats, gusset plates, anchor bolts, bearing plates shall all be fixed as shown in the drawings or as directed by the Engineer.

The items of work shall include supply of materials, fabrication and erection in position on site as shown in the drawings. This shall also include all labour consist, materials and equipment required for all fabrication, hoisting, erection, and satisfactory completion of the item of work.

The supply of materials includes all structural members like rolled sections, plates, brackets, rivets, bolts and nuts and welds.

The steelwork shall be painted as specified in the drawings, described in the bill of quantities or as directed by the Engineer. Unless otherwise provided for in the bill of quantities separately, the rate quoted for the item is inclusive of all costs for painting like cost of paint, cost of labour, scaffolding etc. Welding work shall be done generally using electric arcs welding. Where public electricity is not available, generators shall be arranged by the Contractor shall be arranged by the Contractor himself.

Gas welding shall not be allowed to be resorted to for welding. Under special circumstances if in the opinion of the Engineer it cannot be avoided, gas welding can be done with the prior permission of the Engineer. However gas welding shall not be used where structural strength is the criteria for consideration.

All arrangements shall be made by the Contractors for access for inspection by the Engineer or his representative to the workshop where the welding work is being carried out and necessary equipment like gauges, measuring instruments etc., shall be made available to the inspecting personnel.

Painting work shall not be started without the express approval of the Engineer and the painting shall be started only after his inspection and approval of the works after carrying out surface preparations.

All holes shall be carefully marked. Holes shall have their axis perpendicular to the surfaces bored through. Holes being made through two or more members shall be truly concentric. Holes shall not be formed cutting process.

All the temporary connections of parts during assembly shall be done in the following ways. For welded structures. Tack welding fixtures.

After welding is over, the surface on the joint should be ground and made smooth and even. The welding should be so perfect so as to give required strength as taken for designed

purpose at joints in particular. The Contractor will make necessary arrangements for testing of joints as required by Engineer in Charge.

Welded joints shall be free from defects that would impair the service performance of the construction. All the welds shall be free from incomplete penetration, incomplete fusion, slag inclusion, burns, un-welded creators undercuts and cracks in the welded metal, porosity etc. All the defects shall be rectified as directed by the Engineer. Defective portions shall be removed to the sound metal and re-welded. Rectification of the welds by caulking shall not be permitted.
All welds shall be cleaned of stag and other deposits after completion.

8.5. PAINTING

Painting shall generally comply with IS subject to addition and alterations as may be prescribed in the special provisions for any particular item. It shall also comply with the requirements of the manufacture's specifications. One priming coat of red lead shall be applied immediately after fabrication. Two coats of oil paint of approved shade shall be applied after complete erection. The structural steel to be embedded in concrete shall not be painted.
Inspection and testing shall be carried out in conformity with IS:800.
Riveting, welding and bolting shall not be started until such time as the Engineer has personally satisfied himself that the alignment is correct, in the vertical plumb, the camber correct with camber packs, screwed tight, all joints and cover plates fixed tightened with service bolts and field rivet holes coinciding. While assembling holes in different components shall be made concentric with the use of drills before service bolts are fixed.
Welding if required shall be done as per standard practice and as approved by the Engineer-in-Charge.
All permanent machine fitted nuts and bolts must be perfectly tight and shall be burred or otherwise checked to prevent nuts from becoming loose. No unfitted rivet or bolt holes are to be left in any of the structure.
Structural Steel
All structural steel shall conform to IS:2062-1984. The steel shall be free the defects mentioned in IS given above and shall have a smooth finish. The material shall be free from loose mild scale, rust pits or other defects affecting the strength and directly.

8.5.1. General

Engineer's approval shall be obtained before commencing the painting work. All paints and preserves shall be of approved make and colour and their application shall conform to the manufacture's instructions. Where more than one undercoat is specified it shall be applied in coats of distinctive tints. Workmanship shall conform to the requirement of IS:2395
Unless the manufacturer's instructions state otherwise48 hours drying time shall elapse between successive applications of any primer and 24 hours between applications of all subsequent coats. The surface of bituminous paints shall be left at least 3 days before further handling.
No paints in any coats shall be applied until the engineer is satisfied that the surface is clean and dry. And that any previous coat is satisfactory and has hardened adequately. When a surface has been approved, it must be painted immediately.
Paint work shall be rubbed down with a glass paper between coats. No paint shall be applied to a surface, which is damp, dirty or otherwise inadequately prepared.

8.5.2. Ironwork and Ungalvanised Steelwork

Structural steelwork shall be shot blasted to a "white metal" finish, and grease and oil removed prior to painting. Priming shall immediately follow blast cleaning and no

cleaned surface shall be left unprimed for more than four hours. Only primers that chemically inhibit corrosion shall be used. Where the iron or steelwork is not in contact with raw or treated water, the primer shall be red lead complying with IS: 57. Where there is a possibility that the steel or ironwork may come in contact with water, the priming treatment shall be non toxic, zinc chromate or equivalent. Where it is anticipated that further welding will be required. an approved welding primer shall be applied to the areas to be welded and re primed with the main primer when welding has been completed. Primer coats shall not be less than 0.05 mm each.

After erection, all damaged areas shall be made good, and re primed where the original coat has spread under the primer, the affected surface shall be cleaned down to bare metal to the satisfaction of the Engineer and then re primed.
Repainting shall be carried out as soon as possible after erection. If` it is to he exposed to weather or condensation, it shall receive one further coal of primer.
Metalwork in intermittent or permanent contact with raw or treated water shall have two finishing coats of an approved coal tar pitch epoxy paint such as "Epilux 5" by Berger Paints, or equivalent. The total coating shall be minimum of 0.125 mm thick.

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, be undercoat of synthetic enamel paint conforming-to IS:2932 of optimum thickness shall be applied by brushing 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 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.
At least 24 hours shall elapse between the application of successive coats. Each coat shall very slightly in shade and this shall be got approved by the Engineer.

9. BRICK WORK AND STONE MASONRY

These specifications deal with all types of brickwork required for buildings, manholes, drains, retaining walls or any construction made out of bricks.

9.1. RELEVANT IS CODES

IS:1077 : Common burnt clay building bricks
IS:2180 : Heavy duty burnt clay-building bricks
IS:2212 : C.P. for brickwork
IS:3495 (I - IV) : Method of test for clay building bricks
IS:5454 : Method of sampling of clay building bricks

9.2. MATERIALS

9.2.1. Bricks

Bricks used for the construction of brick masonry shall be sound, hard, rectangular in shape and size and well burnt of uniform deep red, cherry or copper colour and shall conform to IS:1077-1986.

The bricks shall be brought from approved brick kilns. The bricks shall be free from cracks, chippings flaws, stones or lumps of any kind. The bricks shall not show any signs of efflorescence and shall be homogeneous in texture.

They should emit a clear metallic sound on being struck and shall have a minimum compressive strength of 50 kg/sq.cm. They shall not absorb water more than specified in the Indian Standard Specifications, of its dry weight when soaked in cold water for 24 hours.

9.2.2. Mortar

The proportion of the cement mortar used for the masonry work shall be as specified on the various drawings for different places/types of construction, bills of quantities, specifications for each part of the work.

Mortar should be prepared by volume using boxes of appropriate sizes on clean platform or this sheet to avoid mixing of foreign material and maintain consistency of mortar.

Sharp coarse sand is mixed with the required quantity of cement for the preparation of the mortar. Mortar shall be prepared in accordance with IS:2250-1981. The sand used for the masonry mortar shall meet the requirements as specified in IS:2116-1980. Sand for masonry mortars. Sand and cement of required proportions are mixed in small quantities in a dry state first and then water is added to make the mortar of required the consistency suitable for the type of work it is required as directed by the Engineer-in-Charge. No left over mortar shall be used and therefore only that much quantity of mortar that can be consumed within 30 minutes shall be mixed in batches.

9.3. CONSTRUCTION

The brick masonry shall be constructed as per the Indian Standard Code of Practice for Brick Work - IS:2212-1962. The thickness of the joints shall not be thicker than those specified in of the above Code of Practice.

The bricks shall be thoroughly soaked in water before using them on the work for at least six hours and all the air bubbles shall come out during soaking process. The soaked bricks shall be stacked on wooden planks/platforms so as to avoid sticking of the earth and other materials on to the surfaces of bricks. Bricks required for construction in mud mortar or lime mortar shall not be soaked. Brickwork shall be laid in English Bond unless otherwise specified. Half bricks shall not be used except when need to complete the bond. Each course shall be perfectly straight and horizontal. The masonry shall be true to plumb in case of vertical walls and in case of battered construction the batter or

slope shall be truly maintained. The level of the courses completed shall be checked at every metre interval or less as required.

The bricks shall be laid frogs upwards. While laying the bricks they shall be thoroughly bedded and flushed in mortar and well trapped into position with wooden mallets and superfluous mortar shall be removed.
No part of the structure shall be raised more than one meter above than the rest of the work. In case it is unavoidable the brickwork shall be raked back at an angle of not more than 45 degrees so as to maintain a uniform and effectual bond, but raking shall not start within 60 cms from a corner.

In cases of construction of buttresses, counterforts, returns they are built course by course carefully bound into the main walls. At all junctions of walls the bricks at alternate courses, shall be carried into each of the respective walls so as to thoroughly unite both the walls together. The brickwork shall not be raised more than 14 courses per day.

All the beds and joints shall be normal to the pressures applied upon them i.e. horizontal in vertical walls, radial in arches and at right angles to the face in battered retaining walls.

Vertical joints in alternate courses shall come directly one over the other and shall be truly vertical. Care shall be taken to ensure that all the joints are fully filled up with mortar, well flushed up where no pointing is proposed, neatly struck as the work proceeds. The joints in faces, which are plastered or painted, shall be squarely raked out to a depth not less than 12 mm while the mortar is still green. The raked joints shall be well brushed to remove the loose particles and the surfaces shall be cleaned with a wire brush so as to remove any splashes of mortar sticking to the surfaces during the construction.

All iron fixtures, pipes, bolts, conduits, sleeves, holdfasts etc., which are required to built into the walls shall be embedded in cement mortar or cement concrete as shown in the drawings/indicated in the specifications directed during the execution by the Engineerin-Charge as the work proceeds and no holes be left for fixing them at a later date unless authorised by the Engineer-in-Charge.

9.4. CURING

Fresh work shall be protected from rain by covering the work suitably. Masonry work as it progresses shall be thoroughly kept wet by watering on all the faces for atleast 7 (Seven) days after completion of the parts of the work. Proper watering cans, flexible pipes, nozzles shall be used for the purpose. The top of the masonry work shall be kept flooded at the close of the day's work by constructing fillets of mortar 40 mm high all around the edges of the top course. In case of fat lime mortar curing shall start two days after construction of masonry and shall continue for seven days. No additional payment is admissible for curing and the rates quoted are deemed to be inclusive of the cost of curing.

9.5. SCAFFOLDING

Double scaffolding sufficiently strong so as to withstand all loads that are likely to come upon it and having two sets of vertical supports shall be provided. Where two sets of vertical supports are not possible the inner end of the horizontal supporting pole shall rest in a hole provided in a header course only. Only one header for each pole shall be left cut. Such holes, however shall not be permitted in pillars under one meter in width or immediately near the skewbacks of arches. Such holes shall be filled up immediately after removal of the scaffoldings. Safety Code for Scaffolds and Ladders, IS:3696-1987 (Parts I and II) shall be followed. The cost of scaffolding is deemed to be included in the rates quoted for brick masonry and no separate costs are payable.

9.6. STONE MASONRY FOR RETAINING WALLS

Stone masonry in general is to be used for retaining walls as per engineer in-charge's instructions and as per drawings, which will be supplied during course of construction to suit site conditions.

Following Indian Standards shall be applicable:

IS:1122- 1974	Methods of determination of specific gravity and porosity of natural building stones
IS:1200	Method of measurement of stone masonry.
IS:1597	Code of practice of construction of rubble stone masonry.
IS:1805	Glossary of terms relating to stone quarrying and dressing
IS:4101	Stone facing
IS:1121	Determination of strength, properties of natural building stones

9.7. UNCOURSED STONE MASONRY

Uncoursed stone masonry shall be built in layers not exceeding 450 mm in height. No stone shall be less in breadth than 14 times its height and less in length than twice its height. Every stone whether large or small, shall be laid in its natural bed and set flush in mortar, and the small stones used for wedging or filling being carefully selected to fit the interstices between the large stones. Care shall be taken to see that no dry work or hollow space is left in the masonry. The stones shall be so arranged as to break joints at least every 80 mm and long vertical joints of joints shall be avoided. The joints at the face shall be finished off neatly, being struck and smoothed with a trowel while the mortar is fresh. The upper surface of the work shall be brought to a uniform level at the height of each course. The faces of masonry walls shall be kept in perfect plumb and where batter has to be given it shall, be uniform. The stones at all comers and junctions of walls shall be of large sizes and hammer dressed to the correct angle.

Each stone shall be thoroughly wetted before being used in the work. The masonry shall be kept thoroughly wet during the progress of the work, (care being taken to water it even on Sundays and Holidays, special labour being employed if so required for this purpose) until it becomes hard. As far as practicable, the whole of the masonry shall be raised in one uniform level and no part of the masonry shall he allowed to rise more than 1 metre above the rest to avoid unequal settlement. If raising one part of wall before the other becomes unavoidable the end of the raised portion shall be racked back in steps to prevent cracks developing at the junction of the old and new work. Care shall be taken to see that the sides of the wall are not built separately from the hearting, the faces and internal filling being done simultaneously .The stones shall overlap and cross each other as much as possible. No course shall be laid unless the previous course is perfectly set.

Al least one header or through stone per square metre of` wall face shall be built into the work. The headers or through stones shall be at least 0.05 m″ in area al face and shall have at least 0.025 m″ area at the back face. Where the thickness of the wall is more than 600 mm a series of through stones shall be laid through the work so as to form a tie from front to back, breaking joints or overlapping each other for at least 150 mm. No stone whose length is less than 600 mm shall be used in such work as a header.

All the through stones shall be marked inside and outside and the marks shall be retained until ordered by the Engineer to be removed. Sufficient number of headers shall be collected on site before commencing any masonry work. Where adequate sized through stones are not available in required quantities, the use of pre-cast plain concrete headers in M-20 mix may be permitted at the discretion of the Engineer. No extra payment will be made for the provision of substitute headers in concrete

Quoins shall be 150 mm high and formed of header stones at least 300 mm long. They shall

he laid lengthwise alternately along each face and square on their beds, which shall be dressed to a depth of at least 80 mm.

Weep holes 80 mm wide and 150 mm in height shall be provided in retaining walls at the rate of one per square metre as specified or directed. They shall he pointed with 1:2 cement sand mortar after raking the joints to a minimum depth of 25 mm.

Completed masonry shall be kept wet for a minimum period of 14 days. In wet weather newly laid masonry shall be protected from the effects of heavy rainfall by tarpaulins or other approved material.

9.7.1. Pointing of Uncoursed Masonry

Joints in exposed masonry faces shall be formed while the mortar is still green and shall be finished as flush joints, weathered joints, round-recessed joints or square-recessed joints as directed by he Engineer. Masonry which is to be rendered or plastered shall have the joints raked out to a depth of 15 mm to form a key.

9.8. STONE PITCHING

Stone pitching: to slopes shall be carried out where specified or as directed by the Engineer. Stone for pitching shall be obtained from an approved source and shall be hard, sound, durable, clean and generally as specified. The minimum dimension of any stone shall be, at least equal to the specified thickness of the pitching.

After excavation and trimming, slopes to be pitched shall be spread with a 75mm thick layer of crusher run rock or graded coarse aggregate ranging from 75mm particle size to fines. The slope shall then be hand packed with hard broken rock to a total thickness of 150 mm, each stone being individually placed and rammed home, with smaller stones edged into the cracks. 50mm dia weep-holes shall be provided where specified at intervals not exceeding two meter's in both directions. Joints in stone pitching shall be flushed up with sand/cement mortar on completion.

9.9. RUBBLE PACKING

Rubble used for packing under floors, foundations, etc. shall be hard and durable rock, free from veins, flaws and other defects. The quality and size of the rubble shall be subject to the approval of the Engineer.

Rubble shall be hand packed as directed by the Engineer. They shall be laid closely in position on the sub-grade. All interstices between the stones shall be wedged in with smaller stones of suitable size well driven to ensure tight packing and complete filling of interstices. Such filling shall be carried out simultaneously with the placing in position of rubble stones and shall not lag behind. Small interstices shall be filled with hard clean sand and well watered and rammed.

9.10. CONCRETE BLOCK MASONRY

9.10.1. Materials

Masonry units of hollow and solid concrete blocks shall conform to the requirements of IS : 2185 (Part I).

Masonry units of hollow and solid light-weight concrete blocks shall conform to the requirements of IS:2185(Part 3).

Masonry units of autoclaved cellular concrete blocks shall conform to the requirements of IS:2l85(Part 3).

The height of the concrete masonry units shall not exceed either its length or six times its width.

The nominal dimensions of concrete block shall be as under. Length 400, 500 or 600 mm
Height 100 or 200 mm
Width 100 to 300 mm in 50 mm increments

Half blocks shall be in lengths of 200, 250 or 300mm to correspond to the full-length blocks. Actual dimensions shall be 10mm short of the nominal dimensions.

The maximum variation in the length of the units shall not be more than 5 mm and maximum variation In height or width of the units shall not be more than3mm.
Concrete blocks shall be either hollow blocks with open or closed cavities or solid blocks.
Concrete blocks shall be sound, free of cracks, chipping or other defects, which impair the strength or performance of the construction. Surface texture shall as specified. The faces of the units shall be flat and rectangular, opposite faces shall be parallel and all arises shall be square. The bedding surfaces shall be at right angles to the faces of the block.
The concrete mix for the hollow and solid concrete blocks/light weight concrete blocks shall not be richer than one part of cement to six parts of combined aggregates by volume.
Concrete blocks shall be of approved manufacture, which satisfy the limitations in the values of water absorption, drying shrinkage and moisture movement, as specified for the type of block as per relevant IS code. Contractor shall furnish the test certificates and also supply the samples for the approval of Engineer In Charge.

9.10.2. Workmanship

The type of the concrete block, thickness and grade based on the compressive strength for use in load bearing and/or non-load bearing walls shall be as specified. The minimum nominal thickness of nonload bearing internal walls shall be 100mm. The minimum nominal thickness of external panel walls in framed construction shall be 200 mm.

The workmanship shall generally conform to the requirements of IS:2572 for concrete block masonry, IS:6042 for light weight concrete block masonry and 15:6041 for autoclaved cellular concrete block masonry works.
From considerations of durability, generally concrete block masonry shall be used in superstructure works above the damp-proof course level.
Concrete blocks shall be embedded with a mortar, which is relatively weaker than the mix of the blocks in order to avoid the formation of cracks. Cement mortar of proportion 1:6 shall be used for the works.

The thickness of both horizontal and vertical joints shall be 10mm. The first course shall be laid with greater care, ensuring that it is properly aligned, leveled and plumb since this will facilitate in laying succeeding courses to obtain a straight and truly vertical wall. For the horizontal (bedding) joint, mortar shall be spread over the entire top surface of the block including front and rear shells as well as the webs to a uniform layer of 10mm. For vertical joints, the mortar shall be applied on the vertical edges of the front and rear shells of the blocks. The mortar may be applied either to the unit already placed on the wall or on the edges of the succeeding unit when it is standing vertically and then placing it horizontally, well pressed against the previously laid unit to produce a compacted vertical joint. In case of two cellblocks with slight depression on the vertical sides these shall also be filled up with mortar to secure greater lateral rigidity. To assure satisfactory bond, mortar shall not be spread too far ahead of actual laying of the block as the mortar will stiffen and lose its plasticity. Mortar while hardening shrinks slightly and thus pulls away from the edges of the block. The mortar shall be pressed against the units with a jointing tool after it has stiffened to effect intimate contact between the mortar and the unit to obtain a weather tight joint. The mortar shall be raked to a depth of 10mm as each course is laid to ensure good bond for the plaster.
Dimensional stability of hollow concrete blocks is greatly affected by variations of moisture

content in the units. Only well dried blocks should be used for the construction. Blocks with moisture content more than 25% of' maximum water absorption permissible shall not be used. The blocks should not be wetted before or during laying in the walls. Blocks should be laid dry except slightly moistening their surfaces on which mortar is to be applied to obviate absorption of water from the mortar.

As per the design requirements and to effectively control cracks in the masonry, RCC bound beam/studs, joint reinforcement shall be provided at suitable locations. Joint reinforcement shall be fabricated either from mild steel wires conforming to IS:280 or welded wire fabric/high strength deformed basis.

For jambs of doors, windows and openings, should concrete blocks shall be provided. If hollow units are used, the hollows shall be filled with concrete of mix 1:3:6. Hold fasts of doors/windows should be arranged so that they occur at block course level.

At Intersection of walls, the courses shall laid up at the same time with a true masonry bond between atleast 50% of the concrete blocks.

Curing of the mortar joints shall be carried out for atleast 7 days. The walls should only be lightly moistened and shall not be allowed to become excessively wet.
Double scaffolding shall be adopted for execution of block masonry work.
Cutting of the units shall be restricted to a minimum. All horizontal and vertical dimensions shall be in respectively, adopting modular co-ordination for walls, opening locations for doors, windows etc.
Concrete blocks shall be stored at site suitably to avoid any contact with moisture from the ground and covered to protect against wetting.

9.11. DAMP-PROOF COURSE

9.11.1. 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 1:2:1 nominal mix with approved water-proofing compound admixture confirming to IS: 2645 in proportion as directed by the manufacturer. Concrete shall be with 10 mm down graded coarse aggregates.
If he surface of brickwork/stone masonry work shall be leveled 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 atleast seven days after which it shall be allowed to dry for taking up further work.

10. PLASTERING

10.1. RELEVANT IS CODES

IS:1542 : Sand for plaster
IS:1661 : C.P. for application of ferrous metals in building
IS:2394 : C.P. for application of lime plaster finish

10.2. PLASTERING

Cement mortar used for plastering shall be of the mix proportions and thickness as specified on the drawings or bill of quantities or particular specifications for the various different parts of the works.

The materials used i.e. cement, sand and water shall be of the same quality and of the same specifications as indicated for plain and reinforced cement concrete works in the Section D2 of this tender.
Sand further shall meet the specifications as laid down in IS:1542-1977 Specification for sand for plaster.
For plastering on old existing surfaces polymers shall be added as bonding agents.
The surfaces that are to be applied with plaster shall be thoroughly cleaned to remove dust, dirt, loose particles, oil, soil, slats etc. that may be sticking to the surfaces. The surfaces shall be washed clean and watered properly for 4 hours before applying plaster.
Plaster shall not, in any case, be thinner than specified. It shall have uniform specified thickness. When smooth finishing is required the cement plastering shall be floated over with neat cement within 15 minutes after application of the last coat of plastering.

The plaster shall be protected from the sun and rain by such means as the Engineer-in-Charge in charge may approve. The plastered surfaces shall be cured for 7 (seven) days. Construction joints in plastering shall be kept at places approved by the Engineer-in-Charge. When the thickness of the plaster specified is to be made up in more than one layer, the second layer shall be applied only when the lower coat is still green. After applying the first layer the surface should be roughed and wherever specified, approved brands of additives like water proofing compounds shall be added in specified quantities as recommended by the manufacturer of the compound, or as directed by the Engineer-in-Charge.

Wherever scaffolds are necessary for plastering they shall be provided. Stage scaffolding shall be provided for ceiling plaster. To ensure even thickness and true surface, patches of plaster about 15 cms x 15 cms shall be first applied both horizontally as vertically 2 m apart. Plastering shall be done from top to bottom and care shall be taken to avoid joints on continuous surface.

Sand face plaster shall consist of first layer of 16mm average thick cement plaster in cement mortar 1: 6 (One part cement and Six parts coarse sand). A second layer of 4 mm average thick in cement mortar 1:4 (one part cement and four part coarse sand) shall be applied. After the application of final coat, the surface shall be finished with the application of sponge rubber or as directed to obtain a uniform sand particle surface finish.

In case any other finish like rough cast finish or dry dash finish is specified in the drawings the same shall be provided as directed by the Engineer-in-Charge. Surfaces, which are to be plastered, shall be roughened while they are still green or raked so as to give proper bond between the surface and plaster.
All corner, edges, junctions shall be truly vertical or horizontal as the case may be and carefully finished. Rounding or chamfering of corners shall be carried out with proper

templates to the required size and shapes.

No additional charges for works like scaffolding curing etc. are payable over and above the rates quoted for brickwork. The rates quoted shall be deemed to be inclusive of all such works.

Gypsum Plaster

Gypsum shall be fulfill the following bacteriya

Stucco

1. Colour of Finished surface White
2. Bulk Density kg/m3 650-750
3. Setting time in Min 10-20
4. Coverage at 13mm (One coat) (m2/1000 kg) Not Applicable
5. Coverage at 3mm (Stucco) (m2/1000 kg) Min 280
6. Surface Smoothness More
7. Compressive Strength (KN) Min 70

10.3. NEERU

10.3.1. Material

Neeru shall be made of the best description of lime slaked with fresh water and sifted. The lime to be reduced to fine powder by grinding it on a stone or in a hand mill, with a thick solution of mussalla to be made or as may be desired by the engineer. The neeru thus prepared shall be kept moist until used and the quantity to be prepared at one time shall be such that it can be consumed in eight days.

10.3.2. Workmanship

All stone or brick masonry shall be thoroughly wetted and joints raked out to a depth of at least 20mm and walls washed before any plastering is done. The surface shall then rendered with fine sand, to the specified thickness and roughness. The surface shall then be floated or set with a thin coat, 3mm thick of cement and polished, well with a trowel or flat board. The cement mortar shall be used within 30 minutes after it leaves the mixing board or mill. Before any plasterwork is started patches of plaster 150mm x 150mm shall be put on at every 3 meters apart as gauges so as to ensure an even thickness throughout the work. Cement plaster shall be done in even square or strips. Care shall be taken to keep the whole surface thoroughly wetted for at least a week. The finishing surface shall be as specified and directed. If neeru finish is specified then the same shall be applied to the prepared and partially set but somewhat plastic surface with steel trowel to a thickness slightly exceeding 1.5 mm and rubbed down to 1.5mm thickness and polished to a perfectly smooth and even finish working from top to bottom. The surface shall be then colored, if required with 3 coats of white or colour wash for which no extra payment shall be made.

11. FLOORING

11.1. RELEVANT IS CODES

IS:777 : Glazed earthen ware tiles
IS:1237 : Cement Concrete flooring tiles
IS:1443 : C.P. for laying & finishing of cement concrete flooring tiles
IS:2114 : C.P. for laying in-situ terrazzo floor finish

11.2. GENERAL

The materials and workmanship conform to the provisions of the following codes and standards. In particular and with such other standards as mentioned hereinafter. BIS: 269, 385, 515, 653, 712, 809, 1077, 1195, 1196, 1197, 1198, 1237, 1344, 1443.

11.3. CEMENT CONCRETE FLOORING

11.3.1. General

Flooring shall consist of a sub-base laid on the compacted earth or sand fill as required, a base course laid on the sub-base and then a finishing layer of concrete, Terrazzo or any other material as specified to be laid. The materials for filling (Earth or sand as specified in drawings) shall be brought from the source as approved by the Engineer-in-Charge.

11.3.2. Filling

The surface to receive the filling shall be first cleared free of all roots, vegetation and wetted. Filling in plinth or other specified levels shall proceed in layers of 15 cm. Along with the construction of building, it shall be watered and well rammed in layers as mentioned above and compacted to the satisfaction of the Engineer-in-Charge.

Care shall be taken to remove all roots, vegetation, foreign matter, etc. from the earth used for filling. After thorough consolidation, required quantity of the filling corresponding to the thickness of floor shall be scrubbed to make space for the flooring. Where sand filling is specified, the sand shall be clean, free from vegetation and other deleterious materials and same procedure followed as for earth filling. In case of sand filling, if required, flooding shall be done to achieve required compaction.

11.3.2.1. Preparation of Bed

The bed for flooring shall be prepared either level or sloped as per relevant drawings or as instructed by Engineer-in-Charge. Care shall be taken that there are no roots, vegetation, foreign matter, etc.

11.3.2.2. Sub-Base

On the prepared bed as indicated above, boulder, or gravel or broken bricks or sand or cement concrete (1:4:8 as per BIS: 465) shall be laid to thickness as specified. This layer shall be beaten with rammers until thoroughly consolidated. All the material used shall conform to the required specifications.

The materials proportion, mixing, laying, and curing, etc. for cement concrete shall be carried out as specified.

The finished work shall be of uniform depth over the whole floor with surface even and parallel to the prepared bed as per drawing or as directed by Engineer-in-Charge.

a. Boulders as Sub-base Course
   Boulders shall be laid over the prepared bed as per general specification and shall be of size 100 to 150 mm and shall be of approved quality. Boulders being used shall be free from decay, weathering and be stacked in such heaps in place as directed by Engineer-in-Charge, the thickness being as specified in the relevant drawings.
b. Sand Layer
c. Sand for sand layer to be laid over the prepared bond shall be clean, free from admixture as per specification. Sand layer shall be spread in one or more layers to the thickness as indicated in drawings or schedule of item watered and rammed.

11.3.3. Base Coarse

11.3.3.1. Cement Concrete

It shall be of specified mix and shall generally conform to "Construction Specification for Cement Concrete".

11.3.3.2. Panels

To prevent construction cracks, the floor space shall be divided into square or rectangular panels. The base course of specified thickness shall be laid in alternate panels or any other pattern as approved by Engineer-in-Charge. The panels shall be of uniform size, not exceeding 4.0 m. in any direction for a floor having thickness 40 mm and above. Alternate panels shall be laid on different days.

Construction joints shall be formed in between the sequential panels cast, with straight edges, 20 mm deep and 12 mm wide in groove form. These joints on completion of work, shall be cleaned and washed free of dust with the help of brush and shall be treated with hot bitumen poured in the gap, over which fine sand shall be spread to arrest the flow of bitumen.

11.3.3.3. Shuttering

The panels shall be bounded by glass strips having the same depth as the concrete floor. These shall be fixed in position with their top at proper level, giving slope. The floors shall butt against masonry of wall before it is plastered.

11.3.3.4. Concreting

Cement concrete shall be placed in position with or without MS reinforcements as shown in drawings and beaten with trowel and finished smooth or left rough as directed by the Engineer-in-Charge. Beating shall cease as soon as surface is found covered with cream of mortar. The surface shall be checked with the help of straight edge and made true.
The shuttering shall be removed next day. Care shall be taken to see that edges are not damaged and fresh mortar from adjacent panels is not splashed over them. The joints between panels shall come out as fine straight line.
MS reinforcement used for concrete base course with reinforcement shall conform to relevant BIS Specifications as detailed in drawings. Before placing of those reinforcements, they shall be cleared of scales with wire brush and oily stains removed.

11.3.4. Floor Finish Plain Cement Finish

Finishing of the surfaces shall follow immediately after the completion of base course. The surface shall be left for some time till the moisture disappears from it. Use of dry cement or cement and sand mixture sprinkled on the moisture shall not be permitted.

Fresh quantity of cement at 2.2 kg per square metre of flooring shall be mixed with water to form thick slurry and spread over the surface, while the concrete is still green. It shall be pressed twice by means of iron floats, once when the slurry is applied and second time when cement starts setting.

The junction of floor with wall plaster, clods or skirting shall be rounded off uniformly where so required upto 25 mm radius or as directed. The men engaged on finishing operations shall be provided with raised wooden platform to sit on, so as floor finish is specified, the top surface of floor finish shall be chequered with mesh or similar impression before the finish has set.

11.3.5. Curing

Each finished portion of floor, on completion, shall be kept wet with ponding or moist sand or moist gunny bags as per specifications. At no time, cement concrete layer, plain or reinforced

shall be allowed to dry during curing time.

11.4. GRANOLITHIC (IPS) FLOORING

The requirement for filling, preparation of bed, sub-base and base course concrete shall be same as in clauses above.

11.4.1. Finished Layers

Granolithic finish of the thickness as indicated in drawings or as specified shall consist of 2 layer of M15 grade cement concrete. The first layer of concrete shall be laid with 10 mm to 6 mm grade aggregate and well compacted. Within 15 minutes of laying this course the second layer with 6 mm down aggregate shall be laid. The cement and aggregates for the top layer shall be mixed dry.

Sufficient quantity of washed sand and water shall be mixed so as to make it plastic but not flowing. This mixture shall be laid on the first layer so that the two layers firmly grip together. The top layer shall be well tamped, spaded, trowelled and finished with neat cement slurry or with non-skid finish as required. At the junction of adjoining panels a thin string shall be given.

The casting of the granolithic finish layer shall be done in rectangular or square panels not exceeding 1.8 M on any side, using glass strips of height equal to the specified thickness of the floor finish. Required slope in the floor shall be given in the base course concrete without reduction in thickness.

11.4.2. Curing

Curing shall be done as per above mentioned clause.

11.5. ERRAZZO (MOSAIC) TILE

The tiles shall be approximately 22 mm thick of approved shade, color and chips. The tiles shall be pressure made conforming to IS:1237 in all respects. The sizes of the tiles shall be as given in table below:

Table 13 : Sizes of Terrazzo Tiles

Sr.	Nominal Length (cm)	Actual Length (cm)	Nominal Breadth (cm)	Actual Breadth (cm)	Thickness Not less than (mm)
1	20	19.85	20	19.85	20
2	25	24.85	25	24.85	22
3	30	29.85	30	29.85	25

11.5.1. Tolerances

Tolerances on length and breadth shall be ± 1 mm. Tolerance on thickness shall be ± 5 mm. The range of dimension in any one direction of tiles shall not exceed 1 mm on length and breadth and 3 mm on thickness.

11.5.2. Manufacture

The tiles shall be manufactured under hydraulic pressure of not less than 140 kg/cm2 and shall be given the first grinding with machine before delivery to the site. The proportion of cement to aggregate in the backing of the tiles shall not be leaner than 1:3 by weight. Similarly the proportion of cement to marble chips aggregate in the wearing layer of the tiles and the proportion of pigment to be used therein shall not exceed 10% by weight of cement used in the mix. The finished thickness of the upper layer shall not be less than 5 mm for size of marble chips from the smallest upto 6 mm, and also, not less than 5 mm for size of marble chips ranging from the smallest upto 12 mm, and not less than 6 mm for sizes of marble chips varying from the smallest upto 20 mm.

11.5.3. Laying

The sub-grade concrete or the R.C.C slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tiles shall be with lime mortar of either:

i. 1:1:2 (lime putty:surkhi :coarse sand)
ii. 1:3 (lime putty :surkhi)
iii. 1:3 (lime putty : coarse sand)

The bedding ingredients shall be thoroughly mixed by volume in the dry form. Care shall be taken to ensure that there are no hard lumps present. Water shall then be added and the ingredients thoroughly mixed. The average thickness of the bedding mortar shall be 30 mm.

Lime mortar bedding shall be spread, tamed and corrected to proper levels and allowed to be hardened for a day before the tiles are set. Over this bedding, neat grey cement slurry of honey like consistency shall be spread at the rate of 44 kg of cement per sq.m. over such an area as would accommodate about twenty tiles. Tiles shall be washed clean and shall be fixed in this grout one after another each tile being gently tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints shall be kept as thin as possible not exceeding 1.5 mm and in straight lines or to suit the required pattern.

The surface of the flooring during laying shall be the frequently checked with a straight edge atleast 2 m long, so as to obtain a true surface with the specified slope. In situations where full size tiles cannot be fixed, these shall be cut (sawn) to the required size and their edge rubbed smooth to ensure a straight and true joint. Tiles, which are fixed in the floor adjoining the wall, shall enter not less than 12 mm under the plaster, skirting or dado. The junction between the wall plaster and tile work shall be finished neatly and without any waviness. After laying the tiles, the surplus cement grout shall be cleaned off.

11.5.4. Curing, Polishing and Finishing

After laying the tiles the day after all the joints shall be cleaned of the grey cement grout with a wire brush or trowed to a depth of 5 mm and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shade of the topping of the wearing layer of the tiles. The same cement slurry shall be applied to the entire surface of the tiles in a thin coat for protecting the surface from abrasive damage and fill the pin holes that may exist on the surface.

The floor shall then be kept wet for a minimum period of 7 days. The surface shall thereafter be grounded evenly with machine fitted with coarse grade grit blocks No.60. Water shall be used profusely during grinding . The surface shall be washed thoroughly with water to remove all grinding mud, cleaned and mopped. Then it shall be corrected with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that appear. The surface shall be again cured, the second grinding shall then be carried out with machine fitted with fine grade grit blocks No. 120.

The final grinding shall be carried out with the machine fitted with finest grade grit blocks No. 320, the same day after the second grinding described above.

The small areas or where circumstances so required hand polishing may be permitted in lieu of machine polishing after laying. For hand polishing coarse grade stone No. 60 Water shall be used for 1st rubbing stone of medium grade No.80 for second rubbing and stone of fine

grade No.120 for final rubbing and polishing.

After the final polish oxalic acid shall be dusted over the surface of 33 gm/sq.m sprinkled with water and rubbed hard with a 'namdah' block (pad or woolen rags). The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

If any tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with a wooden mallet.

11.6. TERRAZZO (MOSAIC) IN-SITU FLOORING

The requirements for filling, preparation of bed, sub- base and base course concrete shall be same as above.

Trained worker shall carry out terrazzo works.

11.6.1. Material

Best quality marble chips of uniform tint and color, 6 mm maximum and 3 mm minimum size, as approved by Engineer-in-Charge shall be used. They shall be machine crushed, free from foreign matter and of approved quality.

11.6.2. Preparation of Surface and Laying Over Base Course Concrete

Total thickness of cast-in-situ Terrazzo shall be atleast 40 mm unless otherwise indicated. This shall be in two layers bottom layer of M:15 concrete bedding with 10 mm down aggregate of specified thickness and the top layer of 10 mm thickness, consisting of a mix of cement and marble chips in the proportion of 1:1/2 marble powder : 2 marble chips). The bottom layer shall be laid in bays not exceeding 1.2 m on either side and leveled 10 mm below the finished floor level.

The cement and marble chips including powder shall be mixed dry. Water shall be added gradually after through mixing until the mix become plastic but flowing.

Within one hour of laying of the bottom layer of cement concrete the upper layer of marble chips and cement paste shall be laid over a coat of cement slurry and the surface tamped lightly and finished to the required level and slope.

While the bottom layer is still plastic glass dividing strips 35 mm wide x 16 SWG thick shall be fixed on the base course concrete with proper anchoring features to allow top edge to be flushed with the finished floor. The strip shall be laid, forming panels not exceeding 1.2 m x 1.2 m size.

11.6.3. Curing, Polishing and Finishing

The floor shall then be kept wet for a minimum period of six days. The surface shall thereafter be ground evenly to the satisfaction of the Engineer-in-Charge with machine grinders in three phase with grade stones from coarse to fine grade. The surface shall receive wash of neat cement mixed with or without pigment and cured before every grinding operation.

After final grinding, surface shall be cleaned and oxalic acid shall be dusted over the surface @ 35 grams. per sq.m. sprinkled.

11.7. GLAZED TILE FLOORING

11.7.1. White Glazed Tiles

The glazed tiles shall conform to IS:777-1970. They shall be flat and true to shape and free from cracks, crazing spots, chipped edges and corners. The glazing shall be of uniform shade.

11.7.2. Size and Tolerance

The tiles shall be of nominal sizes such as 150 x 150 mm and 100 x 100 mm or as specified. The thickness of the tiles shall be 5 mm, or 6 mm as specified. The tolerance on facial dimension value shall be ± 1.0 mm and ± 0.5 mm on thickness.

The top surface of the tiles shall be glazed. The glaze shall be either glossy or matt as specified. The underside of the tiles shall be completely free form glaze in order that the tiles may adhere properly to the base. The edge of the tiles shall be preferably free form glaze, however any glaze if unavoidable, shall be permissible on any one edge of the tile.

11.7.3. Coloured Tiles

The sizes and specifications shall be the same as for the white glazed tiles described above. The only difference shall be in the colour.

11.7.4. Decorative Tiles

The type and size of the decorative tiles shall be as follows:

a. Decorated white background tiles shall be of 152 x 152 x 6 mm and 108 x 108 x 6 mm sizes.
b. Decorated and having coloured background shall be of 152 x 152 x 6 mm and 108 x 108 x 6 mm sizes.
c. Fantasy glazed tiles (108 x 108 x 6 mm) other specifications will be the same as that of white glazed tiles.

11.7.5. Preparation of Surface and Laying

Sub grade concrete or the R.C.C slab on which the tiles are to be laid shall be cleaned, wetted and mopped. The bedding for the tile shall be with 1:3 (cement: coarse sand) mortar or as specified, having average 10 mm thickness. The bedding thickness under the tiles shall not be less than 5 mm.

The mortar shall be spread, tamped and corrected to proper levels and allowed to harden sufficiently to offer a fairly rigid cushion for the tiles to be set and to enable the mason to place wooden plank across and square on it. Over this mortar bedding neat grey cement slurry of honey - like consistency shall be spread at the rate of 3.3 kg of cement per sq. m over such an area as would accommodate about twenty tiles. Tiles shall be soaked in water washed clean and shall be fixed in this grout one after another each tile gently being tapped with a wooden mallet till it is properly bedded and in level with the adjoining tiles. The joints in between the tiles shall be kept as thin as possible and in straight lines or to suit the required pattern.

The surface or the flooring during laying shall be frequently checked with a straight edge about 2 m long, for obtaining a true surface with the specified slope. Where full size tiles cannot be fixed these shall be cut (sawn) to the required size and their edge rubbed smooth to ensure straight and true joints. The tiles, which are fixed in the floor adjoining the wall, shall enter not less than 10 mm under the plaster, skirting or dado. After laying the tiles the surplus cement grout shall be cleaned off.

11.7.6. Pointing and Finishing

The joints shall be cleaned off the grey cement grout with wire brush or trowel to a depth of 2 mm to 3 mm and all dust and loose mortar removed. Joints shall then be flush pointed with white cement added with pigment if required to match the colour of the tiles. The floor shall then be kept wet for 7 days. After curing, the surface shall be washed and cleaned. The finish floor shall not sound hollow when tapped with a wooden mallet.

11.8. KOTA STONE FLOORING

Kota Stone Slabs- shall be of selected quality hard, sound, dense and homogeneous in texture, free from cracks, decay, weathering and flaws. They shall be hand or machine cut to the requisite thickness and shall be of the colour indicated in the drawings or as directed.

The top (exposed) face of the slabs shall be polished before being brought to site, unless otherwise specified. The slabs shall conform to the size required and samples shall be got approved before starting the work. 20, 30 or 40 mm or specified thickness slabs shall be used.

11.8.1. Tolerances

Of ±2 mm shall be allowed for the thickness. In respect of length and breadth of slabs, a tolerance of ± 5 mm shall be allowed.

11.8.2. Dressing

Each slab shall be cut to the required size and shape and fine chisel dressed on the sides to the full depth, so that a straight edge laid along the side of the stone shall be in full contact with it. The sides (edges) shall be table rubbed with coarse sand or machine rubbed before paving. All angles and edges of the tiles shall be true, square and free from chipping and the surface shall be true and plane.

11.8.3. Surface Preparation and Laying

Sub-grade concrete on the R.C.C slab on which the slabs are to be laid shall be cleaned, wetted and mopped. The bedding for the slabs shall be with cement mortar 1:4 or with lime mortar 1:1:1 (lime putty : surkhi : coarse sand) as given in the description of item. The average thickness of the bedding mortar under the slab shall be 20 mm and the thickness at any place under the slab not be less than 12 mm.

Mortar of the specified mix shall be spread under the area of each slab, roughly to the average thickness as specified. The slab shall be washed clean before laying. It shall be laid on top, pressed, tapped with wooden mallet and brought to level with the adjoining slabs. It shall be lifted and laid aside. The top surface of the mortar shall then be corrected by adding fresh mortar at hallows. The mortar is allowed to harden a bit and cement slurry of honey -like consistency shall be spread over the same at the rate of 4.4 kg of cement per sq.m. The edge of the slab already paved shall be buttered with grey or white cement with or without admixture of pigment to match the shade of the kota stone slabs as given or specified. The slab to be paved shall then be lowered gently back in position and tapped with wooden mallet till it is properly bedded in level with and close to the adjoining slabs with as fine joint as possible. All the subsequent slabs shall be laid

in the same manner. After each slab has been laid, surplus cement on the surface shall be cleaned off. The flooring shall be cured for at least 7 days.

Slabs, which are fixed in the floor adjoining the wall, shall enter atleast 12 mm under the plaster skirting or dado. The junction between wall plaster and floor shall be finished neatly and without any wavings.

11.8.4. Polishing and Finishing

Shall be done as described in the above article of 'Terrazzo Tile Flooring' except that:

a. First polishing with coarse grade carborundun stone shall not be done.
b. Cement slurry with or without pigment shall not be applied on the surface before polishing.

11.9. MOSAIC FINISHED DADO OR SKIRTING

For skirting and dado the brickwork or concrete surface shall be raked and shall be well watered for four hours. A dubbing coat of cement mortar 1:3 (1 cement: 3 sand) of sufficient thickness shall be applied so as to bring the surface in line with the plastered surface. The surface shall be carried by lines with trowel so as to receive mosaic tiles or the top layer or cement and marble chips in proportion of 1:1/2:2 (1 cement: ½ marble powder: 2 marble chips) of 7 mm thickness with 3-5 mm size for flooring including dividing strips (20 mm x 15 SWG) @ 600 mm c/c.

11.10. HARDONITE FLOORING

These specifications cover the guidelines for providing hardonite topping (industrial flooring) for floor subjected to heavy wear and tear viz., workshop and stores, engine room, and Generator room etc.

The item includes providing hardonite topping as specified to the thickness and satisfaction of the Engineer-in-Charge, supply of all material, labour, tools and plant required for completing the work in best workmanlike manner.

11.10.1. Workmanship

The person executing the topping shall be an experienced mason familiar with flooring works of similar nature. Flooring shall be laid uniformly, the tolerance for variation of level being + 3 mm.

Hardonite material shall be mixed with cement concrete thoroughly to give a uniform mix.

11.10.2. Preparation of Surface

Hardonite shall be laid over a wet concrete surface screened to receive the topping. The base shall be leveled to within + 12 mm.

11.10.2.1. Preparation of Topping

Hardonite shall consist of a mixture of cement concrete in proportion of 1:2:4 and well graded iron fillings added in a proportion of 1.50 kg/bag of cement.

11.10.2.2. Application

Hardonite shall be placed uniformly in a layer of specified thickness and finished with a steel troned. Care shall be taken to place hardonite in a separate layer while the base concrete is steel wet.

11.10.2.3. Trowelling

Surface of floor shall be finished with steel trowel only and trowelled just sufficient so as to give a finished surface. The surface shall be left for some time till moisture disappears from it. Trowelling shall be done three times at intervals so as to produce a uniform hard surface in no case cement should come up to the surface.

11.10.2.4. Curing

The entire surface shall be kept uniformly wet for seven days.

11.10.2.5. Opening for use

The surface shall be allowed to be used only after curing period is over.

12. DISTEMPERING AND PAINTING

12.1. GENERAL

Engineer's approval shall be obtained before commencing the painting work. All paints and preserves shall be of approved make and colour and their application shall conform to the manufacture's instructions. Where more than one undercoat is specified it shall be applied in coats of distinctive tints. Workmanship shall conform to the requirement of IS:2395 Unless the manufacturer's instructions state otherwise48 hours drying time shall elapse between successive applications of any primer and 24 hours between applications of all subsequent coats. The surface of bituminous paints shall be left at least 3 days before further handling.

No paints in any coats shall be applied until the engineer is satisfied that the surface is clean and dry. And that any previous coat is satisfactory and has hardened adequately. When a surface has been approved, it must be painted immediately.

Paint work shall be rubbed down with a glass paper between coats. No paint shall be applied to a surface, which is damp, dirty or otherwise inadequately prepared.

12.2. CONCRETE, BRICKWORK AND PLASTER

Where specified to be painted, concrete and plaster shall be rubbed smooth and any cracks, blister holes and other imperfections cut out, filled and made good. The surface shall be dried to the satisfaction of the engineer before painting is commenced and drying time if at least 28 days shall be allowed after laying brickwork and plaster or stripping formwork from concrete. The surface shall be brushed to remove any efflorescence and then painted with the following:

1. for interior brick work and concrete, apply two coats of oil paint up to 1 meter height and for remaining part two coats of plastic emulsion paint over a coat of primer.
2. For exterior brickwork and concrete, apply two coats of cement based paint over a coat of primer with a water repellant coat of siliconate solution of appproved make.

Where painting with plastic emulsion is specified, all uneven surface shall be made up by use of putty of appropriate quality, after the surface has been thoroughly cleaned of all dust and dirt and sand papered.

12.3. IRONWORK AND UNGALVANISED STEELWORK

Structural steelwork shall be shot blasted to a "white metal" finish, and grease and oil removed prior to painting. Priming shall immediately follow blast cleaning and no cleaned surface shall be left unprimed for more than four hours. Only primers that chemically inhibit corrosion shall be used. Where the iron or steelwork is not in contact with raw or treated water, the primer shall be red lead complying with IS: 57. Where there is a possibility that the steel or ironwork may come in contact with water, the priming treatment shall be non toxic, zinc chromate or equivalent. Where it is anticipated that further welding will be required. an approved welding primer shall be applied to the areas to be welded and re primed with the main primer when welding has been completed. Primer coats shall not be less than 0.05 mm each.

After erection, all damaged areas shall be made good, and re primed where the original coat has spread under the primer, the affected surface shall be cleaned down to bare metal to the satisfaction of the Engineer and then re primed.

Repainting shall be carried out as soon as possible after erection. If` it is to he exposed to weather or condensation, it shall receive one further coal of primer.

Metalwork in intermittent or permanent contact with raw or treated water shall have two finishing coats of an approved coal tar pitch epoxy paint such as "Epilux 5" by Berger Paints, or equivalent. The total coating shall be minimum of 0.125 mm thick.

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, be undercoat of

synthetic enamel paint conforming-to IS:2932 of optimum thickness shall be applied by brushing 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 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.

At least 24 hours shall elapse between the application of successive coats. Each coat shall very slightly in shade and this shall be got approved by the Engineer.

12.4. GALVANISED STEELWORK

Newly galvanised steelwork shall be primed with an etch primer such as calcium plumbate. Steelwork that has been galvanised for a long period so that the surface has oxidised adequately to allow adhesion of under-coats, need not have an initial coat of each primer.

After priming, galvanised steelwork in constant or intermittent contact with raw or treated water shall be given two coats of an approved coat of tar pitch epoxy paint such as "Epilux 5" by Berger Paints, or equivalent. The total coating shall have a minimum thickness of 0.1 25 mm.

Protective coats for galvanised steelwork not in contact with water shall be:

1. One coat of micaceous iron oxide paint for interior galvanised steel work.
2. Two coats Of micaceous iron oxide paint for external galvanized steelwork.

Galvanised steelwork not in contact with water shall be finished with at least one coat of gloss paint on top of an approved undercoat.

12.5. BITUMINOUS SURFACES

Metalwork items that have been given a shop treatment of bituminous paint shall be painted with two coats of` an approved anti-bleed paint before applying a coat of decorative finishing paint.

12.6. ALUMINIUM SURFACES

Aluminum surfaces shall be worked clean, dried and thoroughly degreased before painting, by an appropriate solvent (such as one consisting of equal parts of white spirit and light solvent naptha). Flame cleaning shall not be permitted. The clean degreased surface shall be treated to ensure paint adhesion either by mechanical roughening, chemical adhesion, or etch primers or wash primers applied in strict conformity with the manufacturer's instructions or by other treatment approved by the Engineer.

The pretreated surface shall receive a priming coat with an inhibiting pigment containing not less than 20% by weight of fine chromate or other approved chromate in a suitable water-resisting vehicle.

The priming coat shall not contain any copper or mercury compounds and it shall also be free from graphite and carbonaceous materials and shall not contain any lead. Priming coat shall consist of a tung-oil phenolicresin which is pigmented with equal parts of zinc tetoroxy chromate and red iron oxide.

Aluminum surfaces in contact with concrete, or resting on pads on concrete, shall be painted with two coats bituminous paint, and the concrete surfaces shall also receive two coats bituminous paint.

12.7. WOODWORK

Woodwork for painting shall be carefully rubbed down, treated with preservatives and knotted, stopped and primed in the shop. Care shall be taken to ensure that priming is thoroughly brushed into every part of the surface and in particular at end grains, joint and notches where two coats are to be applied. Primers for wood shall he of a standard equivalent to, or better than "Aluminum Wood Primer Sealer A519-3697" by I.C.I.

Paints.

After the woodwork has been fitted and all defects in the surfaces have been made good and re primed, one coat of approved undercoat shall be applied to internal surfaces and two coats to external surfaces. An undercoat of quality equal to or better than "Delux Undercoat A522 line" shall be used.

'Timber work shall be decoratively finished with one coat of finishing paint of standard equal to, or better than "Delux Gloss Finish A365 line".

12.8. WATERPROOF CEMENT PAINT

12.8.1. Surface Preparation

The wall should be washed thoroughly with clean soft water and freed of all loose particles, dust, dirt, lichen, moss, efflorescence and Lime wash by Scrubbing with a wire brush. Inequality and holes shall be filled up with cement paste, which should be allowed to set. To get even uniform mat finish it is necessary to keep the surface damp throughout the operation. In hot dry weather the wall should be frequently sprinkled with water to keep it moist.

12.8.2. Mixing the paint

Loosen the contents by either rolling the drum or shaking the container before opening it. Take one measure of water by volume in a clean pot and add two volumes of approved quality waterproof cement paint conforming to IS: 5410. Stir well to make a paste of high consistency then add one more measure of water constantly stirring the mixture. The final composition of water and paint is now 1:1 by volume. Keep stirring the mixture all the time and use it up within an hour. Do not use the mix if it is left over 'for more than two hours.

12.8.3. Method of Application

Wet the surface by any convenient method. A small surface can be wetted by brush. When applying paint surface should be damp and not wet. While applying the first coat brush hard into the surface to cover pores and cavities to ensure better bond. Twelve hours after applying the first coat cure the surface by sprinkling the water. Before applying the second coat damp the surface and after the application of second coat cure it as directed above. In hot climate repeat curing at least twice at the interval of six hours for optimum best results.

12.8.4. Curing

After sprinkling fine spray of water should cure each application paint normally after twelve hours when paint film is hardened satisfactorily. In summer when weather is hot, curing may be done little earlier. Water marks may be left over the surface if a stream of water is allowed to flow before the paint film is hardened.

12.9. SILICON PAINT

12.9.1. Preparation

A solution for application shall be prepared from Syltrit 1772 or equivalent. The Manufacturer's instructions shall be followed. This solution shall be prepared to a concentration of about 3 % solids by mixing 1 kg. of water dilatable solution of sodium methyl siliconate with 9 kg. of water. Concentration higher than 3% solids are not recommended as they may cause a white precipitate of sodium carbonate formation.

12.9.2. Application

A flooding technique should be used in applying to obtain the best penetration. When spraying, the solution should not be atomized or misted, but flowed on in a solid stream, with the spray gun held, at a distance just enough to eliminate foaming on the masonry surface. If foaming is allowed then certain visible marks might appear after application. The run down of 150 to 300 mm should be maintained with generous overlapping of

passes. Dipping and brushing methods are also suitable. After application of the solution, the treated surface should be allowed to dry at least 24 hours to develop maximum water repellency. This interval may be shortened somewhat by force drying at temperatures to 30 degree C. Though this removes the water quickly, time must still be allowed for the curing. Reaction between the solution and the surface being treated. Until the reaction is complete the applied film still remains water soluble and any rain failing during this time can wash it out. So application should be done in dry weather or at least in absence of rain and fog.

12.9.3. Spraying Equipment

Spraying equipment shall be hand operated stirrup pump with stainless steel nozzle fitted with PVC or polyethylene delivery pipe. Components of the spraying, equipment that are in contact with the treating solution should be of black iron, mild steel, stainless steel, Teflon, PVC or polyethylene. They should not be of aluminum or galvanised steel. .

12.9.4. Safety

The solution should always be applied in a liquid stream, not by misting or fogging. If misting occurs, avoid inhalation. Contact with the eyes or skin should be treated immediately by flooding the area with large quantities of water for at least 15 minutes.

12.10. RELEVANT IS CODES

IS:63 : Whiting for paints
IS:133 : Enamel, interior, undercoating & finishing colour as required
IS:2395 : C.P. for painting concrete, masonry & plaster surfaces
IS:5410 : Cement paint, colour as required
IS:5411 : Plastic emulsion paint for interior use

12.11. DISTEMPERING

12.11.1. Type

Distempering shall be of the oil or water bound type as specified.

12.11.2. Material

Dry distemper or oil bound washable distemper of approved brand and manufacture for water bound and oil bound respectively conforming to IS:426 shall be used. The proportions of the mix shall be as per the approved manufacturer's instructions.

The dry distemper shall be stirred slowly in clean warm water using 8.6 liters of water per kg. of distemper or as specified by the approved makers. The mixture shall be well stirred before and during use to maintain an even consistency.

Thinner as stipulated by approved manufacturer shall be used in case of distemper for oil bound type.

Dry distemper shall not be mixed in larger quantity than is actually required for one day work.

12.11.3. Preparation of Surface and Priming Coat

The surface shall be thoroughly brushed free from mortar dropping and other foreign matter and sand papered smooth.

A priming coat of whiting shall be applied over the prepared surface in case of water bound distempering and distemper primer or cement primer shall be applied in the case of oil bound distemper. The white washing coat shall be used as priming coat for distemper.

12.11.4. Application

After the primer coat is dried for atleast four hours, the entire surface shall be coated uniformly with proper distemper brushed in horizontal strokes, immediately followed by

vertical ones which together shall constitute one coat.

Subsequent coats shall be applied in the same way and only after the previous coat has dried. Enough distemper shall be mixed to finish one room at a time. The finished surface shall be even and uniform and shall no brush marks. After each days work, the brushes shall be washed in hot water and hung down to dry. Old brushes, which are dirty or caked with distemper, shall not be used.

12.12. DECORATIVE FINISH CEMENT PAINT

12.12.1. Surface Preparation

Plastered surface shall be thoroughly cleaned of dust, dirt, grease, oil marks, etc. before the coat is applied. All the holes and depressions should be filled with gypsum prior to application of the paint. The surface shall be wet with clean water before paint is applied. Application of primer shall be as per specifications recommended by approved manufacturer and as directed by the Engineer-in-Charge.

12.12.2. Preparation of Mix and Application

Any approved cement paint shall be mixed in such quantities as can be used up within an hour of mixing. The solution shall be applied on the prepared surface with good quality brushes and no brush mark shall be visible on the finish work.

12.13. PAINTING

12.13.1. Painting General

Paints, oils, varnishes etc. of approved brand and manufacture conforming to relevant Indian Standard Codes shall be used. Ready mixed paints as received from approved manufacturer without any admixture shall be used. The Contractor shall obtain permission for the make and color of the paint he proposes to use and if required, polish for wood work shall be tested as per IS:5807 (parts I and II).

Whenever thinning is necessary, the brand of thinner recommended by approved manufacturer or as instructed by Engineer-in-Charge shall be used. Paints, oil, varnishes, thinner, etc. shall be brought to the site in the original containers in sealed condition and shall be kept in the joint custody of Contractor and Engineer-in-Charge.

12.13.2. Commencing the Work

Painting except priming coat shall generally be taken in hand after all other building work is practically finished. Approval of Engineer-in-Charge shall be sought before commencing the work.

12.13.3. Workmanship

All the work shall be carried out wherever applicable as per IS:1477 (Parts I & II) and IS:2338 (Part I)

12.13.4. Preparation of Surface

The surface shall be thoroughly cleaned. All dirt, dust, scales and grease shall be removed before painting is started. The surface shall be perfectly dry to permit good absorption. The prepared surface shall receive approval from Engineer-in-Charge for commencing the painting work. For wood surfaces, a priming coat without coloring material should be applied after which all the holes, cracks etc shall be stopped with putty and all knots properly killed with quick lime.

Specially for wood surface, knots if visible shall be covered with red lead conforming to BIS:103. Holes and identification on the surface shall be filled with wood putty and rubbed smooth. Surface should be thoroughly dry.

12.13.5. Application

Paint shall be thoroughly stirred in the container when pouring into smaller containers for use. It shall be continuously stirred while applying on the surface. The painting shall be applied evenly and smoothly in the direction of grains of wood and perpendicular to it. Each coat shall be allowed to dry before the next coat is applied.

Specified number of coats shall be applied and atleast 24 hours shall elapse between application of the first coat and the subsequent second coat. No painting shall be carried out on exterior work in wet weather condition or on surface which are not entirely dry. Each coat shall be lightly rubbed down with sandpaper or fine pumice stone and cleaned of dust before the next coat is laid. No left over paint shall be put back into stock tins.

The finished surface shall be free from hair or brush marks, strokes, clogging of paint puddles in the corners of panels, angles of moulding, etc.

12.14. PAINTING WITH SYNTHETIC ENAMEL/ENAMEL PAINT

12.14.1. Material

Synthetic enamel/enamel paint of approved brand and manufacture and of required shade shall be used for the topcoat only. The paint for under coat shall be of shade to match the topcoat, as recommended by approved manufacturer shall be used.

12.14.2. Preparation of Surface

The surface shall be thoroughly cleaned. All dirt, scales and grease shall be removed before painting started. The surface shall be perfectly dry to permit good absorption. The prepared surface shall receive approval from Engineer-in-Charge for commencing the painting work.

Specially for wood surfaces, knots if visible shall be covered with red lead conforming to IS:103. Holes and indentation on the surface shall be filled with good putty and rubbed smooth. Surface should be thoroughly dry.

12.14.3. Application

12.14.3.1. Under Coat

One coat of the specified paint of shade matching with the shade of the top coat shall beapplied and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure smooth and even surface, free from brush marks and all loose particles dusted off.

12.14.3.2. Top Coat

Top coats of specified paint in the desired shade shall be applied after the under coat is thoroughly dried. Additional finishing coat shall be applied if found necessary to ensure a properly uniform glossy surface.

13. EXPANSION JOINTS AND CONSTRUCTION JOINTS

13.1. GENERAL

The item of providing expansion joints and construction joints in concrete includes all the material, labour, tools and plants necessary for completing the item in best workmanlike manner.

13.2. MATERIAL

The Material to be used in the joints shall be ribbed PVC water stop of specified width approved by the Engineer, bitumen impregnated fibre board as filler conforming to IS:10566 and approved sealant material (In case of movement joint only). In addition, IS:12220-1987 and 1838 shall also be adhered.

13.3. JOINTS IN FLOOR

Joints in floor shall be provided as specified on drawings. In case of PVC water stops to be provided horizontal position flat-footed PVC water stops shall be used. The water stops shall be provided in such a way that half the portion of water stop (width wise) is embedded in the concrete and half remains exposed for next concrete. Steel reinforcement shall not be discontinued where construction joints in floor are provided.

13.4. JOINTS IN WALLS

13.4.1. Expansion Joint

Expansion joints shall be provided in the roof slab and wall and divide wall is of R.C.C. The joints shall be so located that in no case the slab shall be more than 45 metres long in one stretch. The general layout of roof slab showing the position of expansion joint is given in the accompanying drawing. The two adjoining portions of the roof slab at the expansion joints shall be separated by a gap of about 25 mm width which shall be bridged by means of 230 mm wide water stop. These water stops shall be fixed in such a manner that it is equally embeded in each portion of the slab on either side of the joint and shall be located at mid section of the slab. The joint shall be continuous in length and shall be properly joined together or welded at all junction along its length. The gap between the adjacent slab below the water stops shall be filled with filler material like thermocol or such compound which may be approved by the Engineer.

This may be achieved by placing a strip of filler material in position adjacent to the face of concreted slab panel while concreting the adjoining panel. The space above, water stop shall be filled with sealant material overlaid by filler material like thermocol and polysulphide sealant as shown in the drawing.

The expansion joints in the end wall and divide wall shall be provided in such a manner that the joint shall divide the structure longitudinally and transversely as shown in the drawing. The two adjacent parts of the wall shall be separated by a gap of about 25 mm width which shall be bridged by 300 mm wide PVC water stop. However, no gap shall be provided in the footing of the wall. The gap on water face shall be treated with polysulphide sealant material as shown in the drawing. The water stops shall be either PVC or either equivalent approved by the Engineer as per specifications given hereinafter.

13.4.2. Construction Joint

The construction joints shall be generally provided at the end of the concreting or colcreting operation of an element or a member of a structure, or at boundary of the panels or segments or at pre-determined locations. The construction joints in the R.C.C.

slab shall be characterised by the continuance of the reinforcing steel, being a structural R.C.C. member. The concreting of a slab at the joint shall be done by laying the concrete against the vertical stopping off boards, the adjoining panels being cast butting against each other.
Const6ruction joints in the side wall and the divide wall of reservoir shall be of two types
(I) horizontal construction joints and (ii) vertical construction joints.

The horizontal construction joints shall be serrated type where stones from the lower lift of the wall shall be projecting out sufficiently and will be embedding into the over laying lift of the wall masonry giving a well bonded, and consequently, a water tight joint.
The vertical construction joints in the wall shall be of tongue and groove type. The groove of these joints shall be 300 mm x 300 mm and it shall be provided 300 mm away from the water face of the wall. These joints shall be provided with PVC water stop at a depth of 200 mm from water face which shall be primarily responsible for the water from water face which shall be primarily responsible for the water tightness of the joints. These joints shall have a plain finish for a depth of 300 mm from water face by virtue of its casting against vertical face of the centering of vertical face of the previously cast panels cast butting against each other while the remaining depth beyond300 mm shall have masonry facing which will present a rough surface and thus provide a good bond between the consecutive panels.

In the case of divide wall the water stop shall be located at the centre of the key which shall be located at the centre of divide wall. The key shall be of the same dimensions as that in the end walls.

The construction joints in the bottom layer of the floor which shall be case in colcrete shall be cast against vertical stopping off boards. On the water face the vertical joints shall have a groove provided with bitumen of 12 mm x 20 mm size which shall be filled with polysulphide sealant material.

No such special treatment need be done for the joints provided in the roof slab, bottom layer of the floor and the horizontal joints in the wall. The joints in roof slab and bottom layer of the floor shall however, be staggered with those in the overlaying layers such as brick bat coba, I.P.S. and top R.C.C. layer of the floor to minimise the chances of leakage by increasing its path, if any.

13.4.3. Complete Construction Joints

These joints are provided in the top layer of the floor of the reservoir with a view to localise shrinkage cracks at these joints. These joints are characterised by complete discontinuity of steel without any initial gap as in the case of expansion joints. The joints between the adjacent panels of the floor shall be provided with a groove at top of dimension 12 mm x 20 mm and it shall be filled with polysulphide sealant and they shall be provided with water stops as specified earlier.

The joint between top layer of the floor and the walls or between the top layer of the floor and the column footing, shall also be provided with a groove of 12 mm x 20 mm which shall be filled with sealant material as per specifications given below:

Joint Fillers : Joint fillers shall be of durable, compressible and non-extruding material. It shall be non-staining, non-absorbent and compatible with sealant material used.

Sealant Material : The joint sealing compounds should be capable of properly ensuring water tightness in vertical and horizontal and inclined joints in water retaining and other structures

having severe service conditions in respect of anticipated movement or exposure to weather. Typical uses include expansion joints in the walls of water tanks, and in roof and deck slabs exposed to the weather.

The compound should be flexible, durable and weather proof and should have sufficient elasticity to allow joint movements of the concrete components wherever necessary.

The sealant shall be polysulphide rubber sealing compound conforming to BS 4254 of 1967 or ASA-A 116-1-1960 or any other equivalent specifications. It shall be capable of cold pouf application for horizontal joints and cold application of vertical and inclined joints. The sealing compounds shall be suitable for use in the tropics where it will be subjected to high ambient temperatures, humidity and very strong sunlight. It shall not degrade under these conditions and shall be suitable for use with raw and treated water including water dosed with chlorine. The sealant shall be odour and taint free from lead. It shall be available in choice of colours and shall give a though, permanent seal, be waterproof, non-staining and remain resilient. Sealing compounds for vertical and horizontal joints shall be used complete with the appropriate quantity of primer as per manufacturer's instruction for use. The primers should ensure good adhesion to the concrete and should be specially developed for respective sealing compounds. The sealants shall be applied with pressure guns or without guns as specified by the manufacturers. Sealing compound shall be fully cured before water is permitted to come in contact.
The sealant material should be formulated as to have a storage period of one year at a temperature of 40oC.

14. EPOXY COATING, BITUMINOUS, POLYMER PAINTING

14.1. EPOXY COATING

14.1.1. General

Epoxy coating is to be applied to the internal surface of the unit wherever specified. The thickness of epoxy film shall be 300 microns.

14.1.2. Materials

A solvent free epoxy coating like “Araldite GY 255” manufactured by Hindustan CIBA Geigy Limited, Bombay or equivalent product of FOSROC is to be used for forming the film. Incase of use of an equivalent it should be got approved by the Employer placing supply orders. Materials used and process of application to the concrete of other surfaces should be strictly according to the instructions of the suppliers of the epoxy. Araldite GY 255 one part by weight is to be mixed with 1 part by weight of Hardener H Y 45. The viscosity should be such that it is convenient for brush application.

14.1.3. Subsurface Preparation

The concrete surface should be cleaned thoroughly by sand blasting. The mild steel parts also are to be cleaned to be free of grease and thoroughly sand blasted. The coverage should not be more than 6 sq.m. for concrete and 5 sq.m. for mild steel per kg of epoxy respectively.

The moisture content of concrete before application of epoxy coating shall be less than 4%. This has to be checked properly through a small sample. To achieve this epoxy coating shall be done in hot season.

14.1.4. Curing

The curing should be done for 7 days at room temperature. if the temperature is less than 15°c the space should be warmed up by incandescent lamps, heaters, blowers or infrared lamp. The instructions of the supplier manufacturer of the product both as for use of materials and application take priority over the above instructions and they should be followed very rightly.

14.2. BITUMINOUS PAINTING

Two coats of bituminous paint of 80/100 grade, with 1.65 kg/m2 spread will be provided on internal face of sludge sump.

14.2.1. Material

The material shall be of best quality un-pigmented bituminous base pain of such a composition as to satisfy the requirements of IS-9862.with total volatile matter contained in the paint shall not exceed 55% by weight.

At least 95% of the solid materials shall be soluble, in carbon di-sulphide or in benzene, and the closed flash point as determined in Abel's apparatus shall not be less than (86 F)30 C. The paint shall remain liquid and retain its consistency at the ordinary atmospheric temperature when packed in suitable containers. The drying time shall not he less than 2 hours and not more than 8 hours, and after drying, paint shall not shoe any surface cracks, tendencies to powder or discoloration due to weathering action or expansion and contraction. It shall also be able to resist the action of acids and alkalis. It shall not soften under the action of mineral turpentine.

The film resulting from brushing the material on a strip of tinned iron, 30 standard wire gauge after being allowed to dry at room temperature not below (65 F) 18.3 C for 48 hours shall not, when bent double over a (quarter inch)6 mm dia rod, show any signs of flaking or cracking. The time occupied for the actual bending shall not exceed one

second. When the paint has dried hard, a 4H pencil should not be capable of scratching it. The weight of the paint shall be firm 0.83 to 1.25 kg per liter, the component of the

paint shall he such as not to react with water chlorinated or otherwise and develop poisonous or harmful elements thereto.

The paint shall be of' Indian manufacture of approved make and quality

14.2.2. Application

All corners and junctions shall be properly rounded off to present a uniform and smooth finish. After complete curing of the plaster, it will be allowed to day up. After drying the moisture content shall be brought to a value less than 4% by using a below-lamp. The surface should be well cleaned with smooth brush to make it dust free. The coating shall be allowed to dry and kept in dry condition till final setting takes place.

14.3. POLYMER PAINTING

Polymer paint shall be elastomeric (450% elongation), thermoplastic, fire retardant, coating skin tensile strength 18 to 21 kg/cm2, antifungal, antibacterial anticorrosive graft polymer paint of approved make Meta Chem or equivalent.

Fire retardant coating shall confirm BS 3119 specifications

15. DOOR, WINDOWS, GRILLS, SHUTTERS, ETC.

15.1. RELEVANT IS CODES

IS:1003 (I) : Timber paneled and glazed door & ventilator shutters
IS:1003 (II) : Timber paneled and glazed window & ventilator shutters
IS:1038 : Steel doors, windows & ventilators
IS:1081 : Fixing & glazing of metal doors, windows & ventilators
IS:1361 : Steel windows for industrial buildings
IS:2202 : Wooden flush door shutter (solid core type)
IS:2202 (I) : Plywood face panels
IS:2202 (II) : Particle board and hardboard face panel
IS:4020 : Methods of test for wooden flush doors
IS:6248 : Metal rolling shutters & rolling grills
IS:7452 : Hot rolled steel sections for doors, windows & ventilators
IS:10451 : Steel sliding shutters
IS:10521 : Collapsible gates

15.2. GENERAL

The items under this clause cover doors, windows, grills, rolling shutters, collapsible gates etc. normally required to be provide in a building used whether for residential, office, laboratory or industrial purpose.

Doors and windows Shutter shall be of Teakwood as specified in the bill of quantities/drawings or as directed by the Engineer. The sizes of the above items and locations of the same shall be as shown in the drawings.

The frames and shutters shall be of either steel or wood of thickness of members as shown on the drawings. The material used shall be of good quality seasoned timber of specified wood or rolled steel sections as the case may be.
They shall be provided with all necessary fittings like hold fasts, hinges, locking arrangements stoppers, eyes and hooks, tower bolts, handles, fixing lugs etc., of sizes and quality grade as specified.
They shall be provided in complete form including painting, glazing, fixing in position true to level and plumb.
Steel rolling shutters shall be of approved make and shall conform to IS 6248 - 1979. Metal rolling shutters and rolling grills.
The builder's hardware shall all be as per relevant Indian Standards.

15.3. WOODWORK IN DOORS, WINDOWS, PARTITIONS, LOUVERS, RAILINGS ETC.

Wood used for all work shall be the best of the respective class specified, and properly seasoned by at least 6 months air drying, suitable for joiner's work, should be of natural growth, uniform in texture, straight grained, free from sapwood, dead knots, open shakes, boreholes, rot, decay and any and all other defects and blemishes.
The thickness specified for joiner's wrought timbers are, unless otherwise specified, prior to planning and 3 mm will be allowed from the thickness stated for each wrought faces.
All joining shall be wrought on all faces and finished off by hand with sandpaper, with slightly rounded arises.
The joints shall be pinned with hard wood pins and put together with white lead. Jointing shall be by means of mortise and tenor or dovetailed joints as approved.
Any joiner's work which shall split, fracture, shrink, or show flaws or other defects due to unsoundness, inadequate seasoning or bad workmanship, shall be removed and replaced with sound material at the Contractor's expense.

Doors, windows and ventilator frames, transoms and mullions shall be rebated. All dimensions shall be as per drawings. The top framing member of doors and top and bottom framing of windows and ventilators shall project about to mm below finished floor. Surface coming in contact with brickwork shall be painted with bitumen as directed by the Engineer-in-Charge. Each of the door and window frames shall be provided with 3 Nos. M. S. 225 x 25 x 6 flat split holdfasts on each side. These holdfasts shall be embedded in masonry of concrete work. The work shall conform to IS:4021.

The doors shall be paneled or solid flush doors as described in the item of work. All flush doors shall be supplied with approved fittings such as hinges, mortise lock of approved make with handles on both sides, oxidised brass tower bolts and latch arrangements, door stops etc. and as shown in drawings but exclusive of door closers. Door closers, where separately specified shall be of heavy duty hydraulic type to be approved by Engineer-in-Charge Paneled doors shall have the same fittings except in place of union lock, an aldrop shall be provided. Each door leaf shall have two 250 mm tower bolts, two aluminum or oxidised brass handles, and one door stopper be made of weatherproof plywood. Flush doors shall conform to IS:2202 (Part-I).

Doors will generally have no sills but if a few have to be provided, the Contractor shall do so at no extra cost to the Owner.
The type of window shall be as specified. Each shutter shall have one pair of hinges, two tower bolts (one 225 mm long and another 150 mm long), one handle and one hook with eye and pegstay. Ventilators shall have two M. S. hold fasts and hinges, one handle and one hook and eye at each and one small tower bolt in the centre. Where so directed by the Engineer-in-Charge, the doors and windows shall be provided with parliamentary type hinges at no extra cost.
The workmanship of all door and window shutters shall conform to the requirements of IS:1003 (Part-I & II) and IS:2202 (Part-I). If required, flush door panels shall be got tested as per IS:4020.
Cupboards, almirahs and shelves shall be provided as per Engineer-in-Charge. The doors could be of either hinged type or sliding type as approved by the Engineer-in-Charge. All dimensions as furnished in the drawings shall be followed. Fixtures and fittings as shown on drawings or as directed by Engineer-in-Charge shall be used.

Railings and architraves shall conform to the shape shown on drawings or as approved and fixed by means of screws (counter sunk or otherwise) or bolts.
The finish expected is of a very high order and the work shall be all-inclusive weather or not all detailed specifications have been spelt out and the work shall be free from blemish.
No iron bars or grills are proposed to be provided in the windows or ventilators. Glass louvred ventilators where specified shall be provided.
Glazed windows, louvres, ventilators and doors shall be provided with either clear or pinheaded glass 5.5 mm thick which shall be free from all blemishes and shall conform to IS:1761. It should be clearly understood that glass which does not have uniform refractive index or which is wavy will be rejected. Woodwork shall not be painted, oiled or otherwise treated before the Engineer has approved it.

15.4. STEEL DOORS, WINDOWS AND FITTINGS

The steel doors, windows, ventilators shall conform or IS:4351 and IS:1038. All steel doors windows, ventilators, louvres etc. shall be of sizes as specified and conform to the description in the respective item of work. Whether or not specifically mentioned, all fixtures and fittings necessary for the satisfactory operation of the doors and windows shall be provided. Doors, windows and ventilators shall be obtained from an approved manufacturer. Specific approval for such purchase shall be obtained before hand. Sample

shall also be got approved before further manufacture starts, unless this is waived in writing by the Engineer-in-Charge. All steel doors shall be of pressed steel (18 gauge) flush type with or without removable transome. All doors shall be provided with a three way bolting device and locking arrangement with duplicate keys and handles of both sides and operable from either side. The Contractor shall obtain windows with friction hinges in place of windows with pegstays if so directed by the Engineer-in-Charge. For centre hung and top hung ventilators suitable spring catch/pulley and chord arrangement shall be provided for facility of opening. Whenever fly mesh over windows have been called for, they shall be fixed on the window and suitable lever type or rototype arrangement shall be provided for opening or closing of the glazed panels from inside. Prior approval of Engineer shall be taken before order is placed with the manufacturer.

Where specified, steel doors supplied shall be airtight. For this purpose, the Contractor shall provide necessary padding material such as rubber, felt or any other approved material.

15.5. ROLLING SHUTTERS

The rolling shutters shall conform to the size indicated in drawings and shall be of quality specified in the Schedule of Quantities. The rolling slats shall be in one piece and be made of heavy gauge steel sheets minimum 18 SWG in thickness. A cylindrical hood shall be provided on the top to enclose the shutter when it is open. The rolling shutters shall be provided with suitable locking arrangements and deep channel guides, In case galvanised rolling shutters are specified the rolling shutter shall be made of hot dip galvanised slats, hood, deep channel guides all preferably in one piece.

In case of hand operated pull & push type rolling shutters of sizes larger than 10 sq.m. in area and in case of very large gear operated and/or as directed by the Engineer, rolling shutters shall be provided with ball bearings for smooth & efficient operation. In case of large rolling shutters & depending upon local wind conditions, the rolling shutters should be provided with special locking type of wider channel guides or it shall be provided with central moveable channel supports to take up design wind pressures in the area.

16. HAND RAILING

Hand railing and vertical posts shall be made from galvanised mild steel / Stainless Steel pipes and its fittings. The design and materials specifications of the railing shall be approved by the Engineer to whom the Contractor shall submit manufacturer's drawings showing positions of vertical posts, joints, expansion joints and joint details and all fixing details. Fabrication shall not start until these drawings have approved by the Engineer.

Hand railing and vertical posts fabricated from galvanised mild steel pipes or stainless steel and its fittings shall conform to the following requirements.

The height of the top railing shall be 1000 mm above finished floor level unless otherwise shown. There shall be total 3 horizontal rows. Top row shall be of 32 mm dia and middle two rows shall be of 25 mm dia GI medium class pipe / SS materials . The lower railing shall 550 mm above finished floor and Toe plate should be provided at the bottom of the rail of the size100mm wide x 5 mm thick subject to the Engineer's approval these and other leading dimensions may be varied slightly to suit manufacturer's standard products.

a. Unless otherwise shown, vertical posts shall be made of galvanised mild steel tubes (medium class) /Stainless Steel of 40 mm nominal bore and fittings such as Tees, Bends, Crossed etc. of heavy class conforming to IS:1239.
b. Unless otherwise shown, top horizontal post shall be made of galvanised mild steel or Stainless Steel materials tubes (medium class) of 32 mm nominal bore and fittings such as Tees, Bends, Crossed etc. of heavy class conforming to IS:1239.
c. Unless otherwise shown, lower two horizontal post shall be made of galvanised mild steel tubes (medium class) / SS of 25 mm nominal bore and fittings such as Tees, Bends, Crossed etc. of heavy class conforming to IS:1239.
d. In general the vertical posts shall be spaced at 1.5 metre c/c and shall be built into the concrete or bolted to the MS plate embedded in concrete as shown on detailed drawing.
e. Hand railing and vertical posts shall be painted with 2 coats of approved paint.

17. RUNGS

Rungs shall be provided in all manholes/inspection chambers/pumping stations over 0.6 mm in depth and shall be of cast iron conforming to IS:5455. These rungs shall be fixed staggered in two vertical runs, 300 mm apart horizontally and 300 mm c/c vertically. The top rung shall be 450 mm below the manhole/inspection chamber cover and the lowest not more than 300 mm above the benching. The rungs shall be of 20 mm diameter with epoxy paint for corrosion resistance or equivalent as approved by Engineer in Charge.

18. PIPING WORK

18.1. MANUFACTURING / SUPPLYING LAYING AND JOINTING OF RCC PIPES

18.1.1. Scope:

This Specification covers the requirements for manufacturing, testing, supplying, jointing and, testing at work sites, of Reinforced Cement Concrete (RCC) pipes, of both pressure and non pressure varieties used for pumping mains, sewers and storm water drains.

18.2. Applicable Codes

The manufacturing, testing, supplying, jointing and testing at work sites of RCC pipes shall comply with all currently applicable statutes, regulations, standards and Codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern.

18.3. Materials

IS: 458	Specification for Concrete Pipes (with and Without Reinforcement).
IS:3597	Method of Tests for Concrete Pipes.
IS:5382	Specification for Rubber Sealing Rings for Gas Mains, Water Mains and Sewers.

18.3.1. Codes of practice

S: 456	Code of Practice for Plain and Reinforced Concrete.
IS: 783	Code of Practice for Laying of Concrete Pipes.
IS: 376	Safety Code for Excavation Work.

18.4. Design

Design of RCC pipes shall be in accordance with the relevant clauses of IS: 458. The details of reinforcement shall be as per Clause 5.2 of IS: 458. The ends of pipes shall be in accordance with relevant clauses of IS: 458.

18.5. Manufacturing

18.5.1. General

1. The method of manufacture shall be such that the form and the dimensions of the finished pipes are accurate within the limits specified in relevant IS: 458. The surfaces and edges of the pipes shall be well defined and true, and their ends shall be square with the longitudinal axis. The ends of the pipes shall be further reinforced by an extra ring of reinforcement to avoid breakage during transportation.
2. The RCC pipes and rubber rings shall be systematically checked for any manufacturing defects by experienced supervisors so as to maintain a high standard of quality.
3. Engineer shall at all reasonable times have free access to the places where the pipes and collars / rubber rings are manufactured for the purpose of examining and testing the pipes and collars / rubber rings and of witnessing the test and manufacturing.
4. All tests specified either in this Specification or in the relevant Indian Standards shall be performed by Supplier / Contractor at his own cost and in presence of Engineer if desired for this, sufficient notice before testing of the pipes shall be given to Engineer.

5. If the test is found unsatisfactory, Engineer may reject any or all pipes of that lot. The decision of Engineer in this matter shall be final and binding on Contractor and not subject to any arbitration or appeal.

18.5.2. Materials

Materials should conform to the requirements given in IS

18.5.3. Curing

Pipes manufactured in compliance with IS: 458 shall be either water cured or steam cured in accordance with the relevant requirements of IS: 458.

18.5.4. Dimensions

1. The internal diameter, wall thickness and length of barrel and collar of pipes, reinforcement (longitudinal and spiral), type of ends and minimum clear cover to reinforcement and strength test requirements shall be as per the relevant clauses / tables of IS: 458 for different class of pipes.
2. The tolerances regarding overall length, internal diameter of pipes or socket and barrel wall thickness shall be as per relevant clauses of IS: 458.

18.5.5. Workmanship and finish

1. Pipes shall be straight and free from cracks except that craze cracks may be permitted. The ends of the pipes shall be square with their longitudinal axis so that when placed in a straight line in the trench no opening between ends in contact shall exceed 3 mm in pipes up to 600 mm diameter (inclusive), and 6 mm in pipes larger than 600 mm diameter.
2. The outside and inside surfaces of the pipes shall be smooth, dense and hard, and shall not be coated with cement wash or other preparation unless otherwise agreed to between Engineer and the manufacturer or supplier.
3. The pipes shall be free from defects resulting from imperfect grading of the aggregate, mixing or molding.
4. The pipes shall be free from local dents or bulges greater than 3.00 mm in depth and extending over a length in any direction greater than twice the thickness of barrel.
5. The deviation from straight in any pipes throughout its effective length, tested by means of a rigid straight edge parallel to the longitudinal axis of the pipe shall not exceed, for all diameters, 3 mm for every meter run.

18.6. Testing

1. All pipes for testing purposes shall be selected at random from the stock of the manufacturer and shall be such as would not otherwise be rejected under the criteria of tolerances as mentioned in IS: 458.
2. During manufacture, tests on concrete shall be carried out as per IS: 456. The manufacturer shall supply, when required to do so by Engineer the results of compressive tests of concrete cylinders or cubes made from the concrete used for the pipes. Every pressure pipe shall be tested by the manufacturer for the hydrostatic test pressure.
3. The specimen of pipes for the following tests shall be selected in accordance with Clause 9.1 of IS: 458 and tested in accordance with the methods described in IS: 3597
   a. Hydrostatic test.
   b. Three edge bearing test or sand bearing test.
   c. Absorption test.
   d. Bursting test.

Note: Three edge bearing strength to produce 0.25 mm crack in case of special design of pipes shall be as follows:

300 mm Ø	1200 kg/m
350 mm Ø	3040 kg/m
400 mm Ø	3460 kg/m
450 mm Ø	4160 kg/m
500 mm Ø	4160 kg/m
600 mm Ø	4720 kg/m
700 mm Ø	5320 kg/m
800 mm Ø	6060 kg/m
900 mm Ø	6760 kg/m
1000 mm Ø	7400 kg/m
1100 mm Ø	8200 kg/m

18.7. Sampling and inspection

1. 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.
2. 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.
3. 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 “r th” 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.
4. All the pipes selected shall be inspected for dimensional requirements, finish and deviation from straight.
5. The number of pipes to be tested for tests shall be in accordance with column of Table 9 of IS: 458. These pipes shall be selected from pipes that have satisfied the requirements mentioned above.
6. A lot shall be considered as conforming to the requirements of IS: 458 if the following conditions are satisfied.
   a. 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 of IS: 458.
   b. All the pipes tested for various tests shall satisfy corresponding requirements of the tests.
   c. 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.

18.8. Marking

The following information shall be clearly marked on each pipe including the details given by Engineer In charge of AMC:

1. Internal diameter of pipe.
2. Class of pipe.
3. Date of manufacture, and
4. Name of manufacturer or his registered trademark or both.

18.9. Carting and Handling

1. Pipes and fittings / specials shall be transported from the factory to the work sites, at places along the alignment of pipe line as directed by Engineer. Contractor shall be responsible for the safety of pipes and fittings / specials in transit, loading / unloading. Every care shall be exercised in handling pipes and fittings / specials to avoid damage. While unloading, the pipes and fittings / specials shall not be thrown down from the truck on to hard surfaces. They should be unloaded on timber with steadying ropes or by any other approved means.

2. Padding shall be provided between coated pipes, fittings / specials and timber skids to avoid damage to the coating. Suitable gaps between pipes should be left at intervals in order to permit access from one side to the other. In case of spigot socket pipes while unloading, as far as possible pipes shall be unloaded on one side of the trench only. The pipes shall be checked for any visible damage (such as broken edges, cracking or splaying of pipe) while unloading and shall be sorted out for reclamation. Any pipe which shows sufficient damage to preclude it from being used shall be discarded. Dragging of pipes and fittings / specials along concrete and similar pavement with hard surfaces shall be prohibited. Wherever a section of pipe, or a fitting is to be lifted or moved, it shall be handled carefully with belt slings. The belts shall be constructed so that no metal bears against the pipe and so that the bearing is uniform. The width of the belts shall be adequate to prevent any damage to the pipe coating. The pipe section may at no time be dropped but shall be lowered carefully into position and may not be slide along the ground. If it is to be rolled, it may be done only on slides or ground specially prepared so as to prevent any damage to the coating.
3. All State and local laws be observed during transportation. The Contractor shall secure permits and licenses and provide all signals, guards and lights that may be required. Upon delivery the pipe sections and fittings shall be placed on specially prepared ground to protect them from distortion and damage. The ground shall be prepared so that they will rest evenly and will have uniform bearing throughout their lengths. Valve and sluice gates shall be placed on blockings.

18.10. 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 laid lengthwise 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 stack shall not exceed 1.5m.

Fittings / specials shall be stacked under cover and separated from pipes. Valves and sluice gates shall be placed on blockings.

Rubber rings shall be stored in a clean, cool store away from windows, boiler, electrical equipment and petrol, oils or other chemicals. Particularly in the field where the rubber rings are being used it is desirable that they should not be left out on the ground in the sun or overnight under heavy frost or snow conditions.

18.11. Jointing

1. Jointing of RCC pipes shall be done as per the requirements of following Specifications and as per the relevant IS. The type of joints shall be as specified in the Contract / Drawing. After jointing extraneous material if any, shall be removed from the inside of the pipe and newly made joints shall be thoroughly cured. In case, rubber sealing rings are used for jointing, these shall conform to IS: 5382.
2. Spigot and Socket Joint (Rigid)
   The spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. The opening of the joint shall be filled with stiff mixture of cement mortar in the proportion of 1:1, which shall be rammed with caulking tool.
3. Collar Joint (Rigid)
   After laying the RCC pipes at proper alignment and gradient their abutting faces shall be coated with hot bitumen in liquid condition by means of a brush. The wedge-shaped groove in the end of the pipe shall then be filled with a tarred gasket in one length for each joint. The collar shall then be slipped over the end of the pipe and the next pipe butted well against the tarred gasket by suitable appliances approved by Engineer so as to thoroughly compress the tarred gasket into the grooves, care being taken that

the concentricity of the pipes and levels are not disturbed during this operation. The collar shall then be placed symmetrically over the end of the two pipes and the space between the inside of the collar and the outside of the pipe filled with a mixture of cement and sand in the proportion of 1:1, tempered with just sufficient water to have a consistency of the semi dry conditions, well packed and thoroughly rammed with caulking tools. The joints shall be finished off with a filled sloping at 45o to the side of the pipe. The finished joints shall be protected and cured thoroughly as directed by Engineer. Any plastic solution or cement mortar that may have been squeezed into the inside of the pipe shall be removed so as to leave the inside of the pipe perfectly clean.

4. Spigot and Socket Joint (Semi-flexible)
   This joint is composed of specially shaped spigot and socket ends on the RCC pipes. A rubber ring shall be lubricated and then placed on the spigot which is forced into the socket of the pipe previously laid. This compresses the rubber ring as it rolls into the annular space formed between the two surfaces of the spigot and socket, stiff mixture of cement and mortar in the proportion of 1:1, shall then be filled into the remaining annular space and rammed with a caulking tool.

5. Collar Joint (Semi-flexible)
   This joint is made up of a loose collar which covers two specially shaped pipe ends. Each end shall be fitted with a rubber ring, which when compressed between the spigots and collar, seal the joint. Stiff mixture of cement mortar in the proportion of 1:1, shall then be filled into the remaining annular space and rammed with a caulking tool.

6. Spigot and Socket Joint (Flexible)

   The RCC pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipes. The manufacturer's instructions shall be used, and the manufacturer's instructions shall be deemed to form a part of these Specifications. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.
   Flush Joint (Internal)
   This joint shall be generally used for culvert pipe of 60 cm. diameter and over. The ends of the pipes are specially shaped to form a self centering joint with an internal jointing spaces 1.3 cm wide. The finished joint is flush with both inside and outside with the pipe wall. The jointing space is filled with cement mortar in the proportion of 1:1, mixed sufficiently dry to remain in position when forced with a trowel or rammer.

7. Flush Joint (External)
   This joint is suitable for pipes which are too small for jointing from inside. This joint is composed of specially shaped pipe ends. Each end shall be butted against the other and adjusted in correct position. The jointing space shall then be filled with cement mortar in the proportion of 1:1, sufficiently dried and finished off flush. Great care shall be taken to ensure that the projecting ends are not damaged as no repairs can be readily affected from inside the pipe.

18.12. Cleaning of pipes

1. As soon as a stretch of RCC pipes has been laid complete from manhole to manhole or for a stretch as directed by Engineer, Contractor shall run through the pipes both backwards and forwards a double disc or solid or closed cylinder 75 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipe line shall be securely closed as may be directed by Engineer to prevent entry of mud or slit etc.
2. If as a result of the removal of any obstruction, Engineer considers that damages may have been caused to the pipe lines, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory Contractor shall amend the work and

carry out such further tests as are required by Engineer.

3. It shall also be ascertained by Contractor that each stretch from manhole to manhole or the stretch as directed by Engineer is absolutely clear and without any obstruction by means of visual examination of the interior of the pipeline suitably enlightened by projected sunlight or otherwise.

18.13. Testing at work site

1. After laying and jointing of RCC pipes is completed the pipe line shall be tested at work site as per the following Specifications and as directed by Engineer. 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. Water used for test shall be removed from pipes and not released to the excavated trenches.
2. After the joints have thoroughly set and have been checked by Engineer and before backfilling the trenches, the entire section of the sewer (or storm water drain) shall be proved by Contractor to be water tight by filling in pipes with water to the level of 1.50 m. above the top of the highest pipe in the stretch and heading the water up for the period of one hour. The apparatus used for the purpose of testing shall be approved by Engineer. Contractor if required by Engineer 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 10 minutes intervals and noting the quantity required to maintain the original water level. For the approval of this test the average quantity added should not exceed 1 liter / hour / 100 linear meters / 10 mm nominal internal diameter. 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.
3. In case of pressure pipeline the completed stretch of pipeline shall be tested for site test pressure of 0.15g/sq.cm. The site test pressure should not be less than the maximum operating pressure plus the calculated surge pressure, but in no case should it exceed the hydrostatic test pressure, as specified in IS: 458.

18.14. Measurement

1. All RCC pipes shall be measured according to the work actually done and no allowance will be made for any waste in cutting to the exact length required. The measurement for pipes shall be in running meters nearest to a cm. of length along the centre line of pipe as actually laid at work sites.

18.15. Rate

1. The rate for providing, laying and jointing of RCC pipes shall be deemed to include the cost of collars / rubber rings, jointing material, testing and the extra excavation required for ordinary bedding of pipes and also for collars and pipe sockets if any.

18.16. Notes

1. If any damage is caused to the pipeline during the execution of work or while cleaning / testing the pipeline as specified, Contractor shall be held responsible for the same and shall replace the damaged pipeline and retest the same at his own cost to the full satisfaction of Engineer.
2. Water for testing of pipeline shall be arranged by Contractor at his own cost.

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18.17. Laying and jointing of Pipes and Fittings / Specials

18.17.1. Excavation

1. 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 and shall be done such that it does not get far ahead of the laying operation as approved by Engineer.
2. 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 until it is safe for the traffic to use the roadways. The Contractor shall provide sign boards 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.

3. Trial pits may be dug by the Contractor, without being directed to do so, along the lines of the trenches as shown on the drawings in advance of the excavations for the purpose of satisfying himself as to the location of underground obstructions or conditions. The Contractor shall proceed with caution, in any excavation and shall use every means to determine the exact location of underground structures, pipelines, conduits etc., and prior to excavation in the immediate vicinity thereof. The Contractor shall be solely responsible for the cost of protection or repair or replacement of any structure, pipeline, conduit etc., above or below ground which may be broken or otherwise damaged by his operations.
4. 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 1.2 m above the surface of the ground. There shall be two rails, one near the top of the posts and the other about 500 mm 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 strong 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.
5. The lighting, barricading, guarding of the trenches and the maintenance of watchman 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. In all streets in the City/Town at every 15 meters interval, blank board shall be provided by the Contractor at his own cost, to facilitate crossing of the trench by the public residing on the either side.
6. 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 Engineer.
7. 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 so as to avoid covering fire hydrants, sluice values, manhole covers, etc. and so as to avoid abutting the wall or structure or causing inconvenience to the public and other service organization or otherwise as Engineer may direct.
8. Contractor shall take into account additional excavation if any as Engineer may require in order to locate the position of water pipes, drains, sewers, etc. or any other works which may be met with, in or about the excavation of trenches / pits while quoting the rates for excavation. 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 Engineer may direct, and shall be protected by Contractor from damage during the progress of the work.
9. Wherever extra width of excavation shall be necessary for shoring and strutting, of the trenches on account of the nature of the soil, such extra width required to

accommodate the shoring boards shall not be paid for separately and the rates quoted for trench work are deemed to be inclusive of all such incidental work.

10. All precautions shall be taken during excavation and laying operations to guard against possible damage to any existing structures/pipelines of water, gas, sewage etc.
11. If the work for which the excavation has been made is not complete by the expected date of the setting in of monsoon which is First week of June or the setting in of rain whichever is earlier, or before the day fixed by Engineer for filling in any excavation on account of any festival or special occasion, Contractor shall backfill such excavation and consolidate the filling.
12. Utmost care shall be taken to see that the width of the trench at the top of pipe is not more than [External diameter of pipe in mm + 500 mm] + [400 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. 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 lean cement concrete of adequate depth, properly consolidated to give the curved seating. The bottom of the trench shall be properly trimmed to permit even bedding of the pipeline. Bottom of trenches / pits shall be saturated with water and well rammed wherever Engineer may consider it necessary to do so. For laying of pipes larger than 1200 mm in diameter, in earth and moorum, the curvature of the bottom of the trench should match the curvature of the pipe as far as possible, subtending an angle of 120 degrees at the centre of the pipe.
13. 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. Such grip shall be of sufficient size in every respect to admit the hand; all around the socket in order to make the joint and the grip shall be maintained clear until the joint has been approved by Engineer.
14. When welding is to be carried out with the pipes and specials in the trench, additional excavation of not more than 60 cm in depth and 90 cm in length shall be made at joints in order to facilitate welding.
15. The excess excavated material shall be carried away from site of works to a place up to a distance as directed by Engineer. This shall be done immediately so as not to cause any inconvenience to the public or traffic. If the instructions from Engineer are not implemented within seven days from the date of instructions to cart the materials and to clear the site, the same shall be carried out by Engineer at Contractor's risk and cost and any claim or dispute shall not be entertained in this respect.
16. Refilling of trenches, where the excavation is in rock shall be with the surplus soft soil from pits located within 200 meters from the reach in question.
17. It is to be distinctly understood that no extra payment shall be made for the excavation from borrow pits located within 200 meters for obtaining earth for refilling, any instructions of the Engineer to bring earth from beyond 200 meters for refilling shall be detailed in writing and a separate extra payment shall be made for the additional conveyance. No payment shall be made for disposal of soil for excavation, surplus to or unsuitable for filling.

18.17.2. Work included in Excavation

Unless otherwise directed on the project Specifications, all of the following items are

included in the excavation:

1. Removing all surface obstructions including shrubs, jungle etc.,
2. Making all necessary excavations true to line and grade,
3. Furnishing and installing all shoring and bracing as necessary or as directed,
4. Pumping and bailing out water to keep trenches free of water during pipe laying and jointing and thereafter until joints mature,
5. Providing for uninterrupted surface water flow during work in progress,
6. Providing for disposing off water flows from storm, drains, nallas or other sources, suitably,
7. Protecting all pipes, conduits, culverts, railway tracks, utility poles, wire fences, buildings, and other public and private property adjacent to or in the line of work,
8. Removing all shoring and bracing which is not ordered to be left in place or not required by the project plans or Specifications to remain in place,
9. Hauling away and disposing of excavated materials not necessary or else unsuitable for back filling purposes. The extra excavated soil will have to be properly dressed in soil banks along with the trench as directed,
10. Back filling the trenches as directed or as per Specifications,
11. Restoring all property injured or disturbed by these construction activities to the condition as near its original condition as possible,
12. Restoring the surfaces and repairing of all roads, streets, alleys, walks, drives, working spaces, and rights of way to a condition as good as prior to excavation
13. In case the Engineer orders that the location of trench be moved a reasonable distance, on account of the presence of an obstruction or due to such other cause or if a changed location is authorized at the Contractor's request, the Contractor shall not be entitled to extra compensation or to a claim for damage. If however such change is made at the orders of the Engineer, which involves abandonment of excavation together with the necessary back fill, will be measured, classified and paid for in the same manner as for other trench excavation and back fill of the same character. In case the trench is abandoned in favor of new location at the Contractor's request, after its approval, the abandoned excavation and back fill shall be at Contractor's expense.

18.17.3. Minimum earth cover

If a profile is not furnished for a pipeline, the main will be constructed with a minimum earth cover of 1000 mm from the top of the pipeline, unless otherwise indicated on plans and ordered by the Engineer.

18.17.4. Dewatering

1. During the excavation, if subsoil water is met with, Contractor shall provide necessary equipment and laborers for dewatering the trenches / pits by bailing out water or water mixed with clay. If pumping out subsoil water is found to be necessary, Contractor shall provide sufficient number of pumps for the same. In both the above cases the excavation shall be done to the required level and the pipes shall be laid to proper alignment and gradient. Contractor shall also make necessary arrangement for the disposal of drained water to nearby storm water drain or in a pit if allowed by Engineer. In no case the water shall be allowed to spread over the adjoining area. Before discharging this water into public sewer / drain, Contractor shall take necessary permission from the local authorities.
2. The Contractor shall be responsible for the adequate pumping, drainage and bailing out of water from the excavation. Failure to make such provisions which results in unsuitable sub grade conditions, and which will require any special foundations as directed by the Engineer, such foundations shall be placed at the entire cost of the Contractor and will not be measured or paid for as separate pay items. If the Contractor selects to undercut the trench and use gravel or tile bailing, drainage of well pointing, the additional work will be considered as incidental work and additional compensation will not be allowed

18.17.5. Special foundation in poor soil

1. Where the bottom of the trench at sub grade is found to consist of material which is unstable to such a degree that in the opinion of Engineer, it cannot be removed and replaced with approved material thoroughly compacted in place to support the pipe properly, a suitable foundation for the pipes, consisting of piling, timbers or other materials, in accordance with relevant Drawings and as instructed by Engineer shall be constructed.
2. During the progress of the work, should the foundation for the pipeline be in soft, yielding or spongy materials which are unsuitable for the sub grade of the pipeline and which is not the result of the Contractor's negligence, to make proper provisions for adequate drainage of the excavation, the Contractor shall remove such unsuitable sub grade materials to the depth directed by the Engineer. The Contractor shall fill the excavated depth in the manner hereinafter described or as directed by the Engineer.
3. The Contract unit for foundation shall be one cubic meter. The foundations will be measured for payment complete in place. The contract unit price shall be the total compensation for furnishing all labor, tools, materials, equipment and incidentals necessary to complete the work, including all excavation and disposal of surplus material.
4. Gravel Foundations
   a. The space resulting from removal of unsuitable material shall be filled with gravel. No extra payments will be made on this account, except for lead charges if any beyond 50m.
   b. Concrete Foundations
   c. The space resulting from removal of unsuitable materials shall be filled with a concrete foundation and the concrete shall conform to relevant Specifications.

18.17.6. Wooden shoring

1. Contractor shall suitably design polling boards, walling 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. 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.
2. 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 as 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. Contractor shall not claim, on any reason, whatsoever for the shoring which may have been left in.

18.17.7. Steel plate shoring

1. 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 Contractor will be required to use steel trench sheeting or sheet piling adequately supported by timber struts, walling, etc., as per the instructions, manner and method directed by Engineer. Contractor shall supply, pitch, drive and subsequently remove trench sheeting or piling in accordance with other items of the Specification.

18.17.8. Boning staves and sight rails

1. In laying the pipes and fittings / specials the centre for each manhole / chamber or pipe line shall be marked by a peg. Contractor shall dig holes for and set up two posts (about 100 mm X 100 mm X 1800 mm) at each manhole / chamber or junction

of pipe lines at nearly equal distance from the peg and at sufficient equal distance there from to be well clear of all intended excavation, so arranged that a sight rail when fixed against the post will cross the centre 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.

2. Boning staves of 75 mm X 50 mm size shall be prepared by Contractor of various lengths, each length being of a certain whole number of meters 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 this tee head, at a distance equal to as the case may be, the outside diameter of the pipe or the thickness of the concrete bed to be laid. The top of cross pieces shall indicate different levels such as excavation for pipe line, top of concrete bed, top of pipe, etc. as the case may be.
3. 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 the sight from rail to rail.
4. 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 hands and cross piece of the boning staves shall be painted black.
5. For the pipes converging to a manhole / chamber at various levels, there shall be rail fixed for every different level. When a rail comes within 0.60 m of the surface of the ground, higher sight-rail shall be fixed for use with the rail over the next point.
6. 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.

18.17.9. Bedding

1. The bedding for pipe shall be provided as specified in the Drawings or as per direction of Engineer.

18.17.10. Concrete cushion, embedment and encasement

1. Concrete embedment and encasement wherever required, shall be constructed as per the details given in approved Drawings or as directed by the Engineer. Where concrete bedding is to be placed beneath the pipeline, the sub-grade shall be prepared to dimensions as shown in the Drawings. The bottom of the trench may be sloped on the sides or kerbed, but the thickness of concrete shall be as specified in the Drawings or as directed by the Engineer. Dry mix will not be permitted.
2. For earth, granular material or concrete embedment, each pipe section shall have uniform bearing on the sub grade for the full length of the pipe barrel, suitable excavation shall be made to receive the pipe, bell or collar and allow adequate room for proper workmanship in making the joint. Adjustment to line and grade shall be made by scraping away or filling in with gravel or concrete and not by wedging or blocking up the bell. Pipe sockets and barrels shall be clean and free from dirt at the time of jointing.
3. The concrete for bedding portion will be mixed moist or damp to give a slump of not more than 25 mm and for sides and top portions of encasement, if specified, will be mixed to obtain a slump between 25 mm and 80 mm. All water in the trench must be disposed off prior to placing of concrete. There should be no cleavage line between the bedding concrete and the side embedment concrete. Clear out space shall be left for jointing and lowering pipe in place and bringing to grade by tamping under pipe or removing excess concrete under pipe. After the joint is made, the remainder of the concrete embedment may then be poured and thoroughly tamped to make bond with

original concrete. Care must be exercised in tamping to prevent lifting of the pipe out of alignment or grade. Back filling shall be done in a careful manner and such time after the concrete cushion, embedment or encasement is placed, as not to damage the concrete in any way.

4. All pipes shall be so laid that the contact in the joint between the two lengths of pipe shall be uniform throughout the circumference of the joint. Where curves in the alignment are indicated on the Drawing and the curves are flat, standard pipe will be used with the outside edge of the joint pulled away from the seat to make a smooth joint. Where curves are sharp, standard or specially made bends will be used. Openings at end of day's work openings in tees, deep cut connections, shall be capped and sealed.

18.17.11. Laying of pipes and fittings / specials

1. 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. 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 Engineer. Pipes and fittings / specials shall be carefully lowered in the trenches.
2. The pipes and specials shall be stacked along the alignment in advance with utmost care during the transit so that they are not damaged. Any damage due to these reasons shall be Contractor's liability. The pipe shall be lowered and laid only after the trenches are finally ready and levels duly checked by the Engineer. It shall be seen that no damaged pipe is lowered in the trench. Every precaution shall be taken to prevent foreign materials from entering the pipes when they are being placed in the line. Normally the socket ends shall face the upstream. When any portion of the excavation shall have been carried down to the necessary depth, the Contractors shall obtain permission from the Engineer before commencing the laying of pipes or concrete or the construction of masonry.
3. 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 crack, wherever applicable. If doubt persists, further confirmation shall be done by pouring a little paraffin on the inside of the pipe at the suspected spot. No sign of paraffin should appear on the outside surface. Pipes and fittings / specials damaged during lowering or aligning shall be rejected by Engineer.
4. All the pipes are to be laid perfectly true both in alignment and to gradient specified. Pipes in a trench shall be laid and fitted previous to the jointing being commenced. In case of spigot and socket pipe the socket end of the pipe shall face upstream, except when the pipe line runs uphill in which case the socket ends should face the 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. Precaution 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 Engineer. During the period that plug is on, the Contractor shall take proper precautions against floatation of the pipe owing to entry of water into the trench. In the 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.

5. Properly fitted temporary wooden stoppers shall be provided to close the ends of all incomplete pipe lines. The stoppers are only to be removed when pipes are being laid and jointed. Pipe laying and jointing shall be started and completed only section wise as per the instruction of the Engineer. During the progress of pipe laying the open ends of pipe shall be closed and water tight. Sight rails shall be provided at all change of direction or gradients at distance of @ 30 m along straight lengths. All the invert levels shall be confirmed from the sight rails with the help of proper boning rods as per the standard practice. The pipe shall be jointed with cement mortar 1:1 and proper caulking shall be done. After a particular section of the pipe is laid and jointed hydraulic testing shall be done section wise.
6. Just prior to placing each pipe section in the line, damaged coating shall be repaired and the interior shall be cleaned off all foreign materials. Cleaning shall be accomplished by brushing, blowing with compressed air and washing with water or as specified by the Engineer.
7. The item for laying of pipe line also includes labour work for lowering, laying and jointing various pipes including jointing with specials, levelling, etc. The Contractors shall transport pipes and specials from stores, for their various sections in such quantities as may be required for laying. Ordinarily no surplus stock shall remain on completion of any section. In case however, such pipe etc. become surplus in any sections, the Contractor shall remove the same to the next section for use in the work. It is likely that on completion of the whole work, some pipes and specials etc. may become surplus at the site and the Contractors shall arrange to hand over the same in good condition to the Engineer at the Owner's store as may be directed if required by Owner. The Contractor shall supply a list of stock so returned to the Engineer. No extra payment shall be made to the Contractors for these works. The rates for laying the pipes shall cover the cost of loading, transporting and unloading as may be required. The fortnight report for pipes collected and laid should be sent to the Engineer.
8. 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.

18.17.12. Jointing

1. Pipes shall be laid to the lines and grades given in the plans, with the ends abutting to form a even joint without shoulders or unevenness of any kind along the invert of the pipes. No joint shall be made under water. The ends of the pipes shall be dry and kept clean before and during laying and jointing operations.
2. All joint work shall be done in an approved manner by skilled workmen so that the completed pipeline shall have a continuous, smooth and uniform interior surface. Extruded joint material shall be removed from the interior of the pipe. In cold weather protective measures must be taken to ensure a satisfactory joint.
3. Jointing for pipes and fittings / specials shall be done in accordance with the relevant Specifications depending on type of pipes being used.

18.17.13. Closure sections and connections to structures

1. Closure sections shall be constructed where required by the Contractor's operations. Connections to pipe specials shall be made as approved by the Engineer. Lining and coating of the pipe lines, which must be cut to provide for closure pieces or to permit the proper location of valves structure shall be repaired by the Contractor. No separate payment will be made for closure pieces installed, but the same will be measured as it is a pipe in place and along the pipeline.
2. 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.

18.17.14. Temporary stoppages of work

1. At times when pipe laying is not in progress, or at the end of the day's work, the open ends of pipe shall be closed by a watertight plug or other means approved by Engineer. During the period that plug is on, the Contractor shall take proper precautions against floatation of the pipe owing to entry of water into the trench.

18.17.15. Backfilling

1. Trenches shall be backfilled with approved selected excavated material only after the successful testing of the pipe line. 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 to 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. Back filling shall be consolidated by watering, ramming, care being taken to avoid damage to the pipe line. In case of 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 pipe line to aid alignment, these timbers shall be removed before backfilling.
2. Reinstatement of road / footpath
   Reinstatement of road / footpath shall be done as per the requirements of local authorities and the relevant Specifications after the completion of work.

18.17.16. Clearing of site

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by Engineer and the construction site left clean to the satisfaction of Engineer.

18.17.17. Measurement

1. The measurements for excavation in trenches shall be done in following manner and will be paid accordingly.

Length	As per actual length of pipe and fittings / specials laid at work
Width & cross	As per Drawing.
Depth	Average depth of trench from ground level to invert of pipe plus thickness of bedding.

2. Excavation of asphalt road and reinstatement of road shall be measured on per square meter basis and the length and width at top of trench shall be considered same as those mentioned for excavation of trench.
3. The measurement for removal of excess excavated material up to a specified distance shall be as per the relevant item(s) in the schedule of Quantities and Rates and shall be measured on cubic meter basis. In case of soil 30% deduction shall be done to take account for voids where as it will be 40% in case of rubble.
4. Measurement for pipes and fittings / specials shall be in accordance with the relevant clause(s) of Specification for particular types of pipes.

18.17.18. Notes

1. Fencing provided along the sides of trenches and pits shall not be paid for separately and Contractor shall take into account the costs of such works and quote accordingly.
2. In case of the metal packing or dressed stones not being deposited as specified or being mixed up with excavated materials and not available for the reinstatement of

road / pavement, the cost of the new metal packing or dressed stones required shall be charges to Contractor by Engineer.

3. Service lines if damaged during excavation shall be made good either by Contractor or by other agency as Engineer may decide and the cost of the same shall be borne by the Contractor wholly in either case.
4. Contractor shall not be paid any additional compensation for excess excavation over what is specified as well as for any remedial measures that are specified.
5. The excess excavated material shall be carried away from site of works as specified, failing which in view of public safety and traffic convenience Engineer may carry out the work by any other agency at Contractor's risk and cost.

18.17.19. All works to be clear clean and perfect

The Contractors shall after completion or whenever required by the Engineer in charge, prove all pipes and fitting to be clear clean and perfect, and for this purpose shall at their own expense and in the presence of the Engineer in charge or his appointee, provide suitable instruments and appliances and pass them through the pipes and shall, if required, throw in water and show that it passes freely through every portion of the work. Brick, mortar and rubbish shall not be allowed to fall into the manholes of sewer lines while fixing or if allowed, shall be removed by the Contractors at their own expense

18.17.19.1. Handling of Rubber rings

The rubber rings shall be stored in a cool dark, dry and dust free environment. The room temperature should not be more than +20o C.
The storage location may not be exposed to direct sunlight or radiator appliances.
The rubber rings should not come into contact with fuels such as diesel, Kerosene oil or Lubricants.
Rings stored free of tension, i.e. not subjected to severe deformation (hanging from a hook etc.)

18.17.19.2. Checking & preparing the pipe ends, mounting rubber ring

The pipe ends especially the sealing surfaces of the socket & spigot must be carefully cleaned and inspected for any damage. Minor chippings shall be corrected on site according to instructions. Seriously damaged pipes shall not be installed unless they have been explicitly cleared for use.

Roll on rubber ring joint - The ring must be mounted on the groove of the spigot.
Confined rubber ring joint - The ring is placed directly in the groove. Both ring and the inside of the socket are coated with a lubricant (vegetable soap).

The ring shall not become twisted during mounting, no matter what type of joint is used. Just as important is the uniform tension of the ring along the entire circumference of the pipe. Prior to fitting, the rings should be inspected for dirt and /or damage such as buckling, scratching, or cracking. Damaged rings shall never be used.

18.17.19.3. Finishing the Trench Bottom

The bottom of the trench must possess a prerequisite load-bearing capacity to ensure that no settling will occur, after pipe laying and during pipeline operating which could result in damage to the pipeline. Where the ground is a poor load-bearer, suitable measures must be taken to increase the load-bearing capacity, e.g. soil stabilization as approved by the Engineers.
In rocky or stony ground, the bottom of the trench be excavated at least 15 cm deeper and that this excavation be replaced by a stone less layer. In order to avoid uneven compression loads in the bedding, adequate stone less soil is particularly important in the area of the pipe

joints.

Socket pits of 15 to 30 cm depth, depending on the pipe diameter, are to be provided for the socket of the pipe so that, during placement of the pipe, the socket does not come in contact with the bedding.

18.17.19.4. Laying Procedure, Pipe Jointing, Deviations

In the phase 1, the trench is prepared by leveling and cleaning the bottom and excavating the socket pit for the next pipe.
In the phase 2, Suspended from a crane, the pipe is oriented in the direction of the pipeline and so placed into the previously laid pipe that the rubber ring coincides uniformly with the circumference of the beveled guide of the socket, in which direction pipe laying is carried out. However, it is more common because more simple - to insert the spigot of the pipe to be laid into the bell of the pipe already laid.
In the phase 3, pulling the pipe home can be accomplished by means of suitable pulling devices, when the pipe is suspended in the device to eliminate friction between the pipe and the bedding.
It may prove operationally advantageous, especially for pipes pulling/ device into the or inside of the pipeline having a diameter of 800 mm and greater, to guide the cable of the 60 % of the weight of the pipe can be assumed as a rough guide for the force required to pull the pipe home.

18.17.19.5. Confined Rubber Ring Type

When commencing the pulling-home procedure, the lubricant must be fully present over the rubber ring and the inside the socket. When placing the spigot into the conical inside of the socket, the pipe is first centered and the gasket then compressed by it in the seating groove. In this phase of the procedure, attention must be paid to ensure that the gasket is not squeezed out of the groove either partly or fully due to uneven pressure. Completion of location must then proceed without any appreciable increase in force.
The gap between the end surfaces of the pipes (c) must be approximately 10 mm in a straight-line joint for all types of rings in order to maintain the required freedom of movement in the joint. The gap can be set by inserting small wooden wedges or bonded rubber pads.
After completing the pipe joint, the angular arrangement of the pipes can be imposed as required. The maximum permissible values for pipe defection are indicated by the value “d” in the table below

Tabulated data of angular deviation

DN	Min.c (mm)	D (cm)	R (m)
900 1000	5 5	11 9	240 265

d = Maximum permissible deviation of a pipe 5 m long pipe.
r = Minimum bend radius.
c= Minimum gap between pipes

18.18. CENTRIFUGALLY CAST (SPUN) DUCTILE IRON PIPE

The material of construction for the pipe line shall be Ductle Iron (DI) with internal cement mortar lining (Class K7 and K9)

18.18.1. Scope of Work

Laying in trenches centrifugally cast (spun) ductile iron pressure pipes of class K7 and K9 as per IS: 8329: 2000 (Code of practice for use and laying of ductile iron pipes) including jointing

(tyton push joint), bends of all degrees, tees, collars, tapers, crosses, flange sockets & spigots, branched pipes, chamfering etc. where required. Testing of pipes should be done as per IS: 8329: 1994.

18.18.2. Applicable Codes

Important IS codes applicable in case of Ductile iron pipes, fittings, jointing & laying are:

Sr.	IS Codes	Description
1	8329	Centrifugally cast (spun) ductile iron pressure pipes for water, gas and sewage - specification
2	9523	Ductile iron fittings for pressure pipes for water, gas and sewage
3	12288	Code of practice for use and laying of ductile iron pipes
4	12820	Dimensional requirements of rubber gasket for mechanical joints and push-on joints for use with cast iron pipes and fittings for carrying water, gas and sewage

18.18.3. Pipe & Pipe Joint

Ductile iron pipe of K7 and K9 class of socket & spigot end suitable for tyton push on joints or mechanical joints is recommended for the project wherever required.
Push-on-Joint: A flexible joint in which an elastomeric gasket is located in the socket and the joint assembly is effected by entering the spigot through the gasket into the socket. Allowable angle of deflection for push on joints are tabulated below.

Nominal Diameter,mm	Allowable angle of
80 to 200	5.0 degree
250 to 350	4.0 degree
400	3.5 degree
450 to 600	3.0 degree
700 to 900	2.5 degree

Mechanical Joint: A flexible joint in which an elastimeric gasket is located in the socket, sealing being obtained by applying pressure to the gasket by means of a gland bolted to the socket. Allowable angle of deflection for mechanical joints is tabulated below.

Nominal Diameter,mm	Allowable angle of
80 to 300	5 degree
350	4 degree, 50 seconds
400	4 degree, 10 seconds
450	3 degree, 50 seconds
500	3 degree, 20 seconds
600	2 degree, 50 seconds
700	2 degree, 30 seconds

Ductile iron pipe having screwed on flanges and welded on flanges shall conform to the requirement of Table 4 & 13 of IS 8329:1994. Shielded Nickel- iron electrodes is the preferred material for manual arc welding of flanges. Flange shall preferably be of ductile iron.
For screwed on flanged pipes, the method of screwing and the exact form of thread are left to the discretion of the manufacturer in view of the fact that flanges are never removed after screwing on the barrels of the pipes.

18.18.4. Rubber Gasket

Rubber gasket for use with push-on-joints or mechanical joints shall conform to IS 12820:1989.

Rubber gasket for use with flanged joints shall conform to IS 638: 1979.

Rubber gasket shall be compatible with the fluid to be conveyed for materials, pressure and temperature. While conveying potable water the gaskets should not deteriorate the quality of water or should not impart or odour.

18.18.5. Hydrostatic Test

All pipes shall be tested hydrostatically at a pressure specified below. To perform the test, pressure shall be applied internally and shall be steadily maintained for a period of minimum 15 seconds during which the pipes may be struck moderately with a 700 g hammer. The pipes shall withstand the pressure test and shall not show any sign of leakage, sweating or other defects of any kind.

Nominal Diameter, mm	80 - 300	350 –
Class	K9	K9
Working Pressure	1.8 MPa	1.8 MPa
Max. works test pressure	5.0 MPa	4.0 MPa
Max. site test pressure	3.2 MPa	2.4 MPa

18.18.6. Pipe Lining

Lining of pipes & fittings are recommended for corrosion resistance & improved hydraulic carrying capacity.

External surface of pipe & fittings is protected with epoxy coating material having a minimum dry film thickness of 80 microns.

Pipe should be internally lined with sulphate resistance cement mortar of minimum thickness as given below. The internal lining should be done by centrifugal method.

Dia of pipe, mm	Thickness of lining,
Upto 250	4
300 - 600	6
700 - 900	8

Cement lining of the fitting is done with spray gun and then by hand to give a smooth and uniform thickness, as it is not practicable to utilise centrifugal methods.

18.18.7. Use and Laying of Ductile Iron Pipe

Excavation, backfilling, laying & jointing of pipe should be strictly as per IS: 12288-1987 (Code of practice for Use & laying of Ductile Iron Pipes).

The width of trench at bottom between the faces of sheeting shall be such as to provide 300mm clearance on either side of the pipe. Trenches may require extra width to permit placement of timber supports, sheeting, bracing and appurtenances if they are employed. Holes for pipe socket should be provided at each joint, but should be no longer than necessary for joint assembly and for assurance that pipe barrels will lay flat on the trench bottom. Pipe bottom should be true and even in order to provide support for full length of the pipe barrel.

Special consideration should be given to the depth of the trench. Minimum earth cover over pipeline should not be less than 1000mm. It may be necessary to increase the depth of pipeline to avoid land drains or in the vicinity of heavy traffic roads, railways or other crossings.

A minimum earth cushion of 150mm depth should be provided below the pipe line to

protect the pipe and its coating. Earth cushion should be of sand or fine graded excavated material.

Back Filling: 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. Backfilling in zone A shall be done by hand with sand, fine gravel or other fine graded material placed in layers of 150mm and compacted by tamping. The back filling material shall be deposited in the trench for its full width of each side of the pipe, fitting and appurtenances simultaneously.

Zone B : From the level of the centre line of the pipe to a level 300mm above the top of the pipe. Backfilling in zone B shall be done by hand or approved mechanical methods in layers of 150mm. The type of back fill material to be used and the method of placing and consolidating shall be prescribed by the executing authority keeping in view the local condition.

Zone C : From a level 300mm above the top of the pipe to the top of the trench. Back filling in zone C shall be done by hand or approved mechanical methods. The types of back fill material and method of filling shall be as prescribed by the executing authority.

When pipes are laid under roads and pavement subjected to heavy traffic loads, the trenches may be covered with reinforced concrete slabs of suitable dimensions.

Laying of pipe: Pipes shall be lowered into the trench with tackle suitable for the weight of pipes. For smaller sizes, up to 250mm nominal bore, the pipe may be lowered by the use of ropes but for heavier pipes, either a well designed set of shear legs or mobile crane should be used.

On gradients of 1:15 or steeper, precautions shall be taken to ensure that the spigot of the pipe being laid does not move into or out of the socket of the laid pipe during the jointing operations. As soon as the joint assembly has been completed, the pipe should be held firmly in position while the trench is backfilled over the barrel of the pipe. The backfill should be well compacted.

Supporting pipes above ground: It is recommended that above ground installations of spigot and socket pipes be provided with one support per pipe, the supports being positioned behind the socket of each pipe. If necessary, unsupported spans between 4 and 6 m may be obtained by positioning the pipe supports relative to the pipe joints. The recommended maximum unsupported span for flanged pipe is 8m.

Pipe should be fixed to the supports with mild steel straps so that axial movement sue to expansion or contraction resulting from temperature fluctuation, is taken up at individual joints in the pipe line.

Cutting of pipe for inserting valves, fittings, etc, shall be done as per para 5.4 of IS: 12288 - 1987.

Pipeline Anchorage: All pipelines having unanchored flexible joints require anchorage at the changes of directions and at dead ends to resist the static thrusts developed by internal pressure. Anchorage is also required on steep slopes to resist pipe against slippage.

18.18.8. Hydraulic Testing of Pipeline

After a new pipeline is laid and jointed, testing shall be done for: Mechanical soundness and leak tightness of pipes and fittings, Leak tightness of joints, and

Soundness of any construction work, in particular that of the anchorages.

The completed pipeline may be tested either in one length or in sections. The length of

section depends upon the availability of suitable water, number of joints to be inspected and difference in elevation between one part of the pipeline and another. The maximum field hydrostatic test pressure for ductile iron pipelines with flexible joints as per IS 12288: 1987 is tabulated below.

Nominal	Maximum field hydrostatic test pressure, N/mm2
Up to 300	4.5
350 to 600	3.0
700 to 1200	2.1

18.18.9. Restoration and cleaning up

Where any road, payment, shrubbery, fences, poles or other property and surface structures have been damaged, removed or disturbed during the course of work, such property and surface structures shall be replaced or repaired after completion of work.

All roads, pavements, paved footpaths, curbing, gutters, shrubbery, fences, poles or other property and surface structures removed of disturbed, as a part of the work shall be restored to a condition equal to that before the work began.

All surplus materials, and all tools and temporary structures shall be removed from the site as directed by the executing authority.

18.19. GENERAL SPECIFICATIONS FOR CI PIPING WORK

18.19.1. Cast Iron Pipe and Specials

1. All CI Pipes and specials supplied for this contract shall confirm to the following specifications:

a. IS 1536 - 1976 Specification for centrifugal cast (Spun) iron pressure pipes for water, gas and sewage.

b. IS 1538 - 1976 (Part V) Specification for cast iron fittings for pressure pipes.

Wherever reference is made for Indian Standard Specification the latest specification is applied.

2. All cast iron pipes supplied shall confirm to class LA of Indian Standard specifications. The work test pressure and the hydrostatic test pressure shall be as follows:

a. Hydrostatic Test pressure at works 3.5 N/mm2 (35 kg/sq.cm.)

b. Hydrostatic test pressure after installation 1.2 N/mm2 (12 kg/sq.cm.) All pipes to be supplied in this contract shall have SBR quantity rubber gaskets rubber tyton joints as per BIS 5282, 12820 with the spigot end suitably chamfered for smooth entry of pipe in the socket fitted with SBR quality rubber gasket. Care shall be taken to ensure that fittings fit easily into this pipe.

c. Each pipe shall be coated in accordance to Indian Standard specification. All pipe shall be marked as under:
   - Manufacturer's name or identification mark
   - The Nominal Diameter
   - Class Reference
   - Mass of pipe
   - The number of this Indian Standard and
   - The last two digits of the year of manufacture.

18.19.2. Cast Iron fittings

All cast iron fittings supplied shall confirm to heavy class of IS:1538, Part 1 to 23. The work of Test pressure and Hydrostatic test pressure shall be as follow:

18.19.2.1. Test Pressure

- 300 mm to 600 mm 2.5 N/sq.mm (25 kg/sq.cm)
- 600 mm to 1200 mm 1.0 N/sq.mm (10 kg/sq.cm)

Where non standard fittings are required in special locations, this shall be supplied of steel of minimum plate thickness of 6 mm and fabricated as per drawings and directions of Engineer-in-Charge. These mild steel fittings will be specially protected against corrosion with painting as shown on drawing.

All Standard fittings marked as under:

a. Manufacturer's name or identification mark,
b. The Nominal Diameter,
c. Class Reference,
d. Mass of pipe,
e. The Number of this Indian Standard, and
f. The last two digits of the year of manufacturer.

18.20. SPECIFICATION FOR LAYING, JOINTING & TESTING OF CI PIPE

18.20.1. Stacking

The pipes and specials shall be handled with sufficient care to avoid damage to them. These shall be lined up on one side of the alignment of the trench, socket facing uphill or in the direction of flow of water.

18.20.2. Trench For CI Pipes and Specials

The trenches for the pipes shall be excavated to lines and levels as directed. The bed of the trench shall have to be truly and evenly dressed throughout from one change of grade to next. The gradient is to be set out by means of bonning rods and the required depth is excavated at any point. The depth of the trench shall not be less than 1 meter measured from the top of the pipe to the surface of the ground under roads crossing and not less than 0.75m elsewhere.

The width of the trench shall be the nominal diameter of the pipe plus 40 cm. but it shall not be less than 60 cm. in case of all kinds of soils excluding rock and not less than 55 cm. in case of rock. The bed of the trench, if in soft or made up earth, shall be well watered and rammed before laying the pipes and the depressions if any shall be properly filled with earth and consolidated in 20 cm. layers. If the rock is met with, it shall be removed to 15 cm. below the level of the pipe and the trench will be refilled with excavated materials and consolidated to the required grade.

The excavated materials shall not be placed within 1 meter or half of the depth of the trench whichever is greater from the edge of the trench.

The materials excavated shall be separated and stacked so that in refilling they may be re-laid and compacted in the same order to the satisfaction of the AMC. The trench shall be kept free of water. Shoring and Timbering shall be provided wherever required. Excavation below water table shall be done after dewatering the trenches.

After the excavation of the trench is completed, hollows shall be cut at the required positions to receive the sockets of the pipes and these hollows shall be sufficient depth to ensure that the barrels of the pipes shall rest throughout their entire length on the solid ground and that sufficient spaces left for jointing to underside of the pipe joint. These socket holes shall be refilled with sand after jointing the pipe.

All types of pipes water mains, cables, etc. met within the course of excavation shall be carefully protected and supported. Care shall be taken not to disturb the electrical and communication cables.

18.20.3. Laying of Pipes and Specials

Before being laid the pipes shall be examined to see that there are no cracks or defects. The

cracked or defective pipes shall be summarily rejected. The pipes shall be thoroughly cleaned of all dust and dirt and special care shall be taken to clean the inside of the socket and outside of the spigots.

The pipes shall be lowered into the trench by means of suitable pulley blocks, sheet legs, chains ropes etc. In no case the pipes shall be rolled and dropped into the trench. After lowering, the pipes shall be arranged so that the spigot of one pipe shall be carefully centered into the socket of the next pipe, and pushed to the full distance that it can go. The pipeline shall be laid to the levels required. Specials shall also be laid in their proper position as stated above. For pipe bedding PCC of grade M10 shall be used for which payment shall be done as per PCC 1:3:6 item of work.

Where so directed, the pipes and specials may be laid on masonry or concrete pillars. The pipe laid on the level ground shall be laid with socket facing the direction of the flow of water. In all other cases, the sockets shall be laid facing up hill.

Any deviation either in plan or elevation less than 11 ¼ degree shall be effected by laying the straight pipes round a flat curve, of such radius that minimum thickness of lead at the face of the socket shall not be reduced below 6 mm. or the opening between spigot and socket increased beyond 12 mm at any point. A deviation of about 2 ¼ degree can be affected at each joint in this way. At the end of each day's work, the last pipe laid shall have it's open ends securely closed with a wooden plug to prevent entry of water, soil, rats and any other foreign matter into the pipe.

Cement concrete thrust blocks of suitable design as approved by the Owner/ Consultants shall be provided at 45 degree and 90 degree bands of the pipes and also at places where there is likelihood of thrust so as to withstand the dynamic and static forces developed due to water in the pipe line. The thrust blocks shall be made after the joints have been made.

18.20.4. Jointing

Jointing shall be carried out using approved quality rubber rings.

18.20.5. Testing of Joints

After laying and jointing, the pipes and fittings shall be inspected under working conditions of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost. For hydraulic tests, all pipes shall be kept under test for 15sec at works and shall withstand hydrostatic test pressure as specified in BIS 1536/1989. The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock or water hammer.

The draw off takes and stopcocks shall then be closed and specified hydraulic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrate before the test. The test pump having been stopped the test pressure should maintain without loss for at least half an hour. The pipes and fittings shall be tested in sections as the work of laying proceeds, keeping the joints exposed for inspection during the testing.

18.20.6. Backfilling

The trenches prepared for laying of pipes shall be backfilled as described under Chap. 2.

19. VALVES

Gate Valves shall be either solid wedge or knife gates unless specifically defined on the drawings.

19.1. SOLID WEDGE GATE-TYPE SLUICE VALVES

19.1.1. General

All valves shall be double-flanged. Valves of Indian manufacture and in the size ranging 50mm to 300mm shall conform to BIS 780 and those of size ranging from 350 mm and larger to BIS:2906. Imported valves shall conform to the relevant British or American Standards. The materials used in construction, the design and all other relevant features shall be such that the valves are entirely suitable for use on sewer/sludge pipelines, force mains and within sewage pumping stations. Valve shall be of suitable pressure rating which shall not be less than twice the normal operating pressure. PN rating shall be 1.6 for all types of valves.

19.1.2. Design

The design of the valves will be such that erosion, cavitation, vibration and head loss (in the fully open position) shall be a minimum external lubrication. The valves should be capable of being opened and closed against working pressure which exceed the maximum working pressures by 15 percent.

19.1.3. Materials

The materials used for the manufacture of each component shall be the best available for the specific purpose and shall not, in any case be inferior to the following:

Cast Iron : BIS. 210 Grade 20
Stainless Steel : BIS. 1570 Grade, BS 970 Type EN, ASTM A 473.
Gun Metal : BIS.1400-LG 2 -C or the equivalent Indian Std.
Cast Steel : Plain Carbon Steel complying with BIS. 1570 Grade, or BS: 970 Grade 431 S 29.

19.1.4. Valve Bodies

a. Castings

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.

b. Forgings

All major stress bearing forgings shall be made to a standard specification, which shall be submitted if required to the Engineer-in-Charge for approval before work is commenced. Forging shall be subjected to non-destructive tests to detect flaws if any. Forging shall be heat treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for such forging shall be submitted to the AMC. The Engineer-in-Charge or his inspector may inspect such forging at the place of manufacture with a representative of the Contractor.

c. Workmanship

Workmanship and general finish shall be of first class commercial quality and in accordance with best workshop practice.

All similar items of the valve and their component parts shall be completely interchangeable. Spare parts shall be manufactured from the same materials as the originals and shall fit in place of all similar items.

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

Protective coating shall comply with BS 1218 Clause 16, for use in tropics, or BIS 2906, Clause 7.

19.1.5. Spindle Details

The spindles shall be of Bronze and to permit the solid wedge gate to be so raised as to permit an unimpeded flow passage through the valve in open position. Where handwheels are provided the direction of rotation and the words 'OPEN' shall be marked prominently on the upper side. All spindles contacting surfaces in the valve body shall be bushed with gunmetal.

19.1.6. Valve Gates

Each face of the gate shall be lined with heavy gunmetal rings, which will match with corresponding rings in the body. The rings shall be force fitted by special fixtures and riveted in the case of valves in the size range 450 mm and larger. When finally assembled, the body and wedge faces shall provide a watertight bearing surface. When shut, the gates shall ride on the body seats, to allow for wear.

19.1.7. Operation

The tops of the spindles or gears operated with extension spindles or tee keys shall be provided with caps of dimensions conforming to BIS 2906 Table III. The direction of opening shall be indicated on the caps.

19.1.8. Lubrication

At the points where lubrication is needed the Contractor shall furnish full details of the method to be employed. The requirement of the requisite lubricating equipment and lubricants for commissioning and operating and maintaining the valves for one year shall be furnished by the Contractor.

19.1.9. Spare Parts

One spare spindle and nut shall be supplied under this contract for each group of 10 sluice valves or less of the different sizes. The Contractor shall take this into account while quoting the rates for individual items. No separate payment shall be made for this work. In addition the Contractor shall submit a list of recommended spares for 5 years of operation and maintenance of all mechanical, electrical and instrumentation works covered under this contract. Spares supplied shall be new, unused and interchangeable with the corresponding components they are intended to replace.

19.1.10. Flanges

Valves of sizes from 80 mm to 300 mm shall have flat flanges as per BIS:1538 Part IV Table I. Valves of sizes from 350 mm and larger shall have raised flanges as per BIS: 4504, Table 10/11 for 10 bar valves. The flange to flange distances shall be as per BIS:780 for 80 mm - 300 mm valves and BIS : 2906 for 350 mm and larger valves.

19.1.11. Jointing Materials

Each valve shall be supplied under this Contract, with all-requisite joint rings, nuts, bolts and washers for making the joints on all the valves to be installed under this Contract. Jointing material between the connecting flanges shall conform to the requirements of BIS 638- 1965. Unless otherwise specified bolting used for jointing exposed connections shall be carbon steel, conforming to BIS 210 Grade 20 Grade B, with galvanized finish. Bolting for buried joints and joints that could come into contact with raw sewage shall be Stainless Steel, as per Clause 2.02 A3. Boltholes shall be off-centre and in correct adjustment longitudinally.

19.1.12. Special Requirements - 450 mm and Larger Valves

Sluice valves in the size range 450 mm to 1200 mm shall have, in addition to the above requirements, the following features.

a. The valves shall have machined gun metal gate slides. Hard bronze shoes shall be provided on the gate and machined gunmetal channels in the body. The bronze shoes will be machined accurately to give a close working clearance with the channels.

They shall provide corrosion resistant bearing surfaces and minimize sliding friction and vibration while maintaining accurate alignment. The use of cast iron channels with brass lining will be permitted if the lining is at least 6mm thick. The use of other materials for holding the channels in position will not be permitted.

b. The valves shall be provided with spur gearing consisting of machined mild steel pinions and cast iron wheels for valves installed underground. The pinion shafts shall run in gun metal bushes in a cast iron bearing bracket with provision for lubricating by a grease gun.

Gear wheel ratios will be such that a force of 270 Newton's applied on each end of a bar in combination with a Tee Key or extension spindle at the following distances from the key centre will permit smooth operation.

Valve size range (mm)	Distance of application of force (mm)
450 - 900	600
1200	750

Valves installed above ground shall be provided with worm gearing. These shall be machined cut, with bronze wheel and steel worm enclosed in a cast iron gear case which shall be mounted on a fitting connected to the valve cover flange and shall be complete with indicator column.

The worm shafts shall be equipped with ball thrust bearing and gunmetal bushes. The gearbox shall be oil filled and sealed. The worm shaft bearing shall be provided with grease gun nipples. The gear ratios shall be so selected that the maximum force required to develop the requisite operating torque shall not exceed 180 Newton's.

All valves of size 450 mm or more shall have valve gate indicator columns with 10 mm graduations and indicating the fully open and closed positions. The indicator assembly should be sufficiently watertight to prevent entry of rainwater into the worm gear box in outdoor valves.

19.1.13. Factory Tests

All the valves shall be tested at the factory for smooth, trouble free operation and operating torque requirements by operating between fully open and fully closed position three times.

The hydrostatic tests shall consists of -

a. Application of a pressure equal to 1 and a half times the maximum working pressure specified in this section with both ends closed and valve fully open, for ten minutes. No leakage of water should occur through the metal, flanged joints or valve packing gland, nor should any permanent deformation of any part occur.

b. The pressure shall then be reduced to the working pressure and the wedge gate lowered, thus closing the valve. The stipulated pressures shall then be maintained for 5 minutes on each side in turn during which no leakage should occur on the downstream side of the valve seating.

20. WATER SUPPLY AND SANITARY WORKS

20.1. APPLICABLE CODES

The following standards and codes are made a part of this Engineer-in-Charge. All standards, codes of practice referred to herein shall be the latest editions including all official amendments and revisions.

IS : 210 : Specification for grey iron castings
IS : 269 : Specification for ordinary and low heat Portland cement
IS : 383 : Specification for coarse and fine aggregates from natural sources for concrete
IS : 432: Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement
IS : 456 : Code of Practice for plain and reinforced concrete
IS : 458 : Concrete Pipes (with and without reinforcement)
IS : 516 : Methods of tests for strength of concrete
IS : 554 : Dimensions for pipe threads where pressure tight joints are requiredon the threads
IS : 651 : Salt glazed stoneware pipes and fittings
IS : 774 : Flushing Cisterns for water closets and urinals (valveless siphonic type)
IS : 775 : Cast iron brackets and supports for wash basins and sinks
IS : 781 : Sand-cast brass screw-down bib taps and stop taps for waterservices
IS : 783 : Code of practice for laying of concrete pipes
IS : 1068: Electroplated coatings of nickel and chromium of iron and steel
IS : 1077: Specification for common burnt clay building bricks
IS : 1172: Code of practice for basic requirements for water supply, drainage and sanitation
IS : 1786 : Specification for high strength deformed steel bars and wires forconcrete reinforcement
IS : 1239 : Mild steel tubes (Part I) and mild steel tubulars and other wrought steel pipe fittings (Part II)
IS : 1536: Centrifugually cast (spun) iron pressure pipes for water, gas and sewage
IS : 1626: Asbestos cement building pipes, gutters and fittings (spigot and socket types)
IS : 1703: Copper Alloy float valves (horizontal plunger type) for water supply purposes
IS : 1726: Cast iron manhole covers and frames
IS : 1729: Sand cast iron spigot and socket soil, waste and ventilating pipes, fittings and accessories
IS : 1742: Code of practice for buildings drainage
IS : 2065: Code of practice for water supply in Buildings
IS : 2116: Specification for sand for masonry mortars
IS : 2212: Code of practice for brickwork
IS : 2250: Code of practice for preparation and use of masonry mortars
IS : 2326: Automatic flushing cisterns for urinals
IS : 2470: Code of practice for design and construction of septic tanks (Parts I& II)
IS : 2556 : Vitreous sanitary appliances (Part I to Part XV)
IS : 2963 : Specification for copper alloy waste fittings for wash basins and sinks
IS : 3306 : Specification for chemically resistant glazed stoneware pipes and fittings
IS : 3025 : Method for sampling and test (Physical and chemical) for water and waste water (Parts 1 to 44)
IS : 3311 : Waste plug and its accessories for sinks and wash basins
IS : 5455 : Specification for cast iron steps for manholes
IS : 4127 : Code of Practice for laying of glazed stoneware pipes
IS : 3495 : Methods of tests of burnt clay building bricks
IS : 4111 : Code of practice for ancillary structures in sewerage system manholes
IS : 5382 : Specification for rubber sealing rings for gas mains, water mains and sewers

IS : 5329 : Code of practice for sanitary pipe work above ground for buildings
IS : 5434 : Non-ferrous alloy bottle traps for marine use

20.2. SANITARY INSTALLATION

The work shall be carried out complying in all respects with any specific requirements of the local body in whose jurisdiction the work is situated, and as approved by the Engineer-in-Charge.

Any damage caused to the building, or to installations therein, either due to negligence on the part of the Contractor, or due to actual requirements of the work, shall be made good and the building or the installation shall be restored to its original condition by the Contractor.
Licensed plumbers shall carry out all sanitary and plumbing work.
All sanitary appliance including sanitary fittings, fixtures, toilet requisites shall be of size, and design as approved by the Engineer-in-Charge.
All white glazed porcelain fixtures, such as wash basin, sink drain board, water closet pan, urinal, `P' trap etc. shall have hard durable white glazed finish. They shall be free from cracks and other glazing defects. No chipped porcelain fixtures shall be used.
Joints between iron and earthenware pipes shall be made perfectly air and watertight by caulking with neat cement mortar.

20.3. INDIAN TYPE WATER CLOSET

Water closets shall be white porcelain Orissa type Indian soil pans, 690mm long conforming to IS:2556 of approved make and pattern. Flushing cistern of 15b litres capacity with accessories such as chain, handle, stop tap, brass unions, jamb nuts, overflow pipe and bends, etc. shall be provided.

20.4. URINALS

Urinals shall be white glazed flat back type of approved make and of size 430 mm x 260 mm x 350 mm conforming to IS 2556. High level automatic CI flushing cistern of 10 litre capacity as per IS 2326 with necessary CI brackets, GI pipes for water connection from cistern to urinals, stop tap, waste pipe upto CI waste shaft etc. shall be provided.

20.5. WASH BASIN

Wash basin shall be of white glazed earthenware conforming to IS 2556 of approved make and of size 560mm x 410mm. The wash basins shall be provided with water supply GI pipe, chromium plated tap, stopcock, CP bottle trap, GI waste water pipe and all necessary accessories and fittings.

20.6. SINKS

Sinks shall be of white glazed earthenware conforming to IS 2556 of approved make and of size 450mm x 300mm x 150mm. The sink shall be provided with CP tap, water supply GI pipe, non-ferrous waste fitting, waste plug and necessary accessories and fittings.

20.7. CAST IRON SOIL WASTE AND VENT PIPES AND FITTINGS

All cast iron pipes and fittings shall be of uniform thickness with strong and deep sockets, free from flaws, air holes, cracks, sand holes and other defects and conform to IS:1536. The diameter approved shall be internal diameter of pipe. The pipe and fittings shall be true to shape, smooth and cylindrical and shall ring clearly when struck over with a light hand hammer. All popes and fittings shall be properly cleaned of all foreign materials before being fixed.

All plug bends of drainage pipes shall be provided with inspection and cleaning caps, covers, which shall be fixed with nuts and screws. Pipes shall be fixed to the wall by W.I or MS holder bat clamps unless projecting ears with fixing holes are provided at socket end of pipe. The pipes shall be installed, truly vertical or to the lines and slopes as indicated. The clamps shall be fixed to the walls by embedding their hooks in cement concrete blocks (1:2:4) 10 cm x 10 cm making necessary holes in the walls at proper places. All holes and breakage shall be made good. The clamps shall be kept 25 mm clear of the finished face of the walls to facilitate cleaning and painting of pipes.

The annular space between the socket and spigot shall be filled with a gasket of hemp or spun yarn soaked in neat cement slurry. The joint shall then be filled with stiff cement mortar 1:2 (1 cement : 2 fine sand) well pressed with caulking tool and finished smooth on top at an angle of 45 °. The joint shall be kept wet for not less than 7 days by tying a piece of gunny bag kept moist. Joints shall be perfectly air tight as well as water tight.
C.I pipes and fittings which are exposed shall be first cleaned and then painted with a coat of red lead primer. Two coats of zinc paint with white base and mixed with pigment of required colour to get the approved shade shall be given over the base primer coat.
The thickness of fittings and their socket and spigot dimensions shall conform to the thickness and dimension approved for the corresponding sizes of straight pipes.
The connection between the main pipe and branch pipes shall be made by using branches and bends with access for cleaning. Floor traps shall be provided with 25 mm Dia. Puff pipe where the length of the waste is more than 1800mm or the floor trap is connected to a waste stack through bends.

All cast iron pipes and fittings including joints shall be tested by a smoke test to the satisfaction of the Engineer-in-Charge and left in working condition after completion. The smoke test shall be carried out as stated under:
Smoke shall be pumped into the pipe at the lowest and from a smoke machine, which consists of a bellow and a burner. The material usually burnt is greasy cotton waste, which gives out a clear pungent smoke which is easily detectable by sight as well as by smell if there is a leak at any point of the pipeline.
Water test and air test shall be conducted as stipulated in IS:5329

20.8. ASBESTOS CEMENT PIPES AND FITTINGS

All Asbestos Cement (AC) soil, waste, vent pipes, and fittings shall conform to IS 1626. The pipes shall have spigot and socket ends. These shall be composed of an inert aggregate consisting of clean asbestos fibre cemented together by ordinary Portland cement conforming to IS:269, or Portland blast furnace slag cement conforming to IS.455. No organic material shall be added to the composition.

The pipes shall be straight and the ends of the pipes and fittings shall be finished square to their axes. The finished pipes and fittings shall be true and smooth, their inner and outer surfaces shall be concentric. They shall be in all respects sound, homogenous and free from impurities or other imperfections.
The permissible tolerance on the thickness and external dimensions of pipes and fittings including hydraulic test pressure of the pipes and fittings shall conform to IS.1626.
All AC pipes and fittings shall be of approved make and with necessary accessories, wherever required. The diameter wherever approved for pipes and fittings shall be clear internal diameter. All gaps between pipes and fittings and walls shall be filled with cement mortar 1:3 neatly finished. All pipes and fittings shall be supported with standard fixing brackets.
The annular space between the socket and spigot shall be filled with a gasket of hemp

and spun yarn soaked in tar. The joint shall then be filled with stiff cement mortar 1:2 (1 cement: 2 fine sand) well pressed with caulking tools and finished smooth on top with near cement paste at an angle of 45°. The joint shall be kept wet for not less than 7 days by typing a piece of gunny bag kept moist. Joint shall be perfectly airtight as well as watertight.

Pipes and fittings shall be tested with a smoke test as approved.

20.9. GALVANISED MILD STEEL (GI) PIPES

The pipes shall be galvanised mild steel welded pipes and seamless screwed and sockets tubes conforming to the requirements of IS.1239, for medium grade. These shall be of the diameter (nominal bore) approved. The sockets shall be designated by the respective nominal bores of the pipes for which they are intended. The pipes and sockets shall be finished neatly, well galvanised on both inner and outer surfaces, and shall be free from cracks, surface flaws, laminations and other defects. All screws, threads shall be clean and well cut. The ends shall be cut cleanly and square with the axis of the tube.

All screwed tubes and sockets shall have pipe threads conforming to the requirements of IS.554. Screwed tubes shall have taper threads while the sockets shall have parallel threads.

The fittings shall be of malleable cast iron or mild steel tubes complying with all the appropriate requirements as approved for pipes. The fittings shall be designated by the respective nominal bores of the pipes for which they are intended. The fittings shall have screw threads at the ends conforming to the requirements of IS.554. Female threads on fittings shall be parallel and male threads (except on running nipples and collars of unions) shall be tapered.

The pipes and fittings shall be inspected at site before use to ascertain that they conform to the specification. The defective pipes shall be rejected. Where the pipes have to be cut or re-threaded, the ends shall be carefully filled out so that no obstruction to bore is offered. The ends of the pipes shall then be threaded conforming to the requirements of IS.554 with pipe dies and taps carefully in such a manner as will not result in slackness of joints when the two piece are screwed together. The taps and dies shall be used only for straightening bent and damaged screw threads and shall not be used for turning of the threads so as the make them slack, water tight joint. The screw thread of pipes and fitting shall be protected from damage until they are fitted.

The pipes shall be cleaned and cleared of all foreign matter before being laid. In jointing the pipes, the inside of the socket and the screwed end of the pipes shall be oiled and rubbed over with white lead and few turns of spun yarn wrapped around the screwed end of the pipe. The end shall then be screwed in the socket, tee, etc, with the pipe wrench. Care should be taken that all pipes and fittings are properly jointed so as to make the joints completely water tight and pies are kept at all times free from dust and dirt during fixing. Burrs from the joint shall be removed after screwing. After laying, the open ends of the pipes shall be temporarily plugged to prevent access of soil or any other foreign matter.

Any threads exposed after jointing shall be painted or in the case of underground piping thickly coated with approved anticorrosive paint to prevent corrosion.

For internal work the galvanised iron pipes and fittings shall run on the surface of the walls or ceiling (not in chase) unless otherwise specified. The fixing shall be done by means of standard pattern holder bat clamps. Keeping the pipe about 1.5 cm clear of the wall. Pipes and fittings shall be fixed truly vertical/horizontal. When it is found necessary to conceal the pipes, chasing may be adopted or pipes fixed in the ducts of recesses etc, provided there is sufficient space to work on the pipes with the usual tools.

The pipes shall not ordinarily be buried in walls or solids floors. Where unavoidable, pipes may be buried for short distances provided adequate protection is given against damage, but the joints in pipes shall not be buried MS pipe sleeve shall be fixed at a place where a pipe is passing through a wall of floor for reception of the pipe and to allow freedom for expansion/contraction and other movements maintenance. In case the pipe is embedded in walls or floors it should be painted with anti-corrosive bitumastic paint of approved quality. The pipe should not come in contract with lime mortar or lime concrete as the pipe is affected by lime. Under the floors the pipes shall be laid in layer of sand filling or as approved by the Engineer-in-Charge.

GI pipes with socket and spigot ends shall be provided with lead caulked joints wherever specified and the joints shall conform to the requirements of IS:3114.

The work of excavation and backfilling shall be done true to line and gradient in accordance with general Employer's requirements for earthworks in trenches for pipes laid underground.

The pipes shall be laid on a layer of 10.0 cm sand and sand filled upto 15 cm above the pipes. A sand cushion of 15 cm on either side of the pipe shall also be provided. The remaining portion of the trench shall then be filled with excavated earth. The surplus earth shall be got rid of as directed. When excavation is done in rock the bottom shall be cut deep enough to permit the pipes to be laid on a cushion of sand 75 mm minimum.

The pipes and fittings after they are laid and jointed shall be subjected to hydrostatic pressure test as approved by the Engineer-in-Charge and shall satisfactorily pass the test. Pipeline system shall be tested in sections as the work proceeds, keeping the joints exposed for inspection. Pipes shall be slowly and carefully charged with water allowing all air to escape. All draw-off taps shall then be closed and water pressure gradually raised to test pressure. Care shall be taken to ensure that pressure gauge is accurate and preferably should have been recalibrated before the test. Pump used having been stopped the section of the pipeline shall maintain the test pressure for at least half an hour. Any joints or pipes found leaking should be removed and replaced by the Contractor.
The GI pipeline shall be cut to the required length at the position where the meter and stopcock are required to be fixed. The ends of the pipes shall be threaded. The meter and stopcock shall be fixed in position by means of connecting pipe, G.I nuts, sockets, etc. The stopcock shall be fixed near the inlet of the water meter. The paper disc inserted in the ripples of the meter shall be removed and meter installed exactly horizontally or vertically and with the arrow cast on the body of the meter pointing in the direction of flow. Care shall be taken that the factory seal of the meter is not disturbed. Whenever the meter is to be fixed to a newly fitted pipeline, the pipeline will have to be completely washed before fixing the meter. For the purpose, a connecting piece of pipe equal to the length of the meter is to be fixed on the new pipeline. The water shall be allowed to flow completely to wash the pipeline and then the meter installed as described above by replacing the connecting piece.

20.10. STONEWARE PIPE AND FITTINGS

All pipes with spigot and socket ends shall conform to IS.651/3006 and shall be of grade `A'. These shall be sound, free from visible defects such as fine cracks or hair cracks. The glaze of the pipes shall be free from crazing. The pipes shall give a sharp clear note when struck with a light hammer.
The following information shall be clearly marked on each pipe and fitting:

a. Internal diameter
b. Grade

c. Date of manufacture;
d. Name of manufacture or his registered trade-mark or both

All pipes and fittings shall have ISI mark jointing of GSW pipes and fittings shall be done as per the requirements of the following Employer's Requirements and the relevant IS. After jointing, extraneous material if any, shall be removed from the inside of the pipes and fittings and the newly made joints shall be thoroughly cured. In cased, rubber sealing rings are used for jointing, these shall conform to IS:5382.

20.10.1. Spigot and Socket Joint (Cement Joint)

The Spigot of each pipe shall be slipped home well into the socket of the pipe previously laid and adjusted in the correct position. In each joint, spun yarn soaked in neat cement slurry or tarred gasket shall be passed around the joint and inserted in it by means of caulking tool. More skeins of yarn or gasket shall be added if necessary and shall be well caulked. Yarn or gasket so rammed shall not occupy more than one fourth of the depth or socket.

Cement mortar (1:1) shall be slightly moistened and carefully inserted by hand into the remaining space of the joint after caulking of yarn or gasket. The mortar shall then be caulked into the joint with a caulking tool. More cement mortar shall be added until the space of joint has been completely filled with tightly caulked mortar. The joint shall then be finished off neatly outside the socket at an angle of 45 degrees.

The cement mortar joints shall be cured at least for seven days before testing.

The approximate quantities of cement required for each joint for certain common sizes of pipes are given below for guidance:

Nominal diameter of pipe (mm)	Cement (kg)
150	1.5
200	2.0
250	2.5
300	3.25
350	4.5
400	5.5
450	6.5

20.10.2. Spigot and Socket Joint (Rubber Ring Joint)

The pipe with the rubber ring accurately positioned on the spigot shall be pushed well home into the socket of the previously laid pipe by means of uniformly applied pressure with the aid of a jack or similar appliance. The rubber rings conforming to IS: 5382 shall be used and the manufacturer's instructions shall be deemed to form a part of this Employer's Requirements. The rubber rings shall be lubricated before making the joint and the lubricant shall be soft soap water or an approved lubricant supplied by the manufacturer.

20.10.3. Cleaning of Pipes

As soon as a stretch of GSW pipes has been laid complete from manhole to manhole or for a length as approved by the Engineer-in-Charge, the Contractor shall run through the pipes both backward and forward a double disc or solid or closed cylinder 50 mm less in diameter than the internal diameter of pipes. The open end of an incomplete stretch of pipeline shall be securely closed as approved by the Engineer-in-Charge to prevent entry of mud or silt etc.

If as a result of the removal of any obstruction the Engineer-in-Charge considers that damage may have been caused to the pipelines, he shall be entitled to order the length to be tested immediately. Should such a test prove unsatisfactory the Contractor shall repair the pipeline and carry out such further tests as are required by the Engineer-in-

Charge.

It shall also be ascertained by the Contractor that each length from manhole to manhole or the length as approved by the Engineer-in-Charge is absolutely clear and without any obstruction by means of visual examination of the interior of the pipeline suitably illuminated by projected sunlight or otherwise.

20.10.4. Testing at Work Site

After laying and jointing of GSW pipes is completed the pipeline shall be tested as per the following Employer's Requirements and as approved by the Engineer-in-Charge. All equipment for testing at work site shall be supplied and erected by the Contractor. Potable water for testing of pipeline shall be arranged by him. Damage during testing shall be the Contractor's responsibility and shall be rectified by him to the full satisfaction of the Engineer-in-Charge. Water used for test shall be removed from pipes and not released to the excavated trenches.

After the joints have thoroughly set and have been checked by the Engineer-in-Charge and before backfilling the trenches, the entire section of the sewer or storm water drain shall be proved by the Contractor to be water tight. Before commencing the hydraulic test, the pipelines shall be filled with water and maintained full for 24 hours by adding water. If necessary, under a head of 0.6 m of water. The test shall be carried out by suitably plugging the low end of the drain and the ends of connections, if any, and filling the system with water. A knuckle bend shall be temporarily jointed at the top end and a sufficient length of vertical pipe jointed to it so as to provide the required test head, or the top end may be plugged with a connection to a hose ending in a funnel which could be raised or lowered till the required head is obtained and fixed suitably for observation. The pipeline shall be subjected to a test pressure of at least 2.5 m head of water at the highest point of the section under test. The leakage tolerance of two litres per centimeter of diameter per kilometer may be allowed during a period of 10 minutes. 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.

If any damage is caused to the pipeline during the execution of work or while cleaning/testing the pipeline as specified, the Contractor shall be held responsible for the same and shall replace the damaged pipeline and re-test the same to the full satisfaction of the Engineer-in-Charge.

Water for testing of pipeline shall be arranged by the Contractor.

20.11. STOP COCK AND BIB COCK

Stopcocks and Bibcocks shall be of brass heavy class, chromium plated and of approved manufacture and pattern complying with IS: 781. They shall be of specified size and of the screw down type. The cocks shall open in anti-clockwise direction and chromium plating shall be done in accordance with IS: 1068.

20.12. SOAK PIT

Soak pit shall be constructed at the location specified by the Engineer-in-Charge. Earthwork excavation shall be carried out to the exact dimensions. Brick masonry lining with open joints shall be constructed in the pit upto 150 mm below the outlet pipeline. Brick masonry in cement mortar 1:6 shall be constructed above this level up to ground. Well burnt brick aggregates of nominal size 40 mm to 80 mm and coarse sand shall be filled within the chamber. Construction of pit lining and filling of the brick ballast shall progress simultaneously.

20.13. MANHOLES/INSPECTION CHAMBERS

20.13.1. Scope

This Specification covers the requirements for providing and construction ancillary works such as manholes, scraper manholes, vent shafts, etc.

20.13.1.1. Applicable Codes

The following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the Codes shall be referred to. If requirements of this Specification conflict with the requirements of the Codes and standards, this Specification shall govern.

IS: 111	Code of Practice for Ancillary Structures (Part I) - Manholes.
IS: 555	Cast Iron Steps for Manhole.
IS: 1077	Common Burnt Clay Building Bricks
IS: 3102	Classification of Burnt Clay Bricks.
IS: 395	Method of Sampling and Testing Clay Building Bricks.
IS: 2212	Code of Practice for Brick Work.

20.13.2. Location

Manholes / Inspection chambers shall be constructed at places approved by the Engineer-in-Charge.

20.13.3. Excavation

Excavation, shoring, dewatering etc. for the pits of manholes / Inspection chambers, laying of pipes and fittings/specials shall be done in accordance with Engineer-in-Charge requirements described elsewhere in the document.

20.13.4. Bed Concrete

The bed concrete (min grade M15) for manholes/Inspection Chambers shall be done in accordance with Engineer-in-Charge's requirements described elsewhere in the document.

20.13.5. Bricks

Bricks used for construction of manholes / Inspection chambers shall conform to the relevant Indian Standards. They shall be sound, hard, homogeneous in texture, well burnt in kiln without being vitrified, table moulded, deep red, cherry or copper coloured, of regular shape and size and shall have sharp and square and parallel faces. The bricks shall be free from pores, chips, flaws or humps of any kind. Bricks containing unground particles and/or which absorb water more than 1/6th of their weight when soaked in water for twenty-four hours shall be rejected. Overburnt or underburnt bricks shall be liable to rejection. The bricks shall give a clear ringing sound when struck and shall have a minimum crushing strength of 50 kg/sq.cm, unless otherwise noted in drawings. The class and quality requirements of bricks shall be as laid down in IS: 1077.

The size of the brick shall be 23.0 x 11.5 x 7.5 cm unless otherwise specified; but tolerance upto + 3 mm in each direction shall be permitted. Only full size brick shall be used for masonry work. Brickbats shall be used only with the permission of Engineer-in-Charge to make up required wall length or for bonding. Sample bricks shall be submitted to the Engineer-in-Charge for approval and bricks supplied shall conform to approved samples. If required by the Engineer-in-Charge, brick samples shall be tested

as per IS:3495 by Contractor. Bricks rejected by the Engineer-in-Charge shall be removed from the site within 24 hours.

20.13.6. Cement Mortar

Mortar for brick masonry shall be prepared as per IS:2250, Manholes / Inspection chambers shall be constructed in brick masonry with cement mortar (1:3) unless otherwise specified. Gauge boxes for sand shall be of such dimensions that one bag containing 50 kg of cement forms one unit. 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 as approved by the Engineer-in-Charge. If required by the Engineer-in-Charge and shall be thoroughly washed till it is free of any contamination.

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. Cement mortar shall be used within 25 minutes of mixing. Mortar left unused in the specified period shall be rejected.

The Contractor shall arrange for tests on mortar samples if so required by Engineer-in-Charge. Retempering of mortar shall not be permitted.

20.13.7. Brick Masonry

All bricks shall be thoroughly soaked in clean water for at least one hour immediately before being laid. Brick work 230 mm thick and over shall be laid in English Bond unless otherwise specified. 115 mm thick brick work 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 pressed into the mortar and shoved into final position so as to embed the brick fully in mortar. Bricks shall be laid with frogs uppermost.

All brickwork shall be plumb and square unless otherwise shown on drawing 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 leveled. The thickness of brick course shall be kept uniform. For walls of thickness greater than 230 mm both faces shall be kept in vertical planes unless otherwise specified. 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 degrees. But in no case the level difference between adjoining walls shall exceed 1.25 m. Workmanship shall conform to IS:2212.

Brick 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 12 mm by raking tools daily during the progress of work when the mortar is still green, so as to provide a proper key for the plastering to be done. When plastering 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 of all dirt before another course is laid on top. If mortar in the lower course has begun to set, the joints shall be raked out to a depth of 12 mm before another course is laid.

20.13.8. Cement Plaster

All joints in masonry shall be raked to a depth of 12 mm with hooked took made for the purpose when the mortar is still green and in any case within 48 hours of its laying. The surface to be rendered shall be washed with fresh clean water free from all dirt, loose material, grease etc. and thoroughly wetter for 6 hours before plastering work is commenced. Concrete surfaces to be rendered will however 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.

Cement shall be mixed thoroughly in dry condition and then just enough water added to obtain a workable consistency. The quality of water, sand and cement shall be as per relevant IS. The mortar thus mixed shall be used immediately and in no case shall the mortar be allowed to remain 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. Curing shall be done by continuously applying water in a fine spray and shall be carried out for at least 7 days.
Plastering shall be done on both faces of brick masonry in cement mortar (1:2) and 20 mm thick unless otherwise specified.

Plastering work shall be carried out in two layers, the first layer being 14 mm thick and the second layer being 6 mm thick. The first layer shall be dashed against the prepared surface with a trowel to obtain an even surface. The second layer shall then be applied and finished leaving an even and uniform surface, trowel finished unless otherwise approved by the Engineer-in-Charge.

20.13.9. Cement Concrete Channel

The channel for the manhole shall be constructed in cement concrete of M15 grade. Both sides of the channel shall be taken up to the level of the crown of the outgoing sewer. They shall be benched up in concrete and rendered in cement mortar (1:1) of 20 mm thickness and formed to a slope of 1 in 12 towards the channel.

20.13.10. Pipe Entering or Leaving Manhole / Inspection Chamber

Whenever a pipe enters or leaves a manhole / inspection chamber, bricks on edge must be cut 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) 13 mm thick between it and the bricks.

20.13.11. Cast Iron Steps

Cast iron steps shall be as per IS:5455. The steps shall be of grey cast iron of grade 15 as per IS:210. The steps shall be clean, well cast and they shall be free from air and sand holes, cold shuts and wrappings. The portion of the step which projects from the wall of the manhole / inspection chamber shall have a raised chequered design to provide an adequate non-slip grip CI steps shall weigh not less than 5.5 kg each and shall be of 150 mm x 375 mm overall dimensions. These steps shall be coated with a black bituminous composition. The coating shall be smooth and tenacious. It shall not flow when exposed to a temperature of 63 degrees C and shall not be brittle as a chip of at temperature of 0 degree C.

Where the depth of invert of manhole exceeds 800 mm, cast iron steps of approved pattern shall be fixed in the brick work at the interval of 300 mm vertically and staggered at 380 mm horizontally centre to centre. In case of pipe diameter greater than 600 mm, box type CI steps weighing 19 kg each shall be provided at 300 mm vertically in channel of manhole / inspection chamber.

20.13.12. Frame and Covers

Frame and covers for manholes shall be of required type and dimensions as per the relevant drawings prepared by the Contractor. Following information shall be clearly marked on each cover.

- Year of manufacture,
- Identification mark of the purchaser

- SEWERS/SWD
- Arrow showing direction of flow

Preferable Makes: KK Manholes and Gratings
S.S. Manholes
Bharat Pipes and Covers
and approved by Engineer In charge

20.13.12.1. Cast Iron Frame and Cover

The cast iron frame and cover shall be of gray cast iron as per IS: 1726. The general requirements for casting and coating of CI frame and cover shall be as specified for CI steps in Clause 15.15.10. The covers shall have a raised chequered design to provide an adequate non-slip grip. The rise of the chequer shall be not less than 4 mm. The locking device for the cover shall be provided as approved by the Engineer-in-Charge. The CI covers for the load test shall be selected at one for every lot of fifty or part thereof for each type and size manufactured and as approved by the Engineer-in-Charge. The frame shall be fixed in cement concrete of M15 grade all round and finished with neat cement. The manhole frame shall have 560 mm diameter clear opening and shall weigh not less than 208 kg. Including cover. In case of rectangular CI frame and cover of 900 mm x 600 mm clear opening, the total weight shall not be less than 275 kg. In case of scraper manhole the frame shall have clear opening of 1200 mm x 900 mm and shall weigh not less than 900 kg including cover. The manhole / inspection cover and frame shall be painted with three coats of anti-corrosive paint after fixing in position.

20.13.12.2. Fibre Reinforced Concrete Frame and Cover

Fibre reinforced concrete frame and cover shall be capable of withstanding load of 35 tonnes. The frame shall be fixed in cement concrete of M15 grade all around and finished with neat cement. The fibre-reinforced frame shall have clear opening of 560 mm diameter and weighing 103 kg. The cover shall have a minimum thickness of 100 mm and weighing 78 kg. The fibres shall constitute 1% of the weight of the concrete in the form of 50 mm to 100 mm long high tensile steel wires. For the cover, MS sheet lapping of 18 gauge shall be provided to avoid damage to the edges. Similarly for frame, MS angle/flat shall be provided along the edge. Both MS sheet and angle shall be painted with black bituminous paint. The cover should have suitable lifting arrangement. The fibre reinforced frame and cover shall be manufactured as approved.

20.13.12.3. Reinforced Cement Concrete Frame and Cover

Reinforced cement concrete frame and cover for manholes shall be of required dimensions and shape as shown on the drawing prepared by the Contractor and approved by the Engineer-in-Charge. The frame and cover shall be cast in cement concrete of M20 grades. Minimum cover to the reinforcement shall be 40 mm. The edges of frame and covers shall be provided with mild steel angles to avoid damages to the corners. These angles shall be painted with black bituminous paint. The covers should have suitable lifting arrangement.

20.13.13. Drop Manhole

When a sewer connects a main sewer, and where the difference in level between water line (peak flow levels) or 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 black 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 should be surrounded with 150 mm thick concrete.

In the case of sewers over 450 mm in diameter the drop in level may be accomplished by one of the following approved methods.

a. A cascade,
b. A ramp,
c. By drops in previous manholes.

20.13.14. RCC Manhole

M20 grade of concrete used for construction of RCC manhole shall have min cement content of 300kg/cum of concrete. Min cover to the reinforcement shall be 50mm. The construction of RCC manholes are proposed at major road junction according to the vehicular movement of the roads. Also RCC manholes are proposed in the main sewers pipelines along the nalla /river for avoidance of damage.

20.14. VENT SHAFTS

20.14.1. General

Vent shafts shall be erected at places shown on the Drawings of longitudinal sections of the sewers or as directed by Engineer.

20.14.2. RCC Vent Shafts

1. RCC vent shaft shall be of precast RCC M20 with cowl, 125mm and 225mm internal and external dia. respectively at top, 300 and 450 mm internal and external dia. at bottom and 6.0 m overall length, The vent shaft shall be embedded in concrete of M10 grade and anchored by 2 nos. of 16 mm diameter and 600 mm long MS bars. The vent shaft shall be connected to manhole as specified in (b) above through a brick masonry flue chamber. The vent shafts shall be provided with GI flyproof mesh of 26 guage.

20.14.3. Measurement for Vent Shaft

1. The rate quoted in Schedule of Quantities and Rates for Vent shaft shall be deemed to include the cost of RCC vent shaft, necessary excavation to manhole inclusive of concrete encasement, erecting, etc. complete. The measurement for vent shaft shall be on per number basis.

20.14.4. Testing of Materials:

The various materials to be used in the work shall be subject to mandatory tests in accordance with latest relevant specifications with upto date corrections. These tests shall be got done as directed by Engineer. All expenditure required for testing the samples, conveyance, packaging, etc. including cost of material shall be borne by the contractor himself.For all field tests, the contractor shall setup laboratory and arrange / keep the required equipments at site. The record of test shall be kept for checking by the employer/engineer.

20.14.5. Requirements for Cement:

The Contractor shall procure 43/53 grade (conforming to IS : 12269) Or 43 grade (conforming to IS : 8112) Ordinary Portland Cement or Sulphate resisting cement (conforming

to IS 12330) as required in the work, from reputed manufactures of cement such as ACC, L&T (ULTRA-TECH), J.P. Rewa, Vikram, Shri Cement, Birla Jute, Ambuja and Cement Corporation of India, etc., as approved by Ministry of Industry, Government of India, and holding license to use ISI certification mark for their product whose name shall be got approved from Engineer. Supply of cement shall be taken in 50kg. Bags bearing manufacture's name and ISI marking, samples of cement received at site shall be taken by the Engineer and got tested in accordance with provisions of relevant BIS codes and QA/QC manual. In case test results indicate that the cement arranged by contractor does not conform to the relevant BIS codes, the same shall be rejected and shall be removed from the site by the contractor at his own cost within a week's time of written order from the Engineer to do so. Adequate water proof cement storage shed with proper protection against moisture and water shall be constructed by the contractor at site of work. The contractor shall be responsible for the watch and ward and safety of the cement godown. The contractor shall facilitate the inspection of the cement godown by the Engineer at any time.

The Contractor shall supply free of charge the cement required for testing. The cost of tests shall be borne by the Contractor. The cost of all tests as per IS/QA-QC Manual each consignment shall be borne by Contractor and if any additional tests are required then the cost shall be borne by the Employer. The actual issue and consumption of cement on work shall be regulated and proper accounts maintained. The theoretical consumption of cement shall be worked out as per procedure prescribed and shall be governed by conditions laid therein.

20.15. SEPTIC TANK

The sewer line shall be connected to a septic tank of adequate capacity and design including necessary soak pit. All the works involved, such as excavation, refilling, accessories, fittings, vent pipe, cowl cap, etc. as specified & directed shall be carried out.

20.16. MISCELLANEOUS

If any damage is caused to the other services such as water supply pipeline, sewer, cable, etc. during the construction of manholes and erection of vent shafts, the Contractor shall be held responsible for the same and shall replace the damaged services to the full satisfaction of the Engineer-in-Charge. The interior of manholes shall be cleared of all debris after construction and before testing the same for water tightness by the Contractor.

21. ROAD SIDE DRAINS

21.1. APPLICABLE CODES AND SPECIFICATIONS

The following specifications, standards and codes are referred to in this part
All earthwork shall be according to Engineer-in-Charge specified under Section n "Earthwork".

21.2. SLAB CULVERT

Slab culverts shall be constructed at specified locations of the existing cross drainage works as directed by the Engineer-in-Charge. The Concrete works specifications for construction of RC slab and the rubble masonry specifications for the supporting rubble walls shall be followed as per Employer's Requirements described elsewhere:

21.2.1. Bitumen at Location of Contact

The bitumen to be used on the top of the bed concrete at the location of contact of RCC slab above in two coats shall be straight run bitumen of specified grade.

21.2.2. Graded Gravel Free Draining Backfill

On each side of the uncoarsed rubble walls supporting the slab culvert a free draining backfill of thickness 200 mm shall be provided. The material for this backfill shall be granular consisting of sound, tough, durable particles of crushed or uncrushed gravel, crushed stone or brickbats which will not become powdery under loads and in contact with water. The material shall be free from soft, thin, enlongated or laminated pieces and vegetable or other deleterious substances. It shall be graded and shall meet the grading requirements given in hereunder.

Sieve Designation	Percent Passing by Weight
10 mm	100
4.75 mm	30-65
425 microns	5-30
150 microns	0-10

21.2.3. Weep Holes

Weep holes as shown on the drawings or as directed by the Engineer-in-Charge shall be provided in the masonry to drain water from the backfilling. Weep holes shall be of asbestos cement pipes conforming to IS: 6908 in rubber walls with necessary M10 concrete cushioning 75 mm thick. They shall extend through the full width of the masonry at a spacing of 1.5 m c/c and with slope of about 1 vertical to 20 horizontal towards the drainage face.

21.3. PIPE DRAINS

Wherever required, pipe drains shall be provided for cross drainage purposes.The sequence of construction shall be as follows:
laying of sand/shingle bedding on the original ground
laying of PCC of M10 grade
laying of concrete pipes of NP3 class as per IS:458
Constructing embankment above in compacted murum, laying of the sub-base and Water bound Macadam as specified hereinabove.
The details of above works as directed by Engineer-in-Charge shall be followed.

21.3.1. Materials for Pipe Drains

All materials used in the construction of pipe drains shall conform to Engineer-in-Charge. RCC pipes class NP3 shall conform to IS: 458.

Each consignment of cement concrete pipes shall be inspected, tested if necessary, and approved by Engineer-in-Charge at the place of manufacture or at site before their in Corporation in the Works.

21.3.2. Excavation for pipes

The foundation bed for pipe drain shall be executed true to the lines and grades shown on the drawings or as directed by the Engineer-in-Charge. The pipes shall be placed in shallow excavation of the natural ground in open trenches cut in the existing embankment, taken down to levels as shown in the drawings. Where trenching is involved, its width on either side of pipe shall not be less than 150 mm nor more than one-third the diameter of pipe. The sides of the trench shall be as nearly vertical as possible.

When during excavation, the material encountered is soft, spongy or other unstable soil, unless other special construction methods are called for as indicated on drawings, such unsuitable material shall be removed upto a depth of 600 mm or as directed by the Engineer-in-Charge. Before placing any backfill material, exposed surface of the soft soil shall be lightly compacted with one pass of 0.5 T roller. On the lightly compacted surface, coarse sand and shingle shall be spread in two successive layers of 300 mm and each layer shall be compacted by rolling with a min 0.5 T roller and with a minimum of 10 passes each, both in longitudinal and transverse directions.

When bed rock or boulder strata are encountered, excavation shall be taken down at least 200 mm below bottom level of pipe as directed by Engineer-in-Charge and space filled with approved sand and shingle and thoroughly compacted to provide adequate support for the pipes. Trenches shall be kept free from water until the pipes are installed and the joints have been hardened.

21.3.3. Bedding for pipe

The bedding surface shall provide a firm foundation of uniform density throughout the length of the pipe drain and shall conform to the specified level and grade. The pipe shall be bedded in a cradle of concrete having a mix not leaner than M-10. The pipe shall be laid on the concrete bedding before the concrete has set.

21.3.4. Laying of pipes

No pipes shall be placed in position until the foundations have been approved by Engineer-in-Charge. When pipes are to be laid adjacent to each other, they shall be separated by a distance at least equal to or greater than half the diameter of pipe subject to a minimum of 450 mm.

The laying of pipes on the prepared concrete foundation shall start from the outlet and proceed towards the inlet and be completed to the specified lines and grades. The pipes shall be fitted and matched so that when laid they form a drain with a smooth uniform invert. Any pipe found defective or damaged during laying shall be removed at the cost of the Contractor.

21.3.5. Jointing

All the joints shall be made with care so that their interior face is smooth and consistent with the interior surface of the pipes. The ends of the pipes should be so shaped as to form a self-centering joint with jointing space 13 mm wide. The jointing space shall be filled with cement mortar (1 cement to 2 sand) mixed sufficiently dry to remain in position when forced with a trowel or rammer. Care shall be taken to fill all voids and excess mortar shall be removed. After finishing the joints shall be kept covered and damp for at least four days.

21.3.6. Back filling

Trenches shall be backfilled with selected materials as per Employer's Requirements given in this part. Backfilling upto 0.3 metre above the top of pipe shall be carefully done and murum shall be thoroughly consolidated under the haunches of the pipe.

21.3.7. Concrete Encasement

Concrete encasement shall be provided at places wherever directed by the Engineer-in-Charge. Concrete shall be of M 20 grade.
MAKES AND SPECIFICATIONS OF MATERIAL (GENERAL CIVIL WORKS)

21.4. Double Wall Corrugated (DWC) Pipe

Double Wall Corrugated Pipe of Polyethylene (PE) with smooth internal and profiled external surface for non-pressure underground drainage and sewerage as per ISO 21138-3 in 6 meter length bar of SN4/ SN8. With coupling arrangement.
The pipe shall be confirming to ISO 21138-3 and also IS 16098 (Part-2):2013. The pipes and specials shall be ISI marked.

21.4.1. LAYING OF PIPES

a) The pipes are to be laid with sockets facing up the gradients beginning at the lower end. No pipe to be laid until the trench has been excavated its required depth for a distance of 20 M in front of the pipe to be laid (This distance may vary as directed by the Engineer).

b) All the pipes are to be laid perfectly true, both in line and on gradient. The pipes in a trench shall be all laid and fitted previous to the jointing being commenced.

c) Properly fitted temporary wooden stoppers shall be provided and constantly used to close the ends of all incomplete pipe lines. The stopper is only to be removed when pipes are being and jointed.

21.4.2. Bedding of HDPE (DWC) Pipe

The bedding for stoneware pipes shall be of murum bedding filling in plinth and floors murum bedding in trenches with approved murum from excavated materials or brought from outside 15cm to 20cm layers including watering and compaction complete.
These DWC HDPE Pipe and DWC HDPE Corrugated Pipe are flexible, tough and available as per IS-16098(Part -2):2013

21.4.3. Dimensions

The width of a sewer trench depends on the soil condition, type of side protection and the working space required at the bottom of trench for smooth installations. Increase in width over required minimum would unduly increase the load on pipe and cost of road restoration. Considering all above factors, the minimum trench width is specified as per below Table.

21.4.4. Marking

The following information shall be clearly marked on each pipe including the details given by Engineer In charge of AMC:
Internal diameter of pipe.
Class of pipe.
Date of manufacture, and
Name of manufacturer or his registered trademark or both.

21.4.5. Excavation

Excavation of sewer trenches shall be in straight lines as much as possible and to the correct depths and gradients as specified in drawings. However, because of inherent flexible property, these pipes can also be laid at very wide and smooth curvatures without transitional manholes. Instead of conventional manholes, the specified fitting such as tees and bends, etc, can be used at transitions

Minimum Trench Widths

All dimensions in millimetres.

Sl No.	Nominal Diameter mm	Minimum Cover mm
(1)	(2)	(3)
i)	75	65
ii)	100	77
iii)	150	102
iv)	200	127
v)	250	178
vi)	300	368
vii)	400	505
viii)	600	711
ix)	900	1067
x)	1050	1219
xi)	1200	1372

Excavated soil shall not be deposited in the near proximity to prevent the collapse of side of the trenches. The sides of the trench shall, however, be supported by shoring (where necessary) to ensure proper and speedy excavations and concurrently ensuring necessary protections to contiguous structures.

In the event, the presence of ground water is likely to cause instability in soil conditions, a well point system may be adopted for lowering of ground water tab below the requisite trench bed level. If excavation made deeper than necessary the same shall be filled and compacted.

21.4.6. Shoring/mild steel sheet piling

The protective shoring works shall be strong enough to prevent caving in of trench walls or subsidence contagious areas adjacent to trench.

For wider and deeper trenches, (a system of wall plates wales) and struts of heavy timber section is commonly used as per the requisite structural design.

In non-cohesive soils with high water table, continuous interlocking mild steel sheet piling may be necessary to prevent excessive movements due to ground water percolation. Such sheet piling shall extend 1.5 m below the trench bottom unless the lower soil strata are adequately cohesive.

21.4.7. Underground services

The underground public and private utility services exposed due to the excavation shall be effectively supported under the guidance of the owners of such services.

21.4.8. Dewatering

Sewer installation trenches shall be adequately dewatered for the placement of pipe at proper gradient till the pipe is integrated through socket and spigot joint/coupler assembly with the already laid segment. Precautions are to be taken to arrest floating of installed sewer segments against buoyant forces in case of sudden accumulation of water in the trench. The diameter wise minimum cover necessary to counteract the buoyant forces is given in below Table.
For exceptional cases of higher level of ground water, additional anchoring at equal intervals would be necessary.

Required Minimum Cover to Prevent Floatation

Sl No.	Nominal Diameter mm	Minimum Cover mm
(1)	**(2)**	**(3)**
i)	75	65
ii)	100	77
iii)	150	102
iv)	200	127
v)	250	178
vi)	300	368
vii)	400	505
viii)	600	711
ix)	900	1067
x)	1050	1219
xi)	1200	1372

NOTE: Computation is based on the pipes being completely empty water table at the ground surface, solid density of 2.083 kg/m3 and a soil friction angle appropriate for most sand/ gravel mixtures. The average of the inside and outside diameters was used to determine solid and water displacement.

21.4.9. Manholes and Catch Pit Connections

Brick masonry manholes can also be used at changes in pipe material, size, grade, direction and elevation. Manufacturer specified pre-fabricated appurtenant structures made of thermoplastic materials shall also be available for onsite user friendly installations. Similar methodology shall be followed for integration of catch pits.

21.4.10. Sewer Connections

Other connecting lines shall be integrated with the already laid system in the same manner as of original sewer lines.

21.4.11. Construction of Backfill Envelope and Backfilling of the Trenches

These pipes and well compacted backfill envelope work together to support soil and traffic load.

In general, material used for construction of backfill envelop around the pipe comprises the following:

a) Initial backfill;
b) Side fill; and
c) Top backfill.

The material for backfill envelop shall be as per the structural design of flexible buried conduit. It can be the same material that were removed in the course of excavation or it can be fine sand/course sand/gravel depending on the over burden and superimposed load, but it should be the concrete which invariably induces undesired rigidity in the system.

The remaining portion of backfilling shall be the materials that were removed in the course of excavation. These materials shall consist of clean earth and shall be free from large clod or stone above 75 mm, ashes, refuse and other injurious materials.

After completion of laying of pipes, etc, first the backfill envelope shall be constructed as per design around pipe. Voids must be eliminated by knifing under and around pipe or by some other technique and compacted with necessary watering, either by hand rammers or compactors to-a possible maximum level of proctor density.

Backfilling shall start only after ensuring the water tightness test of joints for the concerned sewer segments. However, partial filling may be done keeping the joints open.

Precautions shall be taken against floatation as per the specified methodology and the minimum required cover.

21.4.12. Jointing

Various methods for jointing such as regular coupler made by online process, spigot and sockets are used.

The moulded socket will have a suitable internal surface with profiles ribs for insertion of the next pipe into it. The socket end of the pipe to be inserted will have corrugated outer layer. On first valley segment of corrugated pipe (destined to e bushed into the coupler) one elastomeric rubber ring needs to be placed which is pushed into the coupler socket. This provides sufficient gripping lock and leak proof joint.

Similar system is also used for fabricated accessories or moulded fittings required such as tee, bends, elbows, reducer end caps for the purpose of installation of the system related to drainage/sewerage.

For quality connections following steps are to be ensured, failing which the performance aspects are to be severely compromised:

a) The non-coupler end needs to be thoroughly cleared and shall be free from any foreign material.
b) Use a clean rag or brush to lubricate the non-coupler end with lubricant.
c) Clean and lubricate the coupler end of the pipe to be laid in similar manner.
d) Lubricate the exposed gasket in the same manner with pipe lubricant.
e) Keep the lubricated non-coupler end free from dirt, backfill material, and foreign matter so that the joint integrity is not compromised.
f) Push the coupler into non-coupler and align properly. Always push coupler end into non-coupler end.

For smaller diameter pipes simple manual insertion shall be sufficient. In every methodology, it should be ensured that the coupler end is adequately `homed' within non-coupler end to ensure installation and tight joining seal. Therefore, prior to insertion always place a homing mark on appropriate corrugation of the non-coupler end.

21.4.13. Jointing different pipe types or sizes

Sewerage/drainage system often encounters connecting pipes of difference materials/sizes, etc. The fittings or adapters specifically designed for the purpose are available.
A selection of fittings designed to make the transition from material directly to another are also available. In few cases fitting may need to be used in combination with separate manufacturer's gasket or coupler to give proper effect to the transition.

21.5. Works to facilitate House Sewer Connections:

The work involves the laying of DWC HDPE pipes from the property boundaries / road side chambers to the street manholes as per drawings, site layout and as directed by the Engineer to facilitate house sewer connections.

No work shall be carried out inside the property boundaries.

This work is classified as under:

- **With road side chamber.** A road side chamber of 90 x 60 cm shall be constructed close to the property boundaries, inside the road width. The proposed location of the roadside chamber shall be such that it shall be possible to connect at least two properties to the roadside chamber with minimum length of pipes. Provision for extra future connection into the road side chamber may be kept as directed / approved by the Engineer. Wherever construction of road side chambers is not possible due to site constrain (for road widths between facing property boundaries less than 4 metres) the pro rata payment shall be applicable.

The murrum bedding as per standard drawing shall be provided for the HDPE DWC pipes. HDPE DWC pipes are to be plugged with end cap near the property boundaries as shown in the Drawing and / or as directed by the Engineer.

21.6. Dismantling & reinstatement of BT & WBM roads

The Contractor shall be paid actual depth of dismantling & reinstatement of the road to its original conditions earthwork if any up to 0.5 meter depth which come in the way of sewer trench alignment. The quantity shall be measured in sq. mtr.

21.7. Reinstating the road surface

The road surface shall be remade using 1 layers of 80mm compacted trap stone of 200 mm thick, 1 layers of 40 mm compacted trap stone of 100 mm thick, spreading and compaction of soft murrum of 100 mm thick, and as a bearing surface 20 mm thick premix carpet (as per clause 511 & 512 of M.O.R.T. &H Specifications) and seal coat, as per clause 513 of M.O.R.T. &H Specifications. The road restoration shall be carried out as soon as possible after completion of inspection, testing and approval of the pipeline and manhole by the Engineer.

Cement Concrete Pavement / Roads:

The restoration of dismantled existing concrete pavement shall be measured in cubic meters. The thickness of the concrete for the restoration works shall be same as the thickness of existing pavement. The re- concreting shall be done with utmost care and cement slurry shall be applied on the edges of old cement concrete pavement before laying the fresh concrete. The grade of concrete shall be M-15 for bottom 15 cm. layer & M-20 for top layer of 15 cm. The works shall be done in accordance with the Standard Specifications and the M.O.R.T. & H / IRC Specifications shall be followed for the repair / restoration works.

VOLUME II - C

MECHANICAL SPECIFICATIONS

Table of Content - Volume II C,
Mechanical Specifications

PREAMBLE

1.0 The Volume IIC: Mechanical Specifications are to be read for the purpose of pricing in conjunction with "Volume-I : Conditions of Contract" of the Tender Documents containing instructions to Tenderer and General Conditions of Contract; “Volume IIA : Scope of Work” under this tender; “Volume IIB : Civil Specifications”, “Volume IID : Electrical Specifications” “Volume IIE : Operation and Maintenance”, Volume IIF : Quality Control and Quality Assurance” and “Volume-III : Financial Bid” of this tender.

2.0 The prices quoted in the Volume III: Financial Bid shall be all inclusive value for the work described including all costs and expenses which may be required in and for the execution of the work described together with all general risks, liabilities and obligations set forth or implied in the document on which the tender is based.

3.0 All works shall be carried out strictly as per detailed specifications whether actually specified or not. If not specified work shall be carried out as per directions of Owner/Engineer I/C.

4.0 The total amount entered in the Volume III : Financial Bid document shall be written in ink and shall be entered both in figures and words.

5.0 Specifications of items of work are described in Section D for each item of Volume III : Financial Bid shall read this in conjunction with other technical specifications and specific technical requirements and quote accordingly.

6.0 No separate payment whatsoever shall be made for dewatering if required to be done during excavation, laying of PCC and RCC laying and jointing of pipes, construction of manholes, testing and backfilling etc. and Contractor should quote accordingly.

7.0 If Tenderer needs any clarification, they shall obtain the same in writing from Owner/Engineer. No notice will be taken of any verbal discussions in such matters.

8.0 Abbreviations used in the Volume IIC : Mechanical Specifications have the meanings shown below:

mm	Millimetre	CI	Cast Iron
cm	Centimetre	GI	Galvanized Iron
m	Metre	GSW	Glazed Stone Ware
km	Kilometre	BBCC	Burnt Brick Cement Concrete
sq.m	Square Metre	RCC	Reinforced Cement Concrete
cu.m	Cubic Metre	PCC	Plain Cement Concrete
M.T.	Metric Ton	Wt	Weight
SWG	Standard Wire Gauge	Kg	Kilogram
R.M.	Running Metre	I.D.	Internal Diameter
nos.	Numbers	C.M.	Cement Mortar
MS	Mild Steel	IS	Indian Standards
M.D	Metre Depth of Manhole	SS	Stainless Steel

1. SCOPE OF MECHANICAL WORKS

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

1.1. GENERAL

The contract includes design, manufacture, testing at works and Manufacturer plant, supply and delivery at site, unloading, storing till the time of erection, installation, testing and commissioning of mechanical equipment as mentioned in the following sections.

1.2. MECHANICAL EQUIPMENT

The details of the Mechanical equipment required for this contract are presented under tender document: Mechanical Equipment and to be read in conjunction with 'Volume IIA : Scope of Work'. This table below represents an extract of the said section for the Tenderer's reference.

Sr.	Particulars
1	Raw Sewage Pumps
2	Screens for pumping station
3	Mechanical Fine Screen
4	Manual Bar screens
5	Mechanical Degritter
6	Primary clarifier
7	Air blowers and diffusers
8	Air piping
9	Secondary clarifier
10	SBR Decanter
11	Moving Bed Bio Reactor media
12	Chlorination System with cylinders, Booster Pumps and
13	Primary sludge pumps
14	Return sludge pumps
15	Anaerobic sludge digester with mixers
16	Digester feed pumps
17	Centrifuge feed pumps
18	Centrifuge Press
19	Sludge agitator
20	Filtrate transfer pumps
21	Polyelectrolyte dosing tanks and pumps/ Alum Dosing pumps and
22	Flow Measurement devices
23	Gates, Valves, Actuators, EOTs, Items required to completed

1.3. SPARES

Sr.	Particulars	Quantity
1	**Pumps**	
(i)	Impeller	1 set
(ii)	Bearings	1 set
(iii)	Rubber bellows	1 set
(iv)	Seals, gaskets	1 set
(v)	Pumpset Power Cables	1 set
2	**Mixers**	
(i)	Oil seal for housing	1 set
(i)	Oil Seal for Gear Box	1 no.
(iii)	Gear Box Bearing	1 no.
		1 set
3	**Air Blower**	
(i)	Oil Seal	1 set
(ii)	Bearing	1 set
(iii)	Suction Filter	1 set
4	**General Utility**	
(i)	Racking Arms (M.S.)	4 Nos.
(ii)	Wheel Barrows (M.S.)	2 Nos.
(iii)	Tokari (Ghamela) Paras Miracle Brand Plastics of Versatile	6 Nos.

Note:

1. Contractor should provide spares and list of spares required for one year after handing over the plant.
2. All other miscellaneous items necessary for completing the installation and commissioning of the equipment under this contract, as per the existing codes of practice.
3. Technical specific requirements shall conform to Volume IIA - Scope of Work and Volume IID - Electrical Specifications, if any should be brought out separately in deviation schedule.

2. MATERIALS & WORKMANSHIP

2.1. INTRODUCTION

1. This part of the specification sets out the general standards of materials to be supplied and the workmanship required to be ensured by the Contractor and mention of any specific material or plant does not necessarily imply that such is included in the works. All component parts of the works shall, unless otherwise specified comply with the provisions of this part or be subject to the approval of the Engineer.
2. 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 shall be furnished by the Contractor.

2.2. COMPLIANCE WITH STANDARDS

1. Where reference is made in the Specification to the British Standard Specification (hereinafter abbreviated to 'BS') issued by the British Standards Institution of 2, Park Street, London W.I., or to an Indian Standard Specification (IS) issued by the Bureau of Indian Standards, (earlier known as Indian Standard Institution), Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110 002, American Society for Testing and Materials (ASTM) issued by ASTM 1916 Race Street, Philadelphia, P.A., 19103, U.S.A or American National Standards Institute (ANSI) issued by ANSI 1430, Broadway, New York, N.Y., 10018, U.S.A or to any other equivalent standard it shall be to the latest revision of that standard at the tender opening date.
2. The Contractor may propose at no extra cost to the Employer, the use of any relevant authoritative internationally recognised Reference Standard, including Indian Standard.
3. All details, materials and equipment supplied and workmanship performed shall comply with these standards. If Contractors offer equipment to other standards, the equipment/material should be equal or superior to those specified and full details of the difference shall be supplied.

4. In the event of conflict between this specification and the codes for equipment, provisions of this specification shall govern.

2.3. MATERIALS - GENERAL

1. All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and of reputed make/approved quality, free from imperfections and selected for long life and minimum maintenance. Non-destructive tests, if called for in the specification, shall be carried out.
2. All submerged moving parts of the Plant, or shafts spindles, etc. of the submerged moving parts or faces etc. in contact with various chemicals, shall be corrosion resistant materials. All parts in direct contact with various chemicals shall be completely resistant to corrosion or abrasion by these chemicals and shall maintain their properties without aging due to the passages of time, exposure to light or any other cause.

2.4. WORKMANSHIP - GENERAL

1. Workmanship and general finish shall be of first class quality and in accordance with best workshop practice.
2. All similar items of the Plant 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. Machining fits on renewable parts shall be accurate and to specified tolerances so that replacements made to may be readily installed.
3. All equipment shall operate without excessive vibration and with minimum noise. All revolving parts shall be truly balanced both statically and dynamically so that when running at normal speeds at any load up to the maximum there shall be no vibration due to lack of balance.
4. All parts, which can be worn or damaged by dust shall be totally enclosed in dust proof housings.
5. All materials incorporated in the work shall be most suitable for duty concerned, free from imperfections, selected for long life and minimum maintenance.

6. 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.
7. All valves shall be closing on clockwise rotation of the hand wheel. The effort required to close/open under all operating conditions shall be limited to 7 kg. The direction of opening/closing shall be cast on the hand wheel.
8. All flanges shall be drilled in accordance with requirements of IS: 1538.
9. All flanges shall be full or spot faced on the backside. The flange thickness be uniform throughout.
10. Flange outside periphery shall be concentric with the bore. Flanges shall be finished smooth on periphery also.
11. Castings and fabricated materials shall be finished smooth all over.

2.5. WELDING

2.5.1. Design Approval

Welding shall comply with the latest revision of the BS 5135 code. In all welded fabrications, the Contractor shall submit to the Engineer-in-Charge before fabrication commences, detailed drawings of fabrication with sizes of weld and weld preparation together with the details of the application codes. The Engineer-in-Charge shall carry out no welding before approval of the details. No alternations shall be made to any previously approved details of weld preparation or size without prior approval of the Engineer-in-Charge.

2.5.2. Qualification of Welders and Procedures

Welders shall be qualified in accordance with the requirement of the appropriate section of BS 4871 part 1. 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 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-in-Charge shall disqualify the welder whose work requires a disproportionate amount of repairs. All procedures where required shall be qualified as per BS 4870 Part 1.

2.5.3. General Welding Requirements

Inspection and quality of surveillance shall not be limited to the examination of finished welds. All aspects of materials, fabrication procedures and examination procedures shall be subject to the approval of the Engineer-in-Charge. The equipment used shall be suitable for the quality of work specified. 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 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 minimise the number of beads needed to fill the joint. However, the width of the deposited pass shall not 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.

All joint fit ups shall comply with the tolerances specified on the manufacturing drawings. The root pass shall have less than 1.5 mm internal reinforcement. Defects like icicles, burn through and excessive “suck 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 attachment 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 of size of tack welds shall be kept as small as 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 removal 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 surface 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. Preparation of weld repair shall have the prior approval of the Engineer-in-Charge. Rewelded areas shall be re-examined by the methods specified for the original welds and repair procedures shall be duly qualified by the Engineer-in-Charge. Red oxide shall be applied soon as the Welding Complete after Proper Removal of burrs and requisite cleaning to accomplish the corrosion resistance. The Contractor shall make the Arrangement for Dye Penetration Test (DTP) whenever Engineer-in-charge asks for.

2.5.4. Pre-heating and Post - heating Treatment

Pre-heating and post heating treatment shall conform to the relevant application codes. Pre-heating not exceeding 121 Degree Celsius for all carbon steel construction above 25

mm thickness would be mandatory. Such pre-heating would be maintained during flame cutting, flame or arc gouging, welding and repairs and may be done by gas heating by gas torches/gas rings with neutral flame. The temperature shall be checked by temperature indicating crayons. However, such pre-heating will not be necessary for welds less than 6 mm size. In large diameter pipe fabricated out of plate materials, production control test plates in accordance with the BS 4870 Part I Table 6 to represent 30% of the long seams and each welder's performance would be mandatory.

2.5.5. Electrodes

The makes and type of electrodes to be used shall be submitted for approval of the Engineer. All electrodes shall be stored in their original sealed containers under dry conditions. Electrodes shall remain identified until consumed. All electrodes shall be dried before use. Drying ovens shall be provided in work areas for drying purposes. Electrodes withdrawn from oven shall be promptly used and excess unused electrodes shall be promptly returned to oven.

2.5.6. Examination/NDT/Radiography

The various stages of examination and types shall be a stipulated in the respective fabrication codes. Radiographic examination shall be carried out as per provision of BS 2600 or BS 2910: Ultrasonic tests where called for shall be carried out as per provision of BS 3923; magnetic particle tests shall be carried out as per BS 6072. Liquid penetration tests shall be carried out as per BS 6443.

2.5.7. Stainless Steel Welding

All wires consumable such as electrodes, fillers wires, argon gas for shielding and purging shall be of high quality and the proposed brand shall be furnished for approval of the Engineer. Weld deposits shall have similar or higher physical properties and similar chemical composition to the members joined.

All electrodes shall be purchased in sealed containers only and stored in their packing intact. The packets opened shall be consumed as early as possible. The electrodes removed from the containers shall be kept in holding ovens at temperature recommended by electrodes manufacturer. Special care shall be taken in avoiding

mixing of electrodes in the oven.

The electrodes and filling wires shall be free from rust, oil, grease, earth and other foreign matter.

Argon gas with purity 99.5% shall be used for shielding and purging. The gas manufacturers shall certify the purity of gas.

Non destructive examination of these welds shall be carried out to ensure quality of weld.

The electric current for welding shall be direct current, straight polarity (electrode negative). The welding current shall be kept minimum possible to ensure minimum heat affected zone in the parent material. Other side of the weld joint shall be periodically flushed with argon gas.

2.6. CASTINGS

1. Cast iron shall be of standard grey close - grained quality. The structure of the castings shall be homogenous 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.

2. Minor defects in depth not exceeding 12.5 percent 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-in-Charge shall be notified of large defects and no repair welding of such defects shall be carried out without prior approval of the Engineer-in-Charge. if the removal of metal for repair should reduce the stress resisting across section of the casting by more than 25 percent, or to such an extent that the computed stress in the remaining metal exceeds the allowable stress by more than 25 percent, then that casting shall be rejected. Test coupons cast simultaneously with the main casting shall be identified by the Engineer-in-Charge to check physical, chemical analysis of casting.

3. Major defects on casting are not acceptable. Castings repaired by welding for

minor defects shall be stress-relieved after such welding. Castings subject to hydraulic pressure shall be pressure tested to 1 ½ times the rated pressure or, twice the working pressure, whichever is higher and certified copies of test reports shall be forwarded to the Engineer-in-Charge as soon as each test has been completed. Non-destructive tests as directed by the Engineer-in-Charge will be required for any casting containing defects whose extent cannot otherwise be judged, or to determine where repair welds have been properly made.

4. Unless otherwise specified casting shall be produced to the following standards or equal :

Sr.	Component		Grade
(a)	Grey Iron	:	BS 1452 Grade 220
(b)	Carbon Steel	:	BS 3100 Steel Alloy
(c)	Stainless Steel	:	BS 3100 Steel 316 C16
(d)	Copper & Copper Alloy	:	BS 1400
			Group A Grade LG2
			Group B Grade CT1, AB2
			Group C Grade G1

2.7. FORGINGS

All major stress - bearing forgings shall be made to a standard specification. Forgings shall be subjected to magnetic particle testing or dye penetration test at the areas of fillets and change in section. The testing shall be conducted after rough machining (10 microns). Any defect which will not machine out during the final machining, will be gouged out fully, inspected by dye penetration or magnetic particle inspection to ensure that the defect is fully removed and repaired using an approved repair procedure. Any indication, which proves to penetrate deeper than 2.5% of the finished thickness of the component, shall be reported to the Engineer giving the details like location, length, width and depth. For the magnetic particle inspection the choice of wet or dry particles shall be at the Contractor's discretion. All forgings shall be demagnetised after test and shall be heat-treated for the relief of residual stresses. The name of the maker and particulars of the heat treatment proposed for each such forging shall be submitted to the Engineer-in-Charge. The Engineer-in-Charge or the Inspector may inspect such forgings and identify test coupons to check physical and chemical analysis and witness

such tests at the place of manufacture with a representative of the Contractor.

2.8. PIPES AND SPECIALS

All interconnecting piping included in these tenders are of CI except for potable water supply and chemical piping. The pipe shall be as per the specifications. Use of tailpiece will be allowed for adjustment of length.

Piping for water supply shall be GI Class 'C'. The piping for chemical dosing shall be HDPE/PVC/PP/SS316, whichever is best suited. The piping includes joints, gasket and supports. The fasteners and washers used shall be of GI

2.9. VALVES

1. All the valves shall be hydraulically tested open ended. Valves bodies for all valves shall be tested for either side (except for non return valves, where it will be one side) to one and half times the maximum pressure or twice the working pressure, whichever is higher, for a duration of 10 mts, during which there should not be any leakage.
2. Sluice valves shall be double-flanged and shall have knife gates manufactured in close-grained cast iron or equal material unless otherwise specified. The seats and faces shall be of bronze and rings shall be forced fitted. Sluice valves of nominal dia 300 mm and above shall be provided with gunmetal "shoe" and "channel" arrangement so that the gate shall be guided throughout its travel. Total side clearance between shoe and channel shall be less than 1.5 mm. Valve spindles shall have thrust flange to take up axial thrust.
3. The spindle shall be of high tensile brass.
4. The valves shall be suitably designed to protect the disk edge from corrosion and erosion.
5. Non-return valves on the main pump delivery branches shall possess non-slam characteristics with minimum shock on closing.
6. Packed glands shall be arranged for easy replacement of the packing, which

shall be accessible without removal of the valve from the pipe. Precautions shall be taken to prevent corrosion of the valve spindles in contact with the gland packing. Sluice valves shall have seat arrangement for ease of maintenance.

7. Each valve or its operating equipment shall bear an approved nameplate stating its function. All operating spindles, gears and headstocks shall be provided with adequate points for lubrication.

8. All gate valves shall have non-rising spindles.

2.10. SUPPORT OF PIPENETWORK AND VALVES

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. Valves, 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 support, which can conveniently be so designed, shall be rigidly built up of steel by reveting or welding in preference to the use of castings. No point of passage of pipes through floor or walls shall be used as a point of support, except with the approval of the Engineer in charge.

2.11. DESIGN LIFE

1. The works as a whole shall be new, of sound workmanship, robustly designed for a long reliable operating life and shall be capable of 24 hours per day continuous operation for prolonged period in the climatic and working conditions prevailing at the site, and with the minimum of maintenance. Particular attention shall be given to temperature changes, the stability of paint finish for high temperatures, the rating of engines, electrical machinery, thermal overload services, cooling systems and the choice of lubricants for possible high and prolonged operating temperatures. The Contractor shall be called upon to demonstrate this for any component part either by service records or evidence of similar equipment already installed elsewhere or relevant type test. Routine maintenance and repair shall as far as possible not requires the services of highly skilled

personnel.

2. The Plant shall be designed to provide easy access to and replacement of component parts, which are subject to wear, without the need to replace whole units. No parts in the contact with water shall have a life from new to replacement or repair of less than five years. Where major dismantling is unavoidable to replace a part, the life of such part shall not be less than ten years.

3. 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.

4. Plant located outside lockable areas/buildings shall have additional features to prevent unauthorised operation.

2.12. LUBRICATION

5. 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-in-Charge for approval before incorporation in the Instruction Manuals. In the case of grease lubricated roller type bearings lithium base grease is preferred.

6. Contractors shall indicate indigenously available equivalent lubricants, with complete duty specification, to enable the Employer to arrange for regular supply.

7. 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 and grease systems having shorter periods between greasing should be avoided.

Where necessary for when a number of such points can be grouped conveniently, the nipples shall be brought to a battery plate mounted in a convenient position. 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.

8. Where more than one special grease is required, a grease gun for each special type shall be supplied and permanently labeled.

9. Oil containers shall be supplied complete with oil level indicator 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 levels 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.

10. All lubrication systems shall be designed so as not to cause a fire or pollution 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 any other potential source of fire.

11. 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 the commercial operation of the plant for two years after the Taking-over Certificate has been issued.

2.13. NAME PLATES

1. Each item of the plant shall have permanently attached to it in a conspicuous position, a nameplate and rating plate, each of stainless steel. Upon these shall be engraved or stamped, 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-in-Charge. All indicating and operating devices shall have

securely attached to them or marked upon them designations as to their function and proper manner of use.

2. Details of proposed inscriptions shall be submitted to the Engineer-in-Charge for approval before any labels are manufactured. Such nameplates, rating plates and designations shall be of stainless steel with engraved or stamped lettering items such as valves shall have direction of rotation for closing and opening indicated.

3. Nameplates, rating plates and labels shall be of a non-flame propagating materials, either non-hygroscope or transparent plastic with engraved lettering of a contrasting colour. Fixing shall be by means of non-corrosive screws, drive rivets or adhesives shall not be used.

4. Warning labels shall be provided where necessary to warn of dangerous circumstances or substances. Inscriptions or graphic symbols shall be black on a yellow background and to internationally recognised standards.

5. Instruction labels shall be provided where safety procedures such as wearing of protective clothing are essential to protect personnel from hazardous or potentially hazardous conditions. These labels shall have inscriptions or graphic symbols in white on a blue background.

2.14. NUTS, BOLTS, STUDS AND WASHERS

1. Nuts, bolts, studs and washers for incorporation in the plant shall conform to the requirements of the appropriate standard. Nuts and bolts shall be of the best quality of specified grade, machined on the shank and under the head and nut. Bolts shall be of one-piece construction and shall be of sufficient length so that only one thread shall show through the nut in the fully tightened condition.

2. 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.

3. Washers, locking devices and anti-vibrations arrangements shall be provided where necessary and shall be subjected to the approval of the Engineer-in-Charge. Jointing hardware for the entire plant shall be provided with sufficient spares to cater for site losses.

4. Where bolts pass through structural members taper washers shall be fitted, where necessary, to ensure that no bending stress is caused in the bolt. Where there is a risk of corrosion, bolts nuts and studs shall be designed so that the maximum stress does not exceed half the yield stress of the material under any conditions. All bolts, nuts and washers which are subject to frequent adjustment or removal in the course of maintenance and repair shall be made of nickel-bearing stainless steel.

5. The Contractor shall supply all holding down, alignment and leveling bolts complete with anchorage's, nuts, washers and packing required to attach the plant to its foundations, and all bed plates, frames and other structural parts necessary to spread the loads transmitted by the Plant to concrete foundations without exceeding the design stresses.

6. The material of nut, bolts, studs and washers for wetted/submerged areas shall be of SS:316 and others shall be of GI (specifically nut bolts of Aerators, bridge, Filter press, gates, screens, CL_2 dozer, sludge agitator should be only of S.S. either submerged stage or open in air).

2.15. ALLOWANCE FOR WASTAGE

The Contractor shall supply to the satisfaction of the Engineer-in-Charge reasonable excess quantities to cover wastage of those consumable which will be normally subject to waste during erection, commissioning and setting to work.

2.16. PAINTING - GENERAL

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

2. Parts may be cleaned but surface defects may not be filled in before 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. Except where the specification provides to the contrary all painting materials shall be applied in strict accordance with the paint manufacturer's instructions.

3. All protective coatings shall be suitable for use in warm humid climates.

2.17. PAINTING AT PLACE OF MANUFACTURER

1. All stages in painting including cleaning and surface treatment in the manufacturer's works shall be available for inspection.

2. Steel and cast iron parts shall be sand blasted to near white cleaning before painting. Edges, sharp covers etc. shall be ground to a curve before sand blasting.

3. A primer coat of a zinc rich epoxy resin based coating with at least at 75 microns dry film thickness is to be provided. In addition the parts are to be provided with adequate number coats or coal tar epoxy polyamine coating to a dry film thickness of 175 microns including primer coating.

2.18. PAINTING AT SITE

1. 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.

2. Steel and cast iron parts received at site shall be provided with adequate number of further coats of coal tar epoxy polyamine coating to a total dry film thickness of 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.

3. Before painting is commenced the Contractor shall submit for the approval of the Engineer-in-Charge, full details of the paints he proposes to use together with colour charts for the gloss finishes.

   All paint and coating thickness shall be measured by approved Elcometer or coating thickness gauge.

2.18.1. Piping Works

a. Scope of Work

The piping works shall comprise of

1. Connecting the incoming wastewater from the existing manhole to the raw wastewater-receiving sump.
2. All internal interconnecting piping within the plant designed as per the piping specifications.
3. Treated water Line connecting the final discharge point.
4. All piping shall be designed as per the piping design guidelines and specification attached.

b. Specifications of Piping Works

General

1. These specifications are for the design, selection & Procurement, erection, testing & commissioning of piping work.
2. The enclose specifications are the general guidelines for piping work and special requirement if any are given in the chapter entitled Scope of Work & Special requirements.
3. The condition of special requirements shall supersede the requirements/ conditions of this section if in deviation.
4. All fabrication shall be in accordance with relevant IS.
5. All work shall be performed in accordance with the best modern practice

for this type of work and shall be of the highest quality workmanship.

c. Standards

The piping material & work shall conform to the following standards (latest edition) for material & erection & testing:

i. IS-1537 & IS- 15325 Centrifugal Cast (spun) iron pipes and fittings for wastage's and Waste Water.
ii. IS- 1239 GI Pipes & Fittings
iii. IS- 99254 HDPE Pipes
iv. IS- 250025 HDPE fittings
v. IS- 7534 Code of practice for laying HDPE pipes
vi. IS- 3114 Code of practice for laying cast iron pipes.
vii. IS- 7250 Cast iron sluice Valves
viii. IS- 6325 Rubber for flanged joints
ix. IS- 12567 MS hexagonal bolts and nuts
x. IS- 6392 Steel pipe flanges
xi. IS- 7634 Testing of HDPE pipes
xii. IS-3589 Steel Pipes for Water and Sewage
xiii. Relevant IS for SS bolts & fixtures.

d. Pipe Sizing & Design Basis

All piping including inter connecting piping between the various units components of the system as required to meet the duty specification with valves shall be designed as per the following piping design basis.

The piping design including material of construction, class of piping with units sizes installation drawing shall be prepared by the Tenderer and furnished for approval of the Consultant/Engineer in Charge prior to procurement/fabrication and installation.

(i.) Piping Sizing

(ii.) The piping and valves will be sized preferably on the following basis.

Service/ Flow	Basis	Comments/ Limitations
Gravity Lines for Waste Water, Water & Waste Water	Velocity between 0.6 to 1.2 m / sec designed as pipe line flowing full	At peak flows a velocity up to 1.5 m/sec allowable. Minimum velocity to be more than 0.45 m/sec.
Pressure Lines for Waste Water, Water & Waste Water	Velocity between 0.6 to 2.50 m / sec	In small sections at pump delivery a velocity up to 2.5 m/sec allowable. Minimum velocity not to be less than 0.6m/sec
Air (Pressurized Lines)	At velocities between 10 - 25 m / sec (desirable) with a maximum of 15m/ sec in small sections	Velocities in excess of 16m/sec not permitted in any section.
Service Water	Velocities between 1.4 to 2.0 m/sec	In small sections at pump delivery/suction points a velocity up to 2.5 m/sec allowable. Minimum velocity not to be less than 0.9 m/sec
Scum & Sludge Lines	Velocities between 0.6 to 1.5 m/sec	Irrespective of flow diameter shall not be less than 250 mm dia. for gravity lines.
Chemical Feed Lines	Velocity between 0.6 to 1.5/sec	Irrespective of flow diameter shall not less than 20 mm dia.

(iii.) Notwithstanding above the Tenderer shall submit a list of pipelines with tag

nos. flow, size selected for main line and valves at basic engineering stage with the details P & ID and the same shall furnished for approval of the approval of the Consultant / Engineer in Charge prior to any further engineering or procurement/fabrication and installation. The information shall be furnished in the following format.

S.No	Line No	From	To	Type of Flow	Flow m3/h	Selected Main pipe Dia in mm	Velocity in m/sec	Selected Sub Pipe Valve Dia	Velocity in m/sec

e. Erection / Installation / Jointing & Testing Guide Lines

(i) <u>Cast Iron Piping</u>

1) Transportation and Stacking

The transportation of materials to the work size and stacking shall be done in a manner to cause minimum in-convenience to the traffic and other construction works. Pipes shall be protected during handling against impact shocks and free fall, to avoid cracks and damage.

2) Lowering

The pipes shall be lowered cautiously to prevent disturbance of the bed and sides of the trench. The heavy pipes shall be lowered by means of proper shear legs, chain pulley or as directed by Engineer in Charge.

3) Laying

i. Every precaution shall be taken to prevent foreign material from entering the pipe while it is being placed in the line.

ii. If the pipe-laying team cannot put the pipe into the trench and in place without getting earth into it, the Engineer in Charge may require that before lowering the pipes into the trench, heavy tightly woven canvas bag of suitable size shall be placed over each end and left there until the connection is to be made to the adjacent pipe during laying operations, no debris, tools, clothing or other materials shall be placed in the pipe.

iii. The pipe shall be secured in place with approved backfill material under it except at the end. Pipe and fittings which do not allow sufficient and uniform space for joints shall be removed and replaced with pipe and fittings of proper dimensions to ensure such space. Precautions shall be taken to prevent dirt from entering the joint space.

iv. 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 in Charge.

4) Joining

i. Flange faces shall be in a plane perpendicular, true and square to the centerline of the pipe to which they are welded.

ii. Whenever screwed flanges are used the pipe shall extend to within 1.5 mm to 3 mm of the face of the flanges but not beyond.

iii. Bolt holes shall straddle normal centerlines in the vertical and horizontal places unless otherwise specified.

iv. The joining material used between flanges of pipes shall be compressed fiber board or rubber (see IS: 6325-1955) of thickness between 1.5 mm to 3 mm. The fiber board shall have impregnated with chemically, neutral mineral oil and shall have a smooth and hard surface. Its weight per sq.m shall be not less than 112 g/mm thickness.

v. Each bolt should be tightened a little at a time taking care to tighter diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another is high undesirable.

5) Testing

i. The pipe line shall be tested to double the working pressure. Pipe line shall be

tested in suitable before back filling. After all the lines are tested in section, a final test shall be performed before commissioning the system.

ii. Test manifolds, connection piping and all other necessary appurtenances for testing shall be installed by Contractor at the time of test. On completion of testing the test appurtenances shall be removed.

iii. After satisfactory test, the Contractor shall remove water from the pipe line and clean it after testing at his own cost, without flooding and adjoining areas.

6) Procedure of Tests

The pipe shall be completely filled with water and it shall be ensured that no air is left in the line. Pressure shall be applied with a calibrated pressure gauge. Upon reaching the test pressure it shall be maintained for a sufficient time to permit complete inspection of the system under test but in no case shall the time be less

i. than 10 minutes.

ii. If the pipe line fails to maintain the specified test pressure, Contractor shall determine the location of the leak and shall repair the leak by replacing pipes as directed by the engineer in charge and retest the same.

(ii) <u>M. S. Piping</u>

1) Transportation and stacking

Refer clause as above.

2) Lowering

Refer clause as above.

3) Fabrication

<u>Layout, cutting and fitting-up:.</u>

(1) Templates shall be used in laying out headers, laterals and other irregular details to ensure accurate cutting and proper fit-up.

(2) Matching cut bevels to from the welding groove are preferred but smooth,

clean, slag-free flame cut bevels are acceptable.

(3) In fitting up details preparatory to final welding, spacers shall be used with tack welding the pipe and connections in position so that a proper gap is made for full penetration of welds. The following are the recommended gaps.

For pipe size below 150 m - 1.5mm weld gap

For pipe sizes 150mm (inclusive) and above - 3.00 weld gap

(4) Only small tack welds which penetrate to the bottom of the welding groove shall be used and shall become a part of the fitting weld. Tack welds lacking penetration are not acceptable and must be chipped out. Each weld shall be cleaned of all scale, slag, flux and other foreign matter before additional welding beads are applied.

(5) In general, permanently welded-in rings shall not be used. If back-up rings should be necessary or desirable, they may be used only with specific approval of Engineer In Charge. If used, they shall be streamlined to minimize turbulence and resistance to flow through the pipe.

Bending:

Completed bends shall have smooth surfaces and shall be free of flat spots and corrugations.

(1) Hot bending shall be done with the pipe filled with temped sand. Following the bending operation, the bend shall be allowed to cool slowly in still air before the sand is removed. The minimum radius shall be six times the normal pipe diameter.

(2) Cold bends to a radius of six times the nominal pipe diameter or greater may be made without subsequent stress relieving. No cold bending is allowed on pipe larger that 50 mm nominal diameter.

Fabricated pipe:

1) Welders and welding procedures shall be qualified in accordance with the requirements of the codes and IS:2517-1966. Horizontal and/or vertical welding qualifications shall be shown on qualification papers.

2) All welding shall have full thickness penetration and shall be done by the Electric Arc Process. Gas welding may be done if necessary to prepare a bead for the next phase.
3) The completed weld shall be cleaned of slag and spatter metal on all surfaces, and when possible the inside bead shall be ground smooth.
4) No undercutting of pipe adjacent to the completed weld will be permitted.
5) Finished welds shall project not less than 1.5mm but not more than 3mm from the outer surfaces of the pipe.

Electrodes:

Welding electrodes with a suitable coating shall be in accordance with IS specifications and of a recognized quality. Electrodes shall be preserved in an electrode even and only those electrodes, which are so preserved, shall be used in the welding. The electrodes shall have to be approved by the Engineer in Charge.

4) Laying

Refer Clause as above.

5) Joining

Refer Clause as above.

6) Testing

Refer Clause as above.

7) Procedure of Test

Refer Clause as above.

(iii) S. S. Piping

1) Transportation and stacking

Refer clause as above.

2) Lowering

Refer clause as above.

3) Fabrication

Layout, cutting and fitting-up:

(1) Templates shall be used in laying out headers, laterals and other irregular details to ensure accurate cutting and proper fit-up.

(2) Matching cut bevels to from the welding groove are preferred but smooth, clean, slag-free flame cut bevels are acceptable.

In fitting up details preparatory to final welding, spacers shall be used with tack welding the pipe and connections in position so that a proper gap is made for full penetration of welds.

(3) Only small tack welds which penetrate to the bottom of the welding groove shall be used and shall become a part of the fitting weld. Tack welds lacking penetration are not acceptable and must be chipped out. Each weld shall be cleaned of all scale, slag, flux and other foreign matter before additional welding beads are applied.

(4) In general, permanently welded-in rings shall not be used. If back-up rings should be necessary or desirable, they may be used only with specific approval of Engineer In Charge. If used, they shall be streamlined to minimize turbulence and resistance to flow through the pipe.

Bending:

Completed bends shall have smooth surfaces and shall be free of flat spots and corrugations.

(1) Hot bending shall be done with the pipe filled with temped sand. Following the bending operation, the bend shall be allowed to cool slowly in still air before the sand is removed. The minimum radius shall be six times the normal pipe diameter.

(2) Cold bends to a radius of six times the nominal pipe diameter or greater may be made without subsequent stress relieving. No cold bending is allowed on pipe larger that 50 mm nominal diameter.

Fabricated pipe:

1) Welders and welding procedures shall be qualified in accordance with the requirements of the codes and IS:2811 (latest edition). Horizontal and/or

vertical welding qualifications shall be shown on qualification papers.

2) All welding shall have full thickness penetration and shall be done by the TIG welding.
3) The completed weld shall be cleaned of slag and spatter metal on all surfaces, and when possible the inside bead shall be ground smooth.
4) No undercutting of pipe adjacent to the completed weld will be permitted.
5) Finished welds shall project not less than 1.5mm but not more than 3mm from the outer surfaces of the pipe.

Electrodes:

Welding electrodes shall be in accordance with IS specifications and of a recognized quality. Electrodes shall be preserved in an electrode even and only those electrodes, which are so preserved, shall be used in the welding. The electrodes shall have to be approved by the Engineer In Charge.

4) Laying

Refer Clause as above.

5) Joining

Refer Clause as above.

6) Testing

Refer Clause as above.

7) Procedure of Test

Refer Clause as above.

(iv) G.I.Piping

1) Transportation and stacking

Refer clause as above.

2) Lowering

Refer clause as above.

3) Laying & Fixing

i. Screwed GI pipes shall be jointed with screwed socked, joints, using screwed fittings, Care shall be taken to remove any burn from the ends of the pipes. After screwing white lead with a few stands of the hemp shall be applied while tightening.

ii. Compounds containing red lead shall not be used. All pipes above ground shall be fixed with GI holder bat clamps clear of the walls. If the pipes are fixed in chases or embedded in wall, they shall be secured properly in position by grounding and pipe inside chase will painted with bituminous paint.

iii. All underground pipes shall have a minimum cover of 600mm or more as directed by Engineer In Charge.

4) Testing

i. Before any pipes are painted or covered up they shall be tested to required hydrostatic pressure.

ii. In addition to the sectional testing of water supply piping, the Contractor shall test entire installation on completion of the job to the satisfaction of the Engineer In Charge.

(v) <u>HDPE & PVC piping</u>

1) Transportation and Stacking

i. A vehicle with a flat bed, free from nails and other projections which may not cause damage to the pipe, should be used while transporting these pipes.

ii. Black polyethylene (PE) pipes may be stored either under cover or in the open. They are protected from ageing due to sunlight by the addition of appropriate type and quantity of carbon black.

iii. Coils may be stored either on edge, or sacked flatly one on top of the other.

iv. Available storage space can be further saved by 'nesting' i.e., storing smaller diameter pipes inside pipes of relatively larger diameter.

2) Handling:

Polyethylene is a tough, resilient material which is easy to handle. However, dragging pipes/coils over rough surfaces should be avoided. Unlike other plastic materials, this material is not affected by low temperature and there is no need for special precautions in handling during cold weather or even in freezing conditions.

3) Laying

i) Underground Installation:

(1) While trench work is in progress, extensive excavation should be discouraged and advance excavation, as for as possible should be limited to about one day's pipe laying work. This reduces traffic hazards and lowers risk of soil caving in. Whenever gradual curves are involved in pipe alignment, care should be taken to see that the curvature radius of the trench alignment is about 20 to 40 times the diameter of the pipes, depending on the size. These methods maximize benefits of the pipes, flexibility and hereby, reduce the occurrence of any sharp bends.

(2) When laying smaller diameter pipes, considerable savings in time and labor can be affected by using longer lengths of pipes in coils. These longer lengths in coils are available in diameters from 20mm OD to 90mm OD.

(3) In a trench, the pipe may me laid in a curvilinear pattern i.e. snaking the pipe in the trench. This curvilinear laying of pipe allows for thermal Contraction/expansions, subsequent to back-filling the trench without creating any additional stresses during seasonal changes.

(4) Trench preparation: Trench width at the crown of the pipe should be as narrow as is practicable. But it should not be less than the outside diameter of the pipe plus another 300mm to allow proper connection of the side fill. Above the crown of the pipe, the trench may be of any convenient width.

(5) Pipes, especially higher series of pipes, may be laid directly on the trimmed bottom of a trench. However, this should be done in uniform, relatively soft

fine-grand soils free from large flints or stones or other hard objects. And where the bottom can readily be brought to an even finish to provide uniform support for the pipes over their length. In other cases, the trench should be excavated to a sufficient depth below the bottom of the pipe, to allow for the necessary thickness of the selected bedding material.

(6) Bedding and side filling:

a) Clay is a unsuitable material for bedding or side/filling. Other soils excavated from the trench, such as free-draining coarse sand, gravel, loam and soils of suitable nature with adequate compaction fraction for providing support to the pipe are more suitable. Soils such as hard chalk, which break up when wetted, should not be used.

b) If the material excavated from the trench is un suitable, then granular material like coarse sand, or sand and gravel from outside sources, should be used for bedding and back-filling.

c) The thickness of the bedding, under the barrel of the pipe should be of a minimum 100 to 150mm depending upon the irregularity of the trench bottom. The bedding should be properly compacted to provide a uniform bed for the pipe. Bricks or other hard materials should not be placed under the piper even as temporary supports.

(7) After the pipes have been laid and tested, additional material should be placed around the pipe and compacted in 75mm layers upto a level of at least 100mm about the top of the pipe.

(8) Back filling: Material excavated from the trench may be used for the remainder of the back filling. It could be compacted in 150mm layers. Alternatively, it should be in compliance with the special requirements of local or other authorities.

4) Above ground Installation:

A high rate of linear expansion of exposed pipe section can be expected.

A. Joining:

a) Welded Permanent joints:

These are effected by but welding employing of fusion technique. Clean, leak-proof and permanent joints can be affected through the following steps.

i. Cut the pipes cleanly as required for the joint to be made.
ii. Bevel and clean the inner edge.
iii. Bring the cut surfaces together, and check for alignment.
iv. Heat the welding mirror to 210 Deg. C, either electrically or witha blow torch or other external heat sources.
v. Verify the temperature of the mirror with the help of thermo-chrome chalk. The chalk mark will turn from blue to black in about 3 seconds.
vi. Bring the freshly cut surfaces, to be joined, into contact with the mirror.
vii. Take the heated ends away from the mirror, and bring them together under slight pressure, to permit them to fuse.

b) Detachable Flange Joints:

(1) Slip the HD/MS sandwich flange over the pipe ends.
(2) Weld the collar (pipe end) to the pipes.
(3) Bring the flange faces together and tighten with bolt.

(vi) R.C. Pipes / Hume Pipes

a) Handling Pipes

At every point of loading or unloading, pipes or castings must be handled by approved lifting tackle, Unloading by rolling down planks or any other form of inclined ramp will not be allowed unless the written consent of the ER to the method proposed has been obtained. Pipes are to be carefully stacked on site with timber packing under and between the pipes.

b) Laying Pipes

i. The pipes are to be laid up the gradients beginning at the lower end. No pipe is to be laid until the trench has been excavated to is required depth for a distance of 20M, in front of the pipe to be laid. (This distance may vary as directed by the Engineer in Charge).

ii. All the pipes are to be laid perfectly true, both in line and on gradient. The pipes in a trench shall be all laid and fitted previous to the jointing being commenced.

iii. Properly fitted temporary wooden stopper shall be provided and constantly used to close the ends of all incomplete pipe lines. the stoppers are only to be removed when pipe are being laid and jointed.

c) Foundation of RC Pipes.

The foundation for the RC pipes drain or sewer if required shall be formed of cradle block or full encasement of M 20 concrete.

d) Encasing/Bedding

The pipes shall be provided with encasement/bedding etc as directed by the Engineer in Charge.

e) Jointing of RC pipes with Socket Spigot Joints.

i. The RC pipes shall be carefully laid in position over the concrete bedding or over the firm ground at the required level.

ii. The pipe shall be laid with rubber ring neoprene and laid as per standard practice.

iii. The joints shall be finished off with a fillet sloping at 45 Deg. to the side of the pipe and of days or as directed by the Engineer in Charge.

f) Installation & Testing Of Valves

1) General

a) Whenever practicable and except as otherwise specified, valve stems shall be installed in a direction suitable for easy operation.

b) Where not otherwise specified on drawings, control valves shall be located and installed so as provide the following clearance.

i) Below valves – 50mm minimum

ii) Above valves – sufficient to remove bonnet with wedge.

c) A minimum of 50mm clearance shall be kept between the surface of insulation and the adjacent surface either insulated or un-insulated. Exceptions shall have the approval of the Engineer in Charge.

2) Cleaning of Valves

d) Valves will be cleaned before installation. All possible precautions shall be taken to prevent contamination and Valves shall be inspected immediately prior to installation.

e) If a Valve is found to be contaminated in anyway, it shall be cleaned as follows:

i) Remove all foreign particles by wiping with a clean lineless cloth.

ii) Wipe interior of valve with a clean lint less cloth moistened with can trichloroethylene.

iii) If contamination is excessive, suspended the value in a degreasing tank with hand wheel uppermost. Direct a stream of liquid trichloroethylene into the rim of the valve, through both ends and against all inside surface. Flush thoroughly to remove all foreign matter.

2.19. LIST OF STANDARDS

The titles of various standards referred to in the Specification are indicated hereunder for ready reference. This list does not necessarily covers all the Standards referred to :

Standard No		Title
IS 5	-	Colours for ready mixed paints and enamels
IS 210	-	Grey Iron Castings
IS 318	-	Leaded Tin Bronze Ingots and Castings
IS 325	-	Three Phase Induction Motors
IS 807	-	Code of Practice for design, manufacture, erection and

		testing (structural portion) of cranes and hoists
IS 1239	-	Mild Steel tubes, tubular and other wrought steel fittings.
IS 1536	-	Centrifugally cast (Spun) iron pressure pipe for water, gas and sewage
IS 1537	-	Vertically cast iron pressure pipes for water, gas and sewage
IS 1538	-	Specification for cast iron fittings for pressure pipes for water, gas and Sewage
IS 1554	-	PVC insulated (heavy duty) electric cables
IS 2062	-	Steel for general structural purposes
IS 2147	-	Degrees of protection provided by enclosures for low voltage switch gear and control gear
IS 3109	-	Short link chain, Grade M (4)
IS 3177	-	Code of practice for electric overhead traveling cranes and gantry cranes other than steel work cranes.
IS 3618	-	Phosphate treatment for iron and steel for protection against corrosion
IS 3624	-	Vacuum and Pressure gauges
IS 3815	-	Point hooks with shank for general engineering purposes
IS 3938	-	Electric wire rope hoists
IS 4029	-	Guide for testing three phase induction motor
IS 4460	-	Method for rating of machine cut spur and helical gears
IS 4691	-	Degrees of protection provided by enclosure for rotating electrical machinery
IS 6005	-	Code of practice for phosphating of iron and steel
IS 8329	-	Centrifugally cast (spun) ductile iron pressure pipes for water, gas and Sewage
IS 11592	-	Code of practice for selection and design of belt conveyors
IS 13349	-	Cast Iron Single faced thimble mounted sluice gates
BS 436	-	Spur and helical gears

BS 466	-	Specification for power driven overhead traveling crane, semi-Goliath and Goliath cranes for general use
BS 545	-	Specification for bevel gears (machine cut)
BS 721	-	Specification for worm gearing
BS 970	-	Wrought steels for mechanical and allied engineering purposes
BS 1397	-	Specification for industrial safety belts, harnesses and safety
BS 1400	-	Specification for copper alloy ingots and copper alloy and high conductivity copper castings
BS 1452	-	Specification for flake graphite cast iron
BS 1663	-	Specification for higher tensile steel chain Grade 40 (Short link and pitched or calibrated) for lifting purposes.
BS 2573	-	Specification for classification, stress calculations and design of mechanisms
BS 2600	-	Radiographic examination of fusion welded butt joints in steel
BS 2903	-	Specification for higher tensile steel hooks for chains, slings, blocks and general engineering purposes
BS 2910	-	Methods for radiographic examination of fusion welded circumferential butt joints in steel pipes
BS 3017	-	Specification for mild steel forged ram shorn hooks
BS 3100	-	Specification for steel castings for general engineering purposes
BS 3923	-	Methods for ultrasonic examination of welds
BS 4360	-	Specification for weldable structural steels
BS 4772	-	Specification for ductile iron pipes and fittings
BS 4870	-	Specification for approval testing of welding procedures. Part - I : Fusion Welding of Steel
BS 4871	-	Specification for approval testing of welders working to approved welding procedures Part - I : Fusion Welding of Steel
BS 4942	-	Short chain link for lifting purposes
BS 5135	-	Specification for arc welding of carbon and carbon manganese

		steels
BS 5316	-	Specification for acceptance tests Part - 2 for centrifugal, mixed flow and axial pumps- Test for performance and efficiency
BS 6072	-	Method for magnetic particle flaw detection
BS 6405	-	Specification for non-calibrated short link steel chain (Grade 30) for general engineering purposes: Class 1 & 2.
BS 6443	-	Method for penetrate flow detection
ASTM A-36	-	Specification for Structural Steel
ASTM A-216	-	Specification for Steel Castings, Carbon suitable for fusion welding for high temperature service
ASTM A-276	-	Specification for stainless steel and heat resisting steel bars and shapes
ASTM A-351	-	Specification for castings, Austenitic - Ferritic (Duplex), for Pressure Containing Parts
ASTM A-743	-	Specification for casting, Iron - Chromium, Iron - Chromium-Nickel, and Nickel Base corrosion Resistant for General Application
ASTM A-744	-	Specification for casting, Iron Chromium - Nickel, Corrosion Resistant
ASTM B-148	-	Specification for Aluminum - Bronze Castings
IEC - 189	-	Low frequency cables and wires with Parts 1 & 2 PVC insulation and PVC sheath
AWWA C 501	-	Casting Iron Sluice Gates

3. MECHANICAL EQUIPMENT

3.1. GENERAL

The contract includes design, manufacture, testing at works, supply and delivery at site, unloading, storing till the time of erection, installation, testing and commissioning of mechanical equipment as mentioned in the following sections. The scope of the work shall include but not be limited to the following:

The mechanical equipment consists of Inlet Gates, valves, mechanical and manual coarse screens; mechanical and manual fine screens, raw sewage pumps, grit removing mechanism, Aeration equipments, decanting device, sludge dewatering unit, chlorination equipments etc. The equipment should be selected to suit the performance requirements and the prevailing site conditions. The mechanical equipment includes electrical motor, wherever applicable and shall meet the requirements as specified under electrical specifications. The requirements of various mechanical equipment's for SPS, STP and pumping mains are described hereunder.

3.2. MECHANICAL EQUIPMENTS

3.2.1. Mechanical Coarse Screen

The Mechanical Coarse Screen is to be provided upstream of Raw Sewage Pumping Station. The Hydraulic design of the Coarse Screen Channel shall be done in accordance with the CPHEEO Manual. A minimum of 3 times the width of the Chamber shall be ensured in the straight section at upstream of the Mechanical Screens.

The Mechanical Coarse Screen shall be inclined Bar Screen. It should of rake type and sturdy design to take care of all sorts of materials envisaged in the gravity sewer. The Bar Screen shall be fabricated from 50 mm x 10 mm stainless steel flats at clear spacing of 20 mm. The main frame will be fabricated out of SS 304. The framework shall support the drive mechanism platform and inspection and maintenance platform. Bars shall extend from the bottom of the Channel to a

height of at least 1000 mm above ground level and be fastened at that level to added plate.

The drive machinery shall include TEFC motor, speed reducer, head shaft etc. Mechanical raking arrangement and electrical drive shall be suitable for auto/manual operation. The guide Channel for the Screen shall be of SS 304.

The cleaning rake shall be revolving rake type with steel combs or reciprocating type. The rake shall be suitably sized for heavy duty and shaped to effectively clean the Bar Screen. A dead plate 6 mm thick shall be provided from top of the Bar Screen to prevent falling of screenings in the Channel. It shall have pivot plate at the bottom for preventing jamming of bottom shaft incase of revolving rake. The operating unit above the floor shall be totally enclosed with hinged clean outs and Inspection Doors in case of revolving rake. The sprocket chain used shall be split type. The screenings shall be dropped on Conveyor about 600 mm above the top of the Screen Channel.

For inspection and maintenance of the Screens, access ladder and suitable platform shall be constructed along the Screen Chambers to reach the Screens for closer inspection of all Screens and Conveyor System. Isolation of the Screens from the flow during either repair or due to low flow conditions or due to rotational duty shall be through manually operated Sluice Gates placed in the upstream and downstream of the Screen Chambers. Hand Wheels shall be placed for operation of Sluice Gates at a suitable elevation along the local operating platform, which shall be provided with handrails. The Sluice Gates shall confirm to IS: 13349. Necessary Manual Sluice Gates shall be provided at upstream and downstream of the Chamber for isolating the Screen when it is taken out of service.

Mechanical Coarse Screen

Type	:	Inclined with reciprocating rake
Clear Spacing	:	20 mm
Size of Bars (Minimum)	:	10 mm x 50 mm
Inclination	:	60 degree to 75 degree max

Material of Construction

Bars	:	SS 304
Main Frame	:	SS 304
Rake Carriage	:	SS 304
Discharge Chute	:	SS 304
Canopy for Motor	:	MSEP
Wetted Parts and all Fasteners	:	SS 304
Drive type insulation and Protection		
Type	:	TEFC
Insulation	:	Class F
Protection	:	IP 56
Inspection Category	:	A
Acceptable Makes	:	HEADWORKS/ JASH / JOHNSON / HUBER

Mechanically Cleaned Screens - General Description

1. The mechanically cleaned deep water Screens shall be constructed which shall be of appropriate materials to suit the application with adequate corrosion protection.
2. The Screen shall be suitable for installing in Wastewater Pumping Stations for removal of floating and oversized materials coming with the wastewater. The Screens should be capable to screen out most of the medium & large floating and oversized material such as plastic rags, debris, weeds, paper, cloth, rags etc. which could clog the waste water pump impellers.
3. The cogwheels and chains should be so located that these are out of the flow of water.

4. The Screen shall have a built-in discharge chute and a scraper. The scraper should be so designed that it effectively scrapes the screening of the rake in a manner that the raked waste discharges in the discharge chute and does not fall back again into the Channel.
5. The Screen shall be factory assembled and tested at the Manufacturer's Works before dispatch. It shall be dispatched factory assembled.
6. The Screen frame shall be in stainless steel (SS 304) with width as 300 mm from all sides and thickness of 8 mm all along.
7. At site it shall be installed resting on deep inlet chamber floor and sidewalls in a manner that there are minimum chances of misalignment. The screens shall be anchored to the floor / side walls using Stainless Steel fasteners.
8. The screening from the Screen discharge chute shall be deposited in a wheeled Trolley. The chute height shall be minimum 0.6 m above Conveyor Belt.
9. The complete screen above ground level (except for drives & gear reducer) shall be enclosed in a metal enclosure using MSEP sheets and shall be suitably braced with mild steel angle frame. The enclosure shall be such that the covers can be easily removed for inspection and maintenance.

3.2.2. Manual Coarse Screen

One Manual Coarse Screen is to be provided up stream of Raw Sewage Pumping Station. The hydraulic design of the Coarse Screen Channel shall be done in accordance with the CPHEEO Manual. A minimum of 3 times the width of the Chamber shall be ensured in the straight section at upstream of the Screen.

The cleaning screen shall be manual rake type arm to take out the screenings on to a platform / draining board for collection and transfer.

For inspection and maintenance of the Screen, access ladder and suitable platform shall be constructed along the Screen Chamber to reach the Screen for closer inspection the Screen. Isolation of the Screen from the flow shall be through manual Sluice Gates placed in the upstream and downstream of the Screen Chamber. Hand Wheels shall be provided for operation of all Sluice Gates at a suitable elevation along the local operating platform, which shall be provided with Handrails. The Sluice Gates shall confirm to IS: 13349.

Manual Coarse Screen

Number of Units	:	01
Type	:	Inclined with Manual Rake
Clear spacing	:	20 mm
Size of bars (minimum)	:	10 mm x 50 mm
Inclination	:	45 degree to 60 degree max

Material of Construction

Bars	:	SS 304
Main Frame	:	SS 304
Wetted parts and all fasteners	:	SS 304.
Acceptable makes	:	JASH / JOHNSON / HUBER / SHIVPAD / VOLTAS

Manually Cleaned Screens - General Description

1. The manually cleaned Screen to be provided in deep water Chamber. The Screen Bars will extend to at least 0.5 m above the high water level where there shall be concrete platform with screening & draining facilities. This platform could also be used for the rake operation.
2. The screenings shall be collected on the platform using the rake and then be placed in a Bin / Bucket and lifted to the top using a rope and pulley operated Bin / Bucket Liting Device. The Lifting Device should have adequate Safety Devices to prevent its fall on to the platform.
3. The Screen shall be suitable for installing in Wastewater Pumping Station for

removal of floating and oversized materials coming with the sewage and be capable to screen out most of the medium & large floating and oversized materials such as plastic rags, debris, weeds, paper, cloth rags etc. which could clog the impeller of Raw Sewage Pumps. The Screen shall normally operate as a standby to be used when any Mechanical Screen is under maintenance.

4. There shall be a ladder with a protection cage to the Manual Screening Platform fabricated from suitable Mild Steel Sheets.
5. The Screen shall be factory assembled and duly tested at the Manufacturer's Works before dispatch.
6. At site it shall be installed resting on deep floor and sidewalls of the Chamber in a manner that there is a minimum chance of misalignment. The Screen shall be anchored to the floor / side walls using stainless steel fasteners.

Manually Cleaned Screens & Accessories

1. The Manual Screen shall be used only when any of the Mechanical Screens is under breakdown / maintenance and it shall be used using the Manual Penstock Gate as described below.
2. The flow diversion shall be done using Manual Penstock Gate. The headstock of the Gate shall be located at the top of the Chamber.
3. The use of Manual Screen shall be kept to a minimum and shall not exceed 120 hours per year.

3.2.3. Control Panel

The control panel shall have IP 65 protection, painted with epoxy paint and shall be comprising of

- Mushroom head emergency stop.
- Electronic overload relays for motor protection / reset switch.
- Circuitry to operate the screen with ultrasonic level sensor.
- Selector switches to operate the screen in Auto, of and JOG mode.
- Provision to run the screen on timer in case of failure of level sensor.
- Phase sequence motor.

3.2.4. Shop Testing

The screen should be completely manufactured and offered for inspection at the plant of the manufacture confirming the above mentioned eligibility criteria. A screen assembled by a vendor and offered for inspection at the plant of a vendor/ sub contractor shall not be accepted. The screen shall be subjected to following tests at manufacturer's premises for third party inspection with TMC representative(s):

Dimensional Check: The overall dimension of the screen shall be conforming to the approved drawings.

Operational Test: The complete screen including its carriage, rake, drive system and brake motor shall be mechanically operated and tested to verify interference free movement and satisfactory operation.

3.2.5. Submersible Pumps

3.2.5.1. General

a) The total head capacity curve shall be continuously rising towards the shut off with the highest at shut off.
b) Pumps shall be suitable for single as well as parallel efficient operation at any point in between the maximum and minimum system resistance.
c) The pumps shall be designed to handle solid sizes of upto 100 mm for handling raw sewage and 40 mm for handling sludge.
d) Pumps shall run smooth without undue noise and vibration.
e) The pump set shall be suitable for starting with discharge valve open and/or closed.
f) The pump set shall be capable of withstanding the accidental rotation in reverse direction.

3.2.5.2. Features of Construction

a) Pump shall be centrifugal, vertical spindle, non-clog, wear resisting, single stage type.

b) Pump casing shall be of robust construction. Liquid passages shall be finished smooth and designed as to allow free passage of solids. The volute tongue shall be filed to a smooth rounded edge.

c) Double Mechanical seals shall be provided to protect the motor from ingress of sewage along the shaft. The preliminary and secondary seals shall be oil lubricated with tungsten carbide or silicon-carbide faces and they shall be equipped with an electrical monitoring system for seal failure detection.

d) Impeller shall be non-clog enclosed type with smooth blunt edges and large water ways so as to allow free passage of the large size solids. It shall be free from sharp comers and projections likely to catch and hold rags and stringy materials. The number of impeller vanes for pumps upto 1000 m3/hr shall be limited to two and shall be limited to three for the pumps higher than 1000 m3/hr.

e) The critical speed of the rotor shall be at least 30% above the operating speed.

f) Pump sets shall have double bearings. The bearing life shall be minimum 40,000 hrs of operation.

g) Each pump shall be complete with a cast iron delivery connection arrangement for fixing to the concrete floor of the suction well. The joint between the pump discharge flange and the delivery piping shall be made by merely lowering the pump into guide rails / rope from access level. It shall be provided with all necessary fixings for guiding the pumps during lifting/lowering.

h) The pump delivery size shall not be less than 200 mm.

i) Each pump shall be provided with an automatic coupling device for attaching the chain pulley block hook to the pump at low level, even whilst the pump is submerged, without the need for personnel to enter the well. This automatic coupling device shall easily and automatically couple and uncouple the hoist hook and be complete with necessary accessories. All links and cables shall be multi-stranded stainless steel.

The materials of construction for submersible pumps shall be as follows:

Sr. No.	Component	Material
(i)	Impeller*	Stainless steel: ASTM A 743
(ii)	Casing*	Cast Iron to IS : 210 Gr. FG 200 with 1.5 to 2% Nickel
(iii)	Shaft*	Stainless Steel: BS : 970Gr. 316
(iv)	Bush	Bronze IS 318 Gr. L TB2..
(v)	Guide rail pipe	Stainless Steel: BS : 970 Gr.
(vi)	Fastens and Foundation Bolts	Stainless Steel : BS : 970 Gr.

* Material test certificates shall be furnished by the Contractor

3.2.5.3.Induction Motor (Submersible Pump)

Performance and Characteristics

a) The submersible motor shall conform to IS: 9283: 1979 and the submersible cable shall conform to clause no. 4.4 of the IS: 9283: 1979.

b) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under the following supply conditions:

(i) Variation of supply voltage from rated motor voltage: ± 10%

(ii) Variation of supply frequency from rated frequency : ± 5%

(iii) Combined voltage and frequency variation : ± 10%

c) 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.

d) Motors shall be suitable for full voltage direct-on-line starting or star-delta starting.

e) 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 to maximum permissible voltage.

f) The locked rotor current of the motor shall not exceed 600% of full load current

(subject to tolerance as per the applicable standard) unless otherwise specified.

g) Motors shall be designed to withstand 120% of rated speed for two minutes without any mechanical damage in either direction of rotation.

h) The motor vibrations shall be within the limits specified in applicable standard unless otherwise specified for the driven equipment.

i) Except as mentioned herein, the guaranteed performances of the motor shall be met with tolerances specified in applicable standard, IS: 9283-1979.

j) The enclosure for motor shall be IP-68.

k) Protection against increase in stator winding temperature (150°C) bearing temperature, leakage in stator housing and terminal box shall be provided. Minimum three number thermistors in series are to be provided to sense the stator winding temperature. Sensors are to be provided to detect if leakage of sewage into the oil housing is above 30% concentration.

l) Bimetallic thermal switch to trip the motor against increase in temperature shall be provided.

m) The power rating of the motor shall be larger of the following:

(i) 115% of the power input to the pump at duty point at a speed corresponding to the frequency of 48.5 Hz.

(ii) Maximum Power input while operating single pump corresponding to the speed of 50 Hz.

3.2.5.4. Submersible Cable

a) The power cable shall be PVC insulated and PVC sheathed, flexible, 3.5 core flat type. The size of the conductor shal1 be adequate for continuous use under water and air. The half core shal1 be used for earthing.

b) The control cable shall be PVC insulated PVC sheathed, flexible, flat type and shall be adequate for continuous use under water and air. The control cable for stator winding temperature sensor (Thermistors) shall be 3 core x 2.5 sq. mm copper conductor and for bimetallic thermal switch 2 core x 2.5 sq. mm copper conductor shall be provided.

c) In case a joint is required to be made between the lead cable supplied with the motor and the user's cable connectors, a detailed procedure of cable jointing to make a watertight joint shall be provided by the manufacturer.

d) The size of the conductor and length of cable should be suitably selected so that the voltage drop at motor terminals does not exceed 3 percent of the rated voltage.

3.2.5.5. Earthing

a) Earthing of the motor shall be done in accordance with the relevant provisions of 18:3043: 1966.

b) For the purpose of earthing these motors, earthing connection may be made to discharge pipe.

3.2.5.6. Insulation

a) Any joints in the motor insulation such as at coil connections or between slot and end winding sections, shall have strength equivalent to that of the slot sections of the coil.

b) The insulation shall be given tropical and fungicidal treatment for successful operation of the motor in hot, humid and tropical climate. The tropicalising treatment shall be as per the applicable standard.

c) The stator winding shall be made from high conductivity annealed copper conductor. PVC insulated winding wires conforming to IS:8783: 1978 for wet type motors. The stator winding shall be of high conductivity annealed copper enamelled insulated wires conforming to IS:4800 (Part - VII): 1970 for dry type motors.

3.2.5.7. Temperature Rise

The temperature-rise test of the motor shall be taken with the motor coupled to the suitable pump to give the full load output of the motor. When the various temperatures are stabilized, the set is stopped and the temperature-rise of the stator winding by the resistance method shall not exceed 35°C. During the test, the temperature of the cooling water may not exceed 35°C. As the cable resistance will also be substantial, it is necessary that while calculating the temperature rise by resistance method, due care is taken to account for the correct hot and cold resistance of windings.

3.2.5.8. Constructional Features

The motor shall be suitable for continuous use in fully or partially submerged condition. A built in cooling system must allow the motor to operate continuously at its rated output regardless of whether the electric motor is submerged or not, by providing either external or internal cooling arrangement.

3.2.5.9. Terminal Box

Terminal box shall be of weather proof construction to eliminate entry of water and suspended matter. The terminals shall be of the stud type with necessary plain washers, spring washers and check nuts. They shall be substantially designed for the current carrying capacity and shall ensure ample phase to phase and phase to ground clearance.

3.2.6. Aluminium Gates

Gates are provided for the control of the flow and for maintenance of the mechanically raked screens, grit removal system and flow division box. The gates and frame shall be of Aluminum. The frame shall be suitable for channel mounting. The gates provided are self-contained type with flush bottom and suitable for channel mounting. The water sealing will be there at two vertical sides and bottom side of gate frame by means of neoprene rubber seal mounted on shutter having

forced contact with gate opening. The gates shall be provided with manually operated headstock, which is to be mounted on yoke of the gate frame.

The gate shall be suitable for operation by one person needing effort less than 20 kg. The stem/spindle shall be of SS304. The operating/stem nut shall be of leaded tin bronze as per IS318 grade LTB1 / LTB2. The fasteners and anchor bolts shall be of SS316.

The gates shall be shop tested for smooth operation of complete assembly and the clearance between, which should be within the tolerance limit of the relevant IS.

3.2.7. Cast Iron Sluice Gates

The construction of cast iron sluice gate shall be in accordance with the specifications mentioned hereunder and as per IS:13349-1992. The sluice gate shall be capable of performing the duties set out in this specification without undue wear or deterioration. They shall be constructed, so that maintenance is kept to a minimum. The sluice gate shall be rising spindle type, except for the motorised gates.

3.2.7.1. DETAILS OF CAST IRON SINGLE FACE THIMBLE MOUNTED SLUICE GATE

1	Applicable standard	:	IS: 13349-1992
2	Shape of water way	:	Square / Rectangular / Circular
3	Size (W x H) in mm	:	mm x mm
4	Operating head from surface of water to center line of gate in meters	:	meters
5	Design head in meters	:	
	Seating head meters	:	meters
	Unseating head	:	meters
6	Distance between center line of water way to base of operating platform	:	meters

7	Method of operation	:	Manually geared operated.
8	Length and shape of wall thimble	:	As per site requirement
9	Stem	:	Rising type
10	Type of closure	:	Conventional Closure / Flush Bottom closure
11	Seating face	:	The maximum clearance between the seating surface with the slide in the closed positions hall not exceed 0.10 mm. The seating face should be fitted in dove tailed machined grooves.
12	Side and Top wedges	:	Separately adjustable type
13	Shop Testing	:	following shop test at manufacturer site will be conducted as per procedure mentioned hereunder

a. Movement Test

Movement test should be conducted in horizontal/vertical assembled condition using stems & headstock. The gate should be operated once from full close to full open and back to full close condition with a max. force of 135 Newton-meter on the crank of hand wheel.

b. Shop leakage test :

Shop leakage test by applying unseating hydraulic pressure will be conducted at manufacturer's shop. A hydrostatic pressure equal to maximum seating/unseating head shall be applied to gate at center line of gate opening from the back, i.e. Unseating face of the gate in closed position, through pump. The suitable sealed calibrated pressure gauge put on the unseating face of the gate shall indicate constant reading equal to unseating pressure head. The pressure gauge shall be placed at center line of the gate and should indicate the actual pressure being encountered by the gate. It will

not be allowed to put pressure on any other location like delivery line of pump set, etc. Water leakage through the gate under above condition shall be collected in a collection pan and measured. The leakage so measured should not exceed the limit of 2.5, 3.5 and 4.5 litres per minute per meter sealing perimeter for class-I, class II and class III sluice gates as stated in the IS:13349-1992. No alternate testing arrangement will be permitted in place of above method.

c. Hydrostatic Body test

After the leakage test hydrostatic body test will be conducted as manufacturer's shop A hydrostatic pressure equal to 1.5 times the maximum operating head should be applied on the gate for 5 minutes continuously. No permanent deformation in casting should be observed.

d. Torque test at operating head

Torque test at operating head would be head conducted at applicable head at manufacturer's shop for gates upto 2000 x 2000mm size

e. Dimensional Check

Important Dimensions shall be checked with reference to approved GA drawing.

f. Seat clearance check

g. With the gate in closed condition 0.1 mm thick feeler gauge should not pass through between seat facings

14. Indicator on C.I. headstock to be provided for gate travel with transparent / galvanized pipe hood and full scale and with additional mechanicals top nut on threaded stem.

15. Indicate number of hand wheel revolutions required to fully open the gate.

16. Wall guide brackets, bearing and coupling with housing shall be provided as per

site requirement and/or as per I.S. 13349

17. Gate Make : BATLIBOI/JASH/YASHWANT/any other make on the approved list of MJP

18. Material of Construction

	Part		Material
a.	Gate frame, shutter, wall thimble, headstock, stem guide bracket, wedging device, stop nut, lifting mechanism, pedestal gear house and nuts	:	Cast Iron IS-210 Grade FG-200
b.	Flush bottom seal retainer bar, anchor: bolts and buts	:	Stainless Steel AISI-410
c.	Wedge, wedge facings, seating face/seat facings	:	Naval Brass IS - 291 Grade 1, Grade 2
d.	Flush bottom seal (if required)	:	EPDM Rubber
e.	Stem Nut & Lift Nut LTB-2	:	Leaded Tin Bronze IS- 318 Grade
f.	All Fasteners & bolts	:	Stainless Steel AISI-304
g.	Stem & stem extension, stem coupling	:	Stainless Steel AISI-410

19. Painting

a. Paint for gate assembly and stem guide brackets : Ordinary Black Bituminous Paint

b. Paint for headstock pillar : Grey Enamel Paint

3.2.8. Knife Gate Valves

The valve should be provided with gate made of stainless steel and the gate should have beveled knife edge at the bottom to cut through and easily enter in the solids settled in the bottom and ensure positive shut-off / closure in sewage environment. The valve should be bonnet-less and suitable for face to face flange connection in between pipelines. It should be suitable for uni-directional application.

The valve body should be of Cast Iron GR.FG 260. The body shall be designed to withstand 6 bar pressure.

The valve shall be provided with replaceable type flexible seating seats to offer drop tight shut off. The seals should be made of EPDM rubber and should be held in place by an easily removable type seal retainer ring. The seal retainer ring should be designed in a manner so that the flow of the fluid should be away from the sealing perimeter and towards the center of the valve

The valve housing should have integral as cast tapered lugs provided for pushing the gate towards the flexible rubber seal only at the verge of closure with a view to avoid seal wear and achieve drop tight shut off. The surface of the gate coming in contact with the seal should be polished and buffed.

The valve shall be provided with sufficient ply of stuffing seals in the in built stuffing box to seal the rear opening. The stuffing box should have internal tappers for pushing the seals on to the gate. The seals should be of non-asbestos PTFE to reduce the friction and offer higher life. Provision shall be made to enable tighten the stuffing seals by means of a pusher arrangement to minimize the leakage through the back of the valve. Replacement of stuffing seals should be done in installed condition of the valve.

The spindle should be double start threaded and non-rising type for compact and safe operation. The gate movement area should be covered by protection shields. Gate opening indicating arrangement should be provided to find out the extent of gate opening / closing.

Flange drilling suitable to mount between flanges as per IS 1538-1993

Body Test: The valves shall be hydrostatically pressure tested at specified pressure without any visible leakage.

Seat test: The valve shall be hydrostatically pressure tested for seat leakage at 2.8 bars for no visible leakage.

	ZFT-STD-X-CI-F1-M
Body (Housing)	Cast Iron Gr. FG 260 as per IS 210
Flange Drilling	Suitable to mount between DIN PN 10/IS:1538-1993 flanges
Knife gate	Stainless Steel ASTM A 240 AISI:304
Seal Retainer Ring	Cast Stainless Steel ASTM A 351 GR. CF:8
Inlet Seal	EPDM Rubber
Gland Packing	Synthetic Yarn with PTFE
Stuffing Plate	Cast Steel Galvanized
Spindle (Stem)	Stainless Steel ASTM A276 AISI:410
Spindle Nut	Cast Iron
Supporting channels	Mild Steel Painted
Adapter plate	Cast iron / Mild steel painted
Hand Wheel	Cast iron as per IS 210 Grade 260
Fasteners	High Tensile Galvanized
Body test	10 bar (hydro-static)
Seat test	2.8 bar (Hydro-static) generally as per MSS SP-81
Painting Internal	Red Oxide
Painting External	Two coats epoxy paint RAL 5022

3.2.8.1. Pump Check Valves larger than 400 mm Diameter

All check valves larger than 400-mm diameter installed on the pump discharge shall be flanged ductile iron body, cover disc, arm and levers. The seat shall be of renewable bronze ASTM B 148. The disc shall be hinged on a stainless steel shaft. The gate pins shall also be of stainless steel. The valves shall be designed for a working, pressure of 10kg/cm square. Valve operation shall be of the oil cushioned type such that the valve swing to 90 percent closed immediately upon stoppage of flow and cushioning cylinders shall control the final closure, to prevent mechanical slamming, within an adjustable timing of one to three seconds. The valves shall be from approved manufacturers only.

3.2.9. Non Return Valves

3.2.9.1. Cast Iron Check Valves

The valves shall be swing check- valves of the lever and spring type, flanged, and shall have cast iron body and renewable bronze seat, bronze hinge, stainless

steel hinge shaft. The valve shall conform to IS 5312 and, where any of the requirements specified are not covered therein, to U.S. Federal Specification WW-V-51 D, Type IV, and Class A.

Cast Iron shall conform to ASTM A-126-66 and flanges to ANSI B 16.1. The valves shall be designed for low head loss, shall be adjustable for non-slamming closure and shall be seat-tight. An arrow showing direction of flow shall be prominently cast on body of valve. The water working pressure shall be 10 kg/cm square except that the valve shall have pressure rating same as the piping where the pipe class is higher. Valves shall be from approved manufacturer only.

3.2.10. Common Header

This specification covers the requirements for supplying, jointing and testing at work sites of ductile iron pipes and fittings including providing of mechanical joints used for rising main as common header.

3.2.10.1. Applicable Codes

The manufacturing, testing, supplying, jointing and testing at work sites of cast iron pipes and fittings shall comply with all currently applicable status, regulations, standards and codes. In particular, the following standards, unless otherwise specified herein, shall be referred. In all cases, the latest revision of the codes shall be referred to. If requirements of this specification conflict with the requirements of the codes standards, Engineer- in- Charge decision shall govern.

Sr.	IS Codes	Description
1	1536	Centrifugally cast (spun) iron pressure pipes for water, gas and sewage – specification
2	1538	Cast iron fittings for pressure pipes for water, gas and sewage
3	3114	Code of practice for use and laying of Cast iron pipes
4	12820	Dimensional requirements of rubber gasket for mechanical joints and push-on joints for use with cast

3.2.10.2. Marking

Each pipe and fitting shall have cast, stamped or indelibly painted on it the following appropriate marks.

a) The nominal diameter

b) Class reference

c) The IS number

d) Date of manufacture and

e) Manufacturer's name, initials or identification mark.

3.2.10.3. Pipe Jointing

Jointing of CI pipes and fittings shall be done as per the requirements of the following specifications and as per the relevant IS. Before jointing, extraneous material, if any, shall be removed from the inside of the pipe.

Cast Iron pipe of class B of socket & spigot/ Flanged end is recommended for the project wherever required. In general socket & spigot pipe will be used in buried condition whereas flanged end pipes will be used for above ground condition.

Type of jointing for socket & spigot pipes should be tyton push on joints. Tyton Joints:

In jointing Cast iron spigot and socket pipes and fittings with Tyton flexible joints the Contractor shall take into account the manufacturer's recommendations as to the methods and equipment to be used in assembling the joints. In particular the Contractor shall ensure that the spigot end of the pipe to be jointed is smooth and has been properly chamfered, that the rubber ring as per IS: 5382/ IS: 12820, is correctly positioned in Line, before the join is made. The rubber rings andny recommended lubricant shall be obtained only through the pipe supplier or

as otherwise directed by Engineer.

Permissible deflection at socket & spigot joints wherever necessary to deflect pipe from a straight line shall not exceed the following:

Sr	Nominal Diameter, mm	Allowable angle of deflection
1	80 to 300	5.0 degree
2	350 to 400	4.0 degree
3	450 to 750	3.0 degree

Flanged Joints:

The gaskets used between flanges of pipes shall be compressed fibre board or natural/synthetic rubber conforming to IS:638, of thickness between 1.5 to 3mm. The fiberboard shall be impregnated with chemically neutral mineral oil and shall have a smooth and hard surface. Its weight per square metre shall be not less than 112 g/mm thickness.

Each bolt should be tightened a little at a time taking care to tighten diametrically opposite bolts alternatively. The practice of fully tightening the bolts one after another is highly undesirable. The bolts shall be of mild steel unless otherwise specified.

3.2.10.4. Cleaning of Pipe and Fittings

Contractor shall ascertain that each stretch of pipeline is absolutely clear and without any obstruction by means of visual examination of the interior of pipeline suitably lighted by projected sunlight or otherwise. The open end of an incomplete stretch of pipeline shall be securely closed as may be directed by Engineer-in-charge to prevent entry of mud or silt etc.

If as a result of the removal of any obstructions Engineer-in-charge considers that damages may have been caused to the pipeline, he shall be entitled to order the stretch to be tested immediately. Should such test prove unsatisfactory, Contractor shall amend the work and carry out such further tests as are

required by Engineer-in-charge.

3.2.10.5. Use and Laying of Cast Iron Pipes

Excavation, backfilling, laying & jointing of pipe should be strictly as per IS: 3114-1994 (Code of practice for laying of Cast Iron Pipes).

The pipe and fittings shall be inspected for defects and be rung with a light hammer preferably while suspended to detect cracks. If a pipe is mishandled either accidentally or due to carelessness during unloading or lowering, it should be thoroughly inspected before laying and shall be rejected if found unsuitable.

3.2.10.6. Hydraulic Testing of Pipe Line

After the pipes and fittings are laid, jointed and the trench partially back filled except at the joints the stretch of pipeline as directed by Engineer shall be subjected to pressure test and leakage test. Where any section of the pipeline is provided with concrete thrust block or anchorages, the pressure test shall not be made until at least five days have elapsed after the concrete was cast. If rapid hardening cement has been used in these blocks or anchorages, the tests shall not be made until at least two days have elapsed.

The exposed joints shall be carefully examined and all such joints showing visible leaks shall be rectified until watertight. Any cracked or defective pipes and fittings in consequence of this pressure test shall be removed and replaced by sound material by Contractor at no extra cost to Engineer-in-charge and the test shall be repeated to the satisfaction of Engineer-in-charge.

Pressure test: The field test pressure to be imposed shall be not less than the greatest of the following

- One and a half times the maximum sustained operating pressure,
- One and a half times the maximum pipeline static pressure, and

- Sum of the maximum static pressure and surge pressure subject to the works test pressure.
- Where the field-test pressure is less than two thirds the works test pressure, the period of test should be increased to at least 24 hours.

Leakage test: A leakage test shall be conducted concurrently with the pressure test. Leakage is defined as the quantity of water to be supplied into the newly laid pipe, or any valve section thereof with in 0.035 N/mm2 of the specified leakage test pressure after the air in the pipeline has been expelled and the pipe has been filled with water.

No pipe installation shall be accepted until the leakage is less than the number of cm3/ hr as determined by the formula:
Where

qL = N x D x Sqrt(P)/ 3.3

qL = The allowable leakage in cm3/hr,

N = number of joints in the length of the pipeline, D = Diameter in mm, and

P = The average test pressure during the leakage test in Kgf/ cm

Contractor shall arrange necessary equipment and water to be used for testing at his own cost.

Damage during testing shall be Contractors responsibility and shall be rectified by him at no extra cost to Engineer-in-charge. Water used for testing shall be removed form the pipe and not released in the excavated trenches.

After the tests mentioned above are completed to the satisfaction of Engineer-in-charge, the backfilling of trenches shall be done as per

specification.

3.2.11. Mechanical Fine Screens

3.2.11.1. General

Mechanically operated Fine Bar Screen completely made of Stainless Steel (SS 304) having 6 mm clear spacing between the bars shall be provided in inlet screen channel for screening out fine floating materials such as plastic pouches, bags, rags, floating debris, weeds, paper wastes and other fine materials from the raw sewage coming from the pumping station / gravity mains.

The screen shall include discharge chute as required to discharge the screenings on the belt conveyor.

The screen shall be factory assembled, tested and shall only be installed at the site avoiding chances of misalignments.

Fine bar screen having 6 mm clear spacing between bars and suitable for installation at an inclination of 50 degrees in channel.

3.2.11.2. Specifications

Material of construction:

The fixed as well as movable bars, mechanism, support frame, fixings discharge chute shall be manufactured from stainless steel for long life in the aggressive sewage environment. No component of the screen assembly shall be made of carbon steel or any other material, which can get corroded in sewage environment.

Screen Construction

The fine bar screen shall be a complete unit comprising of main frame with an integral mechanism containing movable bars located in between fixed bars without engagement of external mechanism / rake mechanism for pulling out the screened material ensuring minimum movement of the mechanism.

The mechanism comprising of movable bars located between fixed bars shall gradually move the screened material upward and deliver on the up to the discharge chute.

The fixed as well as movable bars shall contain a series of steps to prevent the screenings from falling back into the main flow.

The mechanism shall be mechanically operated by hydraulic system and shall be suitable for automatic operation controlled by a level sensor.

The screen shall operate automatically when the upstream water level of the screen increases beyond a pre-set limit and it shall stop at home position when the upstream level decreases to a preset low level due to upward travel of screened material.

The fine bar screen shall be capable of being tilted out of the sewage flow up to horizontal position for the purpose of cleaning & maintenance.

The base of the screen shall be fitted with a specially profiled stainless steel plate to direct any grit that may be present towards the screen and taken out along with other screened material thus reducing the possibility of building up of grit in front of the screen.

Specifications

Clear Spacing	:	6 mm in one direction
Complete MOC	:	SS 304
Isolating Gates	:	CI
Inclination of Screens	:	50 degree Approx.
Bar Dimensions	:	6 mm x 50 mm

Drive Type Insulation & Protection

Type	:	TEFC
Insulation	:	Class F
Protection	:	IP-56

Material of Construction

Bars	:	SS 304
Main Frame	:	SS 304
Rake Carriage	:	SS 304
Canopy for Motor	:	MSEP
Acceptable makes	:	HEADWORKS / JASH / JOHNSON / HUBER

Control Panel

The Control Panel shall have IP 65 protection, shall be comprises of

- Mushroom Head Emergency stop
- Overload relays for motor protection
- MCB's, HRC Fuses and Glass Fuses
- Circuitry to operate the screen with Ultrasonic type level sensors.
- Selector Switch to operate the screen on JOG mode
- Provision to run the screen with a Timer in case of failure of level sensor.

Dimensional Check: The overall dimensions of the screen shall be conforming to the approved drawings.

Operational Test: The complete screen including its mechanism, hydraulic operating mechanism level probing system and control panel shall be integrated and mechanically operated to verify free movement and satisfactory working.

3.2.12. Belt Conveyor

A common belt conveyor shall be provided for collecting screenings from mechanised fine screens and manual screen. The length of the combined belt conveyor will be as per requirement of screen channel. The conveyor will drop the screening through chute in a wheeled trolley of approximate 0.5 m3 capacity. This trolley will be housed in a roofed enclosure with proper access.

Belt conveyor assembly shall consist of two pulleys with their shaft and bearings for

driving the belt and idler pulleys for supporting the belt. The upper level idler pulleys shall have three roll twenty-degree troughing idlers. The bottom level idlers for belt return shall be flat roll -type.

At the end of the belt drive, an adjustable scrapper shall be provided on the screening hopper for diverting the screening through chute to the wheeled trolley.

The belt material shall be two - ply nylon or equivalent with 3 mm neoprene covering on carrying side and 0.75 mm neoprene covering on pulley side. The speed of the belt will be between 25m to 30 m per minutes. The width of the belt shall be minimum 600 mm. The power transmission shall be by means of TEFC motor coupled to the reduction gears. The gears shall have service factor of not less than 2.25.

The whole conveyor shall be supported on steel structure over the screen channel

3.2.13. Manual Fine Screens

The manually cleaned screen shall consist of bar screen and rake arm. The bar screens shall be fabricated from 50 mm x 10 mm SS 304 flats spaced at clear spacing of 10 mm with structural steel frame work such that all bars project on upstream side and teeth of the rake engages within the clearances of the bars without hindrance. The screen shall be placed at an inclination of 70^0. The screen shall be supplied with rake arm with handle of suitable length.

Manual Fine Screen

Type	:	Inclined with manual Rake
Clear spacing	:	10 mm
Size of bars (minimum)	:	10 mm x 50 mm
Inclination	:	45 degree to 50 degree max.

Material of Construction

Bars	:	SS 304
Main Frame	:	SS 304
Wetted Parts and all Fasteners	:	SS 304
Sluice Gates	:	CI

Rake	:	SS 304 with 9 mm x 65 mm raking fingers and a user friendly handle to rake the cleaning
Acceptable Makes	:	JASH / JOHNSON / HUBER / SHIVPAD / VOLTAS/ Or Any other make Approved by MJP.

3.2.14. Grit Separator Mechanism

Grit separator, suitable for installation in the RCC tank should generally be as specified below:

3.2.14.1. Grit Collection unit

- Bridge cum walkway should span the full length of the tank, the hand railings should be 1 meter high. The walkway would be made of 5 mm chequered plates.
- Main drive head of worm gear type should be capable of handling the torque, and should be driven by a suitable motor and gearbox. There should be chain and sprocket transmission between gearbox and Drive head.
- Overload protection device should be mounted on the drive head.
- Heavy duty 100 NB vertical shaft suspended from the drive head.
- Two truss type torque rake arms fixed to either side of the shaft should be provided. Blades and scoops should be fixed to the rake arms. The rake arms should carry the grit to the discharge pocket.

Suitable number of inlet gates, adjustable type, should be provide

3.2.14.2. Classifier / Grit Cleaning & Raking Unit

- Main drive platform and two bell crank brackets to be anchored on the RCC rake channel.
- Main drive should consist of a suitable motor coupled to worm gear box. Through a gear transmission the raking unit is driven. The gear drive is should be enclosed in an oil bath.
- The raker unit should consist of front, intermediate and bottom links and together should be connected through connecting rods, reach rods, eccentric

straps, yokes, bell cranks and links. The overall balance should be maintained using counterweights.

- Bottom rake frame should be welded with the blades.
- The rake blades should bring up the grit to the top, towards the discharge end.

3.2.14.3. Organic Return Pump

- This unit should be placed directly over the return elbow suitably anchored in the tank.
- A suitable motor should drive the unit.
- The impeller in ph. bronze construction should be supported and suspended just above the elbow. The shaft should be in SS construction.
- The pump returns the organic floats back to the main collection tank.

GENERAL

- Velocity breakers and deflectors should be provided on the inlet stream.
- All wetted parts will be sand blasted and epoxy painted, using standard make bituminized coal tear epoxy paint. Other items will be synthetic enamel painted.

3.2.15. Primary Clarifier

- The Primary Clarifier Tank shall have central driven clarifier mechanism in MSEP with sewage entry through the central column. The clarifier mechanism shall have fixed half bridge resting on the central column with aluminium chequered plate of thickness 6 mm and G.I. handrails upto the wall.
- The clarifier drive will have center mechanism / drive head TEFC motor and speed reducing gearbox. The service factor for the gear will not be less than 2.5 The central drive shall have slewing ring bearing located on the central column. The scrapers ring will be attached to the lower end cage hung and driven by slewing ring drive on the top of the central column. The inlet well shall be hung from the bridge. The MOC of the inlet well shall be FRP. An overload alarm system shall be provided as an overload protection for the drive

- The mechanism shall have skimming arrangement. The squeezes will be of neoprene rubber. The V-notch weir for the clarifier will be of FRP and fixed to the R.C.C launder with adjustable S.S. fixtures for adjusting the level of the weir to have uniform flow throughout the periphery.
- All fasteners below the water level will be of SS 316 and the steel structure will be epoxy painted after sand/ball blasting to near white and after applying zinc rich epoxy primer.

3.2.16. Air Blowers

3.2.16.1. Codes & Standards

- The design, manufacture, testing and commissioning shall conform to the following IS standards in so far as applicable. Equivalent standards in BS / DIN shall also be applicable.
- BS: 1571 Test specification for lobe type blowers Compressors.

3.2.16.2. Design and construction

General

- The equipment shall be designed to perform inter changeability of parts and case of access during inspection, maintenance and repair.
- All parts subject to substantial temperature changes shall be designed and supported to permit free expansion or contraction without resulting in leakage, harmful distortion or misalignment.
- Another bolts nuts and seating steelwork shall be supplied with the equipment. Only hexagonal nuts shall be used for holding down the equipment with proper lock nuts. All bolt holes shall be spot faced for nuts. In specific cases where not necessary, spot facing may be omitted.
- Casting and welding shall conform to their respective specifications and shall be free from flaws and objectionable information, machined true and in a workmanlike manner.

3.2.16.3. Vibration isolator:

Double deflection rubber in shear or rubber in compression type vibration isolators shall be provided with each centrifugal fan. Rubber bushes, washers, wherever needed for the vibration isolators shall be included in the supply. Sufficient number of such isolators shall be provided to ensure isolation of foundation from vibration of the equipment.

3.2.16.4. Drive Motors

a) Blowers shall be provided with V-belts and sheaves. All belts shall be sized for 150% rated horsepower. All V-belt drives shall be equipped with removable guards that do not impede the airflow to the fan inlet. There shall be a minimum of two belts per drive.

b) Motors of all equipment shall be general purpose, constant speed, and preferably three-phase squirrel cage induction type of required BHP rating. The BHP rating of the motor shall provide atleast 15% margin over the driven equipment rated BHP including the drive lose.

c) Motor powers for centrifugal fans with backward curve blades and axial flow fans shall be more than limit load fan power.

d) Preferably direct drive shall be employed between motor and blower.

3.2.16.5. Materials of construction:

The following materials shall be used for the construction of various parts:

a.	'V' pulleys	-	C.I. mutigrooves
b.	'V' belts	-	reinforced rubber of appropriate section
a.	Blowers		
-	Body	-	Fine grained CI
-	Lobes	-	Fine grained CI
-	Shaft	-	alloy steel forged & heat treated
-	Gears	-	Alloy steel forged & heat treated with

induction hardening

3.2.16.6. The lobes shall be dynamically balanced.

The blowers shall be complete with suction filter, silencer, air pressure relief valves, mounting plates, foundation bolts and all other accessories as required.

3.2.16.7. Testing and inspection

- The performance of all blowers and drive motors shall be tested as per applicable standards and codes.
- The test reports and test certificates for the tests shall be submitted for review of the Owner / Engineer.
- The Owners' representatives shall be given full access to all tests. Adequate time ahead to major shop tests, the manufacturer shall inform the Owner so that, if desired, their representative can witness such tests.
- All materials, casing and forging shall be of tested quality.
- Performance test shall be conducted on blowers BS: 1571 Part-II.

3.2.16.8. Cleaning painting and packing

- The equipment cleaning and painting shall be governed by the stipulations of the subsection M.
- The equipment shall be suitably protected in respected packing for the shipping distance and the wear conditions involved.

3.2.16.9. Drawing, Curves, Information

- Besides submitting the enclosed Technical Schedule filled in, the proposal shall also include following drawings, curves and information.
- Outline and general arrangement drawings of the blower assembly of each category.
- Descriptive and illustrative literature and draw from the manufacture on the following items.

a. Blowers
b. Drive Motors
c. Other Accessories
d. Characteristic curves of blowers

- Particulars of drawings, data and instruction Manual
- The various drawings and date shall be submitted for review and afterwards for final distribution various drawings and data to be furnished shall include.
- Outline and general arrangement drawing with data material of construction and foundation requirements.
- Blower characteristic curves.
- Drawings and data sheets on drive motor
- Ducting layout drawings including duct support details and drain piping and valve.
- Other drawings and data
- Shop test reports
- Operation and maintenance instruction manuals
- List of spare parts and specific tools and tackles.

3.2.17. Air Diffusers

For specification please refer Volume II A, Scope of work

3.2.18. Secondary Clarifier

The Secondary Clarifier Tank shall have central driven clarifier mechanism in MSEP with sewage entry through the central column. The clarifier mechanism shall have fixed half bridge resting on the central column with aluminium chequered plate and G.I. handrails upto the wall.

The clarifier drive will have center mechanism / drive head TEFC motor and speed reducing gearbox. The service factor for the gear will not be less than 2.5 The central drive shall have slewing ring bearing located on the central column. The scrapers ring will be attached to the lower end cage hung and driven by slewing ring drive on the top of the central column. The inlet well shall be hung from

the bridge. The MOC of the inlet well shall be FRP. An overload alarm system shall be provided as an overload protection for the drive

The mechanism shall have skimming arrangement. The squeezes will be of neoprene rubber. The V-notch weir for the clarifier will be of FRP and fixed to the R.C.C launder with adjustable S.S. fixtures for adjusting the level of the weir to have uniform flow throughout the periphery.

All fasteners below the water level will be of SS 316 and the steel structure will be epoxy painted after sand/ball blasting to near white and after applying zinc rich epoxy primer.

3.2.19. Horizontal pumps

The pumps shall be of end suction, horizontal dry-pit type, non-clog, centrifugal type. The volute and impeller will be of cast iron with 1.5% to 2% Nickel. The pump shall be capable of handling solids of not less than 40 mm sphere size.

The pump coupling shall be flexible type and shall be provided with coupling guard. The suction and delivery shall be suitable for flange connection.

The pump shall include base frame, electric motor, coupling, coupling guard, etc. The motor shall be TEFC, 415V, 3-phase AC 50 c/s. The base frame shall be fabricated from structural steel sections. The motor HP shall be atleast 10% more than required at duty point and shall be non-overloading at other points of Q-H curve.

Sr.	Unit	Details
A	Data	
(i)	Temperature	Ambient
(ii)	Specific Gravity	1.05
(iii)	Total Head (m)	As per design
(iv)	Capacity (lps)	As per design
B	Pumping Machinery	
1	Pump	
(i)	Pump model	As per Manufacturer
(ii)	Mounting	Horizontal
(iii)	Type	Centrifugal - Non Clog

(iv)	Suction Size	As per Manufacturer
(v)	Suction Location	End
(vi)	Delivery Size	As per Manufacturer
(vii)	Delivery Location	Top
(viii)	Bearing	Ball Bearing
(ix)	Lubrication	Oil / Grease
(x)	Type of Packing	Gland
(xi)	Coupling	Lovejoy
2	Material of Construction	
(i)	Pump Casing	Cast Iron CI - IS 210 GR200
(ii)	Impeller	Cast Iron CI - IS 210 GR200
(iii)	Pump Shaft	Steel-IS-1570 C 40
(v)	Shaft Sleeve	Stainless Steel-AISI 410
(vi)	Base Plate	Mild Steel, IS:226
(vii)	Hardware	Hot Dipped Galvanised
3	Pump Performance	
(i)	Pump Efficiency	As per manufacturer Min. 70%
(ii)	NPHS 'R'	As per design
(iii)	BKW	As per manufacturer
(iv)	BHP	As per manufacturer
C	Prime Mover	
(i)	Type	TEFC, Squirrel Cage, Induction Motor
(ii)	Hp	As per manufacturer
(iii)	Rating, kW	As per manufacturer
(iv)	Speed, RPM	As per manufacturer
(v)	Frame Size	As per manufacturer

3.2.20. Chlorination System

3.2.20.1. Design

The chlorination system will consist of Vacuum type chlorinator. There shall be one working chlorination system and one standby system. The solution type chlorinator is to be vacuum type separately panel mounted. The chlorination system shall have 30 days storage of tonner for chlorination. The system shall

have manual reset visual indicator signals when the chlorine gas supply is exhausted or interrupted. The material of construction of the chlorinator shall be resistant to corrosive action of dry and moist chlorine gas and chlorine solution.

The chlorinator shall be provided for a average flow of STP capacity with a maximum dose rate of 5mg/litre and achieve a residual chlorine of 0.5 mg/l. There shall be 2 chlorinators for chlorination of which one will be operating and the other stand by. Each chlorinator shall have the following facilities-

- Manual adjustment of dose rate
- Gas inlet pressure gauge
- Injector vacuum pressure gauge
- Gas filter
- Internal gas inlet pressure reducing valve
- Flexible connectors
- Safety vent

The chlorinator and chlorine cylinder shall be arranged in chlorine house with partition. Doorways to the room shall be shown as outward opening. Suitable storage for empty drums should be provided. The chlorination system will work on 1 working and 1 stand by basis and automatic switch over to standby chlorinator with alarm raising system should be provided.

3.2.20.2. Chlorine Pipe Work

The standard required for the pipes and the fittings shall be as under:

- Pipe work for chlorine gas near the chlorinators shall be of flexible copper pipe.
- Valve shall be of globe type with forged steel body.
- Gland packing shall be of Teflon.
- Pressure gauges of silver diaphragm type.

3.2.20.3. Booster Pump

The Contractor shall supply one centrifugal booster pump for each chlorinator. Water

supply will be from the backwash water tank which is to be constructed by contractor at

his cost on chlorine house. The pump sets shall be complete with the following units:

- Strainer
- Sluice valve on suction side
- Sluice valve on delivery side
- Reflux valve on delivery side
- Lot GI piping upto the injector
- Pressure gauge on the header

For the post chlorinators the pumps will be so connected that any pump can work with any chlorinator.

3.2.20.4. Safety Equipment

The Contractor shall provide the following safety equipment as a minimum:

- 2 canister type respirators with full face coverage mask suitable for chlorine gaseous atmosphere
- 1 eye wash arrangement/shower and wash basin.
- 25 canisters for respirators
- 2 external wall mounted glass fronted cabinets for the breathing apparatus and for the respirators
- 2 self-contained compressed air-breathing apparatus complete with warning whistle and 2 spare air cylinders.
- Emergency kit for attending chlorine gas leakages (three types)

3.2.20.5. Chlorine Tonners and Tonner Store

The Contractor shall supply chlorine tonners and rented tonners each of 900 kg for 15 days usage. The tonners shall be arranged in two rows. The centre to centre distance of the drums and of the rows should be adhered to for safety aspects.

The Contractor shall provide a over head travelling gantry arrangement with safety type hook and drum lifting beam to handle the drums. The pipe work from the drums shall be rigidly fixed to the walls and supported on the lamp-posts.

One on line and stand by chlorinator will be supported on load cells to allow drum contents to monitored.

3.2.20.6. Construction

The conceptual design envisages a structure for the chlorination room and chlorine cylinder store. Both the structures shall be covered with a flat RCC slab. No intermediate columns shall be provided in the cylinder store.

One lime pit of sufficient dimension shall be provided adjacent to the cylinder store to enable any leaking cylinder to be immersed in the same easily.

The Contractor shall so layout the units that the minimum handling is involved in picking up the cylinder from the trucks and mounting them on saddles or handling of Cl2 tonner shall be easily/directly done by gantry girder from truck to room and vice-versa.

3.2.21. Sludge Thickener

The Thickener is to be provided for thickening of the sludge from the Primary and Secondary Settling tanks. The scraper mechanism is provided in the thickener tank to scrap the settled solids from the bottom of the tank such that the sludge moves to center sludge pocket.

The thickener will have central drive, with inlet from the side. The bridge drive will have TEFC motor and speed reducing gearbox. The service factor for the gear will not be less than 2.5. The squeezes will be of neoprene rubber. The V- notch weir for the thickener will be of FRP and fixed to the R.C.C launder with adjustable fixtures for adjusting the level of the weir to have uniform flow through out the periphery.

All fasteners below the water level will be of SS 316 and the steel structure will be epoxy painted after sand/ball blasting to near white and after applying zinc rich primer.

3.2.22. Mechanical Dewatering System (Centrifuge)

Centrifuge shall be used as mechanical dewatering system

3.2.22.1. General

a) The centrifuge shall be of continuously operating, solid bowl centrifuge and horizontally mounted. It shall be suitable to handle municipal sludge containing 1% to 4% dry solids to be de-watered upto 20 % minimum and maximum 30% of dry solids per hour. The frame shall be of open design with gravity discharge of the dewatered sludge.

b) The material of construction at all the parts coming in contact with the liquid shall be in AISI: 316 grade (stainless steel).

3.2.22.2. Construction

a) Housing:

The housing shall consist of a welded frame with supporting feet, motor bracket, guards and collecting vessel/catcher for the product discharges. Vibration absorbers shall be provided for the machine to supporting feet to prevent most of the vibrations from the machine being transferred to the foundation.

b) Bowl and conveyor screw:

The decanter shall be equipped with flat angle cone bowl with cylinder and cone. The solids discharge shall have replaceable wear bushings and shall be protected against wear and tear. The conveyor scroll shall be of single threaded design and wear protected.

c) Drive:

The bowl shall be driven by a V-belt transmission on the shaft at the conical end. Power shall be transferred to the conveyor by a two stage planetary gear box at the opposite end. An overload protection device shall be provided for the gear box.

d) Drive motor:

The motor shall conform to IS 325 and shall be of weatherproof, jet proof and tropicalised construction.

The motor shall conform to the following date:

Type of motor	3 phase, 4 pole, 415 V, Squirrel Cage
Type of duty	Continuous (S I)
Class of insulation	F
Type of enclosure and cooling	TEFC
Degree of protection	IP55
Maximum motor speed	1500 rpm
Method of starting	to suit the duty
Motor protection	Thermistor

(e) The material of construction shall be as follows:

Sr. No.	Component	Material
(i)	Bowl	Stainless steel: AISI 316
(ii)	Conveyor	Stainless steel: AISI 316 and wear protected
(iii)	Casing cover	Stainless steel: AISI 316
(iv)	Frame	M.S

3.2.23. Biogas Flaring System

Gas flaring system shall be installed to burn excess biogas generated at the STP. The burning capacity of the flare shall be 100 m^3/hr. The biogas flaring system shall consist of the following equipment.

a. Moisture separator
b. Flame Arrestor
c. Check valve
d. Pressure regulating valve
e. Flare gas burner (6m height from ground level)
f. Pilot gas burner with push button ignition complete with ignition electrode
g. Diaphragm type pressure gauge
h. Low gas pressure switches.

3.2.23.1. Flare Gas Burner

The Flare Burner for biogas incinerates the biogas completely and releases environment friendly gases after combustion. It thus protects the environment and surrounding equipment.

Complete incineration can be done by having high temperature, stociometric gas mixtures flame. To achieve this aspirator type pre-mixing burner is made for complete combustion.

To start flare burner, spark igniter initiates the pilot burner. The pilot flame is checked with the help of flame monitor (Flame Rod). As soon as the pilot flame is provided a visual indication on the panel will appear than the main biogas control valve can be opened. To prevent blow off at high winds the aerodynamically designed windshield is provided.

3.2.23.2. Pilot Burner & accessories

Duty	To flare biogas completely
Capacity	0 - 100 cum/hr
Quantity	1 no.
Type	Aspirator type
Inlet Mounting	Flanged 6” NB as per BS Table 10D.
Working pressure	50 mm WC to 500 mm WC
Accessories	

SS 316 Wind Shield to prevent blow off at high winds
Provision for fixing of Pilot Burner, HT Electrode and Thermal flame sensor. Material of Construction

Wind shield	SS 316
Burner	CI
Mounting Flange	CI
Mounting	Flange mounted vertical position

3.2.23.3. Pilot Burner

Duty	:To ignite the biogas
Type	: Premixing type with air aspirations

Material of construction	: SS 316
Mounting	:Threaded on to Flare Burner

3.2.23.4. Ignition System

It consists of SS 316 ignition electrode. The pilot burner will have flame proof solenoid valve.

3.2.23.5. Pressure Gauge

Type	Diaphragm type with isolation valve
Range	0-1000 mm WC
Type	Diaphragm type
Dial size	6”
Wetted Parts	SS 304

3.2.23.6. Check Valve

Size	6”
Type	Flap type
End flanges	As per SS table 10D

Material of Construction

Body	CI
Valve seat	Aluminum/SS/Bronze
Flap	SS 304 / Nylon

3.2.23.7. Gas Flow meter with Indicator and Totaliser Unit

Flow Indicator / Totaliser Unit (Electronic Registration)

Flow indicator Totaliser is used to monitor the flow of gas. Input from venturi type gas flow meter is processed linearly or square rooted to the requirement.

Flow rate is indicated on 3½ digit 7 segment LED / LCD display and totalized value of flow on Electromech / LCD / LED counter having reset facility. The general technical specifications are given below:

Power supply : 230/110V AC ± 10%, 50 Hz

Operating temperature : 0^{o} C to 55^{o} C

Input : 220 V AC / 24V DC ± 10%,

Flow rate : --

Display for flow rate : 3½ digit 7 segment LED / LCD

Polarity indication : Automatic

Decimal point indication : Factory set to suit range/scale of indication of Engineering unit selected Accuracy: Better than ± 0.5% of span

Relay contact rating : 1A one changeover at 230V AC resistive

Specifications for totalizing : Totalizing accuracy ± 0.5% of full scale, input clipping i.e. flow cut-off 0 to 17% of span

Specifications for square Rooting : Square rooting accuracy ± 0.5% of full scale

Total 2 nos. of gas flow meters of suitable capacity shall be provided for measuring flow

rate of biogas at the STP before gas dome and before main line going to DFG station.

Each flow meter shall be provided with electronic gas flow registration unit. These registration units shall be placed in a composite panel at the STP Panel room. Single phase, 230 Volt AC supply shall be given to the composite panel for gas flow registration units from STP MEP Panel.

Type : Microprocessor based Panel mounted Flow Indicator/Totaliser

Input : Analog user configurable to 4-20 mA, 0.5V, and 0-10 V

Display : LED, toggle between Rate of gas flow Totaliser, Peak and Valley

Totaliser : 6 digit confurigable to reset/non-reset options

Rate of Flow : 5 digit, configurable to any engineer unit or time base

Alarm/Presets preset batching : 10A relays configurable to Rate of flow of alarms

or Control Output : 2 potential free relays, configurable to flow rate alarms or batching

Reset : From front keypad to remote pulse

Programming : User configured zero/span settings for input and output

Memory : Upto 10 years memory retention in the event of main failure

Transmitter power : 24 V DC transmitter supply available from 7000 TR

Output : 4-20 m a, analog output linear to flow

Power Supply : 230 V (10% 50 Hz AC

Housing : Standard 1/8 D/N ABS panel mounting enclosure

3.2.23.8. Flame Arrestor

Flame arrestor is provided to prevent the passage of flames if formed accidentally in gasholder or associated pipe network. The flame arrestor, a safety device is recommended for use in venting vessels, storage or transport tanks, protection of fuel / air supply line to gas burners and in industrial plants at temperatures not exceeding above 200^{o}C.

The flame arrestor shall be mounted with the axis vertical and as close as possible to the potential source of ignition. The flame arrestors are provided at the top of each Gasholder. Two nos. flame arrestors are also provided in gas pipeline going to the gas burner and pilot ignition of the gas flare system.

Flame arrestor consists of a tube bank made of spirally wound alternate layers of flat and corrugated stainless steel sheets built around a solid core. The tube offers a multiplicity of small holes parallel to the line of flow. The tube element is retained between two flanged end sections and contained within a steel outer shell. The arrestor assembly shall be fitted with a weather hood. The flame arrestor shall be provided with crimped ribbon design. This enables the unit to be manufactured to very low tolerances and hence can be efficiently size selected to suit the range of application. Pressure drop across the arrestor

shall be very low and the unit shall be suitable to take high gas flow rates.

The flame arrestors are designed as per British Standards BS: 7244-1990 to ensure maximum safety.

The flame arrestors mainly consist of an arrestor element, an arrestor housing and associated fittings necessary for preventing flame de-flagration.

The flame arrestor has been designed specifically for biogas falling in Group 1 of British Standards. (Classification of gases BS 4663 Part 2 and BS 5501 Part 1).

The flame arrestor element is a crimped metal element and is made up of SS 316 to have long life and maximum quenching of flame.

3.2.23.8.1. Technical Specifications

Size	:	6” NB line
Element	:	Crimped metal element
End connections	:	Flanged as per BS Table 10D
Hydrostatic Test Pressure	:	5.0 kg/cm^2
Gaskets	:	CAF Gaskets

3.2.23.8.2. Material of Construction

Housing	:	CI
Flame bank	:	SS 316
Nut & Bolts	:	CS
Flanges	:	CI

3.2.23.8.3. Quantity

6” for gas holders	:	Min.1 No
6” for pipeline in main gas burner	:	Min. 1 No
2” for pipeline to pilot burner	:	Min. 1 No

3.2.23.9. Moisture Trap

The moisture trap is device used for separation of moisture/vapors in two-phase flow in order to reduce corrosion, control problems, efficient and safe combustion of biogas.

The biogas has H2O vapours and traces of H2S. The gas becomes acidic after H2O and H2S combines thus starts corroding the piping and equipment. The presence of this causes a deposition of surfaces and control valves thus affecting that function.

The effect of moisture in biogas burning is to have quenching of flame. Also, latent heat of vaporization is consumed by the vapors during combustion thus reducing the efficiency.

The moisture separation can be done by the following methods.

a) Centrifugal action

b) Impingement action

In centrifugal action the gas is made to rotate at high velocities. The centrifugal force causes the vapours to hit the wall of the chamber. When the vapours hit the wall they also coalesce together to form biogas droplets. These droplets get accumulated in the reservoir just below the moisture separator chamber.

In impingement action the biogas is made to hit a perforated steel wall at high velocity. Due to inertia the vapours do not accompany the biogas after it hits the wall. The moisture vapours then coalesce together to form big droplets and get accumulated in the reservoir. The water accumulated in the reservoir is taken out through auto or manual drain valve. It is proposed to use impingement type moisture trap.

The material for the moisture separator conforms to IS 2062. An epoxy coating is done after surface preparation by sand blasting. The Drip-trap is tested for a pressure of 3.5 kg/cm2 for any leakage or joints. Compressed asbestos gaskets are provided for strong leak proof joints.

3.2.23.9.1. Installation and Operation

Moisture traps shall be installed as specified below in quantity and size. Connect the drain line to a drain-pit through suitable pipe.

Observe the drain level in the peeping window and if the drain level is high open the drain valve till all the accumulated water is drained.

3.2.23.10. Type

Impingement baffle type. The impingement of gas on specially designed perforated baffles is used to achieve moisture separation. The baffles shall be to the drip trap tank for easy accent for cleaning

3.2.23.11. Inlet & Outlet Connections

Flanged 4”/6”/8” NB. The flanges will be as per British Standard Table ‘D’. The flange shall have two nos. joint grooves 25 mm apart.

3.2.23.12. Moisture Drain

1” NB outlet port with auto-drain valve.

Baffles

The baffling arrangement of perforated sheets of SS 304 to remove moisture from the biogas. The baffle will have guides so that moisture will coalesce and the droplets are drained and accumulated in the drip tank.

The baffling arrangement is fitted onto the tank so that it can be removed and cleaned for routine maintenance. The top cover shall be flanged for easy access to internals of drip trap.

Testing

The drip traps shall be pressure-tested up to 3.5kg/cm^2 with compressed air/hydraulically

Painting

All the parts of the equipment shall be painted with two coats of epoxy primer. The external surface shall be painted with epoxy paint. The paint will be done after

proper surface preparation i.e. sand blasting as per out standard practice.

3.2.23.13. Welding Joints

All the parts of the equipment - All welding / joints shall be done as per IS specifications.

Flanges and Gaskets

The flanges will be as per British Standard Table 'D' CAP gaskets of 3 mm thickness

Quantity and Sizes

For common pipelines coming from each UASB Reactor	:	4 nos.
For main gas pipeline	:	4 nos.
For pipeline going to Gas Flare	:	1 no.
For pipeline going to DF Gensets	:	1 no.

3.2.24. Filtrate Transfer Pumps

Two units of filtrate transfer pumps with one working and one stand by shall be provided.

The pumps shall be of end suction, horizontal dry-pit type, non-clog, centrifugal type. The volute and impeller will be of cast iron with 1.5% to 2% Nickel. The pump shall be capable of handling solids of not less than 40 mm sphere size. The speed of the pump shall be less than 1,500 rpm.

The pump coupling shall be flexible type and shall be provided with coupling guard. The suction and delivery shall be suitable for flange connection.

The pump shall include base frame, electric motor, coupling, coupling guard, etc. The motor shall be TEFC, 415V, 3-phase AC 50 c/s. The base frame shall be fabricated from structural steel sections suitably galvanised. The motor HP shall be atleast 10% more than required at duty point and shall be non-overloading at other points of Q-H curve.

3.2.25. EOT Crane

It shall be single girder EOT crane with chain electric hoist.

Minimum capacity	:	As per design
Span	:	As per design
Height of lift	:	As per design
Type of operation	:	Pendent type
Gantry rail	:	40 x 40 sq. bar
Power supply	:	440 V, 3 PH, 50 Hz

Electric hoists shall be complete with hoisting motor, wire rope drum, wire rope, hook, necessary gearing, sheaves, electromagnetic brake for hoisting motion, weather and 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 or welded to sustain concentrated loads 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 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 a 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 x 106 kN/sq.m.

Hooks shall be solid forged, heat-treated alloy or carbon steel or rugged construction of the single hook type and provided with a standard depress type safety latch.

Hoisting motor shall be equipped with electrically released, spring set, fiction 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 part switch is in the ‘OFF’ position or in the event of power failure.

Driver motor shall be designed for frequent reversal, breaking 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.

3.2.26. Monorail Trolley and Chain Pulley Block

Monorail trolley and the chain pulley block shall be provided for maintenance of, filter press, sludge pumps, etc.. The trolley and the chain pulley block shall be hand driven. The capacity of trolley and chain pulley block shall be sufficient to remove complete unit; however, it shall not be less than 3 tonne.

The trolley shall be gearless and shall have four wheels to run on the lower flange of the rolled steel joist. The wheels shall be of carbon steel casting. The trolley shall have arrangement to fix the chain pulley block.

The chain pulley block shall have spur type gears, load sheave, brake unit, hand chain wheel, load chain wheel and hooks for suspension on monorail trolley and load. Each chain pulley block shall be provided with 2 m long GI sling and set of GI D-shackles.

3.2.27. Instrumentation

3.2.27.1. Level switches

Level switches shall be provided in the raw sewage sump. The operation of the raw sewage pump shall be as per the level of the liquid in the sump. During peak flow both the pumps shall be in operation and during lean flow only one pump shall be in operation. The start and stop of the pump shall be automatic.

3.2.27.2. Ultrasonic flow meter

The ultrasonic flow meter shall be provided in the downstream side of the grit channel. It shall have digital type indicator, integrator and recorder fixed in the admin block.

3 ERECTION, TESTING AND COMMISSIONING

4.1. TESTING - GENERAL

a) Testing of the plant at the manufacturer's premises will be required in accordance with the Conditions of Contract. All inspection, examination and testing shall be carried out in accordance with appropriate standards.

b) All instruments used for such tests shall be calibrated and certified by an approved independent testing authority not more than 2 months prior the test in which they are used. The Engineer-in-Charge reserves the right to impound any instrument immediately after test for independent testing. A certificate shall be produced by the Contractor prior to carrying out every test showing the reading obtained calculations and full details of the calibration certificates referred to.

c) If the Engineer-in-Charge witnesses a test he shall be given a copy of the test results and certificates immediately. Whether he witnesses a test or not, copies of test certificate shall be sent to the Engineer-in-Charge. No item of the plant shall be forwarded to the site until its test certificate has been approved in writing by the Engineer-in-Charge. Six copies of the test certificates shall be supplied in suitable folders with proper index.

d) Certificates shall be clearly identified by serial or reference number where possible to the material being certified and shall include information required by the relevant Reference Standard or Specification clause.

4.2. INSPECTION AT MANUFACTURER'S PREMISES

a) The inspection of all equipment required to be supplied to complete the works shall be done as detailed in this specification. Only defect free and sound material meeting the technical requirements of this specification and in accordance with a high standard of engineering would be acceptable to the Engineer-in-Charge.

b) For meeting these requirements of inspection, testing (including testing for chemical analysis and physical properties) shall be carried out by the Contractor and certificates submitted to the Engineer-in-Charge who will have the right to witness or

inspect the above mentioned testing/inspection at any stage desired by him. Calibration certificates or test instruments shall be produced for the Engineer's consent in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test. Items of plant or control systems not covered by standards shall be tested in accordance with the details and programme agreed between the Engineer and Contractor.

c) If during or after testing, any item of the plant fails to achieve its intended duty or otherwise prove defective it shall be modified or altered as necessary, retested and reinspected as required by the Engineer.

d) At least 15 days notice shall be given to the Engineer before the specified tests are carried out.

e) No material is to be delivered to site without the above described inspection having been carried out or officially waived in writing by the Engineer-in-Charge.

f) Third party inspection along with the Engineer In charge wherever necessary shall be arranged by the Contractor at his cost

4.3. TESTS AT MANUFACTURER'S PREMISES

4.3.1. Pumps

a. Hydrostatic testing: All pressure parts of pumps prior to assembly, shall be subjected to hydrostatic tests to the satisfaction of Engineer-in-Charge at 1.5 times the maximum pressure obtained with the delivery valve closed and suction pressure at maximum, or twice the working pressure whichever is higher for a duration of 10 minutes.

b. Balancing Test: Impeller and pump rotating assembly shall be dynamically balanced.

c. Performance Test: Each pump shall be tested for full operating range individually to BS:5316: Part 2. Test shall be carried out for performance at rated speed with minimum NPSH as available at Site. Pump performance shall be within the tolerance limits specified in BS:5316 : Part 2.

4.3.2. Motors

Motors shall be offered for routine and type tests in accordance with IS : 4029 and IS:325 at the manufacturer's works. Test certificates shall be endorsed to the effect that the motors are properly balanced and free from vibration. In addition, a test shall be required to establish the maximum transient starting current.

4.3.3. Pipe work

Testing of pipes/fittings shall be carried out in accordance with relevant standard.

4.3.4. Valves

(a) All valves shall be hydrostatically tested close ended. Body, seat/door and back seat-test pressure shall be 15 bar, 10 bar and 6 bar respectively.

(b) Valves shall be tested with associated actuators for general performance.

4.3.5. Hoists

(a) The hoist shall be completely assembled in the Contractor's or sub-Contractor's works and shall be subjected to the tests as specified in IS:807/IS: 3177. The Contractor shall provide the test weights.

(b) In addition a vertical deflection test shall be carried out with the 'Safe Working Load' suspended from the hook with the crab in the center of the span. The ratio of deflection to span shall not exceed that specified in IS 807. Manufacturer's test certificates for mechanical items shall be furnished.

4.3.6. Electrical Instruments

All electrical instruments shall be tested as specified under electrical specifications.

4.3.7. Other Equipment

Other equipment like mixers, air blowers, agitators, etc. shall be tested at plants and at works as per the relevant IS standards, and applicable standards with test certificate furnished for approval before dispatch.

4.4. ERECTION - GENERAL

1. The Contractor's staff shall include at least one competent erection engineer with proven, suitable, previous experience on similar contracts to supervise the erection of the Works and sufficient skilled, semi skilled and unskilled labour to ensure completion of the works in time.

2. The Contractor shall not remove any representative, erector or skilled labour from the site without the prior approval of the Engineer-in-Charge.

3. One erection engineer who shall be deemed to be the Contractor's representative shall be conversant with the erection and commissioning of the complete works. Should there be more than one erector, one shall be in charge and the Contractor shall inform the Engineer-in-Charge in writing which erector is designated as his representative and is in charge. Erection engineer is to report progress and planning to the Engineer or his representative who will have one mobile phone with him.

4. The Contractor's erection staff shall arrive on the site on date to be agreed by the Engineer-in-Charge. Before they proceed to the Site, however, the Contractor shall first satisfy himself, as necessary, that sufficient plant of his (or his sub-Contractor's) supply has arrived on site so that there will be no delay on this account.

5. The Contractor shall be responsible for setting up and erecting the plant to the line and levels of reference given by the Engineer in writing, and for the correctness (subject as above mentioned) of the positions, levels dimensions and alignment of all parts of the works and for provision of all necessary instruments, appliances and labour in connection therewith. The checking of setting out of any line or level by the Engineer or Engineer-in-Charge shall not in any way relieve the Contractor of his responsibility for the correctness thereof.

6. Erection of Plant shall be phased in such a manner so as not to obstruct the work being done by other Contractors or operating staff who may be present at the time. Before commencing any erection work, the Contractor shall check the dimensions of structures where the various items of Plant are to be installed and shall bring any

deviations from the required positions, lines or dimensions to the notice of the Engineer. Plant shall be erected in a neat and workmanlike manner on the foundations and at the locations shown on the approved drawings. unless otherwise directed by the Engineer, the Contractor shall adhere strictly to the aforesaid approved drawings. If any damage is caused by the Contractor during the course of erection to new or existing plant or buildings or any part thereof, the Contractor shall, at no additional cost to the Employer, make good, repair or replace the damage, promptly and effectively as directed by the Engineer and to the Engineer's satisfaction.

7. During erection of the plant the Engineer will inspect the installation from time to time in the presence of the Contractor's site representative to establish conformity with the requirements of the specification. Any deviations and deficiencies found or evidence of unsatisfactory workmanship shall be corrected as instructed by the Engineer.

4.5. RECORD, PROCEDURES AND REPORTS

1. The Contractors shall maintain records pertaining to the quality of installation/erection work and inspection, testing, compliance with all technical requirements in respect of all his work as described in the previous paragraphs. The reporting formats shall be in the approved formats. The Contractor shall submit such records to the Engineer after the completion of any particular work before submitting the bill of shop inspection reports, shop testing reports, material test reports, based on which dispatch clearances are provided, all the quality control reports of welding, erection and alignment records.

2. All the above mentioned records shall be submitted in the final form duly countersigned by the Engineer-in-Charge attesting conformity to specifications and his approval of installation and duly incorporating all the additions, alternations, and information as required by the Engineer, on the basis of preliminary reports giving the progress of the work. Such records notwithstanding any records submitted earlier with bill of supply/progress etc. shall be duly bound and submitted to the Engineer in

six copies by the Contractor on his notification of the mechanical completion of erection.

4.6. COMPLETION OF ERECTION

1. The completion of plant under section by the Contractor shall be deemed to occur, if all the units of the plant are structurally and mechanically complete and will include among other such responsibilities the following :

   - Plant in the scope of the Contractor has been erected installed and grouted as per specifications.
   - Installation checks are completed and approved by the Engineer.
   - The erected plant is totally ready for commissioning checks.

2. At the stage of 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 commissioning checks/tests on completion.

3. Upon achieving the Completion as described above, the Contractor shall notify the Engineer by a written notice intimating such mechanical completion of units and notify the Engineer for inspection and acceptance of Mechanical Completion. The Engineer/Engineer-in-Charge shall proceed with the inspection of such units within 14 days of such a notice. Thereafter:

   - The Engineer shall certify completion when there are no defaults in the works and the plant is acceptable or
   - The Engineer shall inform the Contractor list of deficiencies for rectification hereinafter referred as Punch List and the Contractor shall complete the rectification work within a jointly agreed period before tests on or approval of the same before proceeding with the Tests on Completion or
   - The Engineer may inform the Contractor that the Works are acceptable with ‘punch’ list (Items which do not hamper operability, safety or maintainability) and allow the Contractors to proceed with the pre-commissioning checks followed by Tests on Completion when the Contractor undertakes to complete such

outstanding works within an agreed time during Defects Liability Period.

4. Taking over shall be based on rectification of all deficiencies as advised by punch lists.

5. The erection period indicated by the Contractor would be deemed to cover all the activities up to completion as stipulated in previous paragraphs, notice of completion by the Contractor, inspection by the Engineer for completion, and Contractor rectification of all deficiencies as noticed by the deficiency/punch list, and acceptance by the Engineer of such rectification, prior to Tests on Completion.

6. Minor defects, which in the opinion of Engineer which do not hamper operability and maintainability will not be taken into account for deciding mechanical completion. Such defects shall be rectified concurrent to commissioning checks before Tests on Completion. However, the Engineer's decision in this regard is final.

7. The commissioning period as notified by the Contractor shall be deemed to occur beyond the date of completion and shall include all periods of pre-commissioning, trails and Tests on Completion.

8. It is in the Contractor's interest to offer the sections/units/systems, progressively under identified milestones within overall erection period, duly completed for inspection by the Engineer-in-Charge, obtain his 'punch' list, for rectification of any deficiencies pointed out by the Engineer and to achieve Mechanical Completion before undertaking the Tests on Completion within the specified erection period. The Engineer also reserves a right to withhold the cost as estimated to be equivalent to the rectification of deficiencies pointed out to the Contractor until such a time such deficiencies are rectified to the satisfaction of the Engineer.

4.7. SETTING TO WORK

1. On completion of erection the Contractor shall request the Engineer-in-Charge to carry out the installation inspection.
2. After the plant has been set to work the Contractor shall continue to operate the Plant for a period of one week.

4.8. INSTALLATION INSPECTION

1. In addition to the progressive supervision and inspection by the Purchaser the Contractor shall offer for inspection to Engineer, the completely erected Plant/Part of Plant on which tests are to be carried out. After such inspection by Engineer-in-Charge, 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 clauses.
2. Pumps, Piping and valves
   - The erected pipework 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 joints. Provision of necessary pumps, gauges, blank flanges, tappings etc. for carrying out these tests shall be included in the Contract.
   - Leakage tests shall be carried out on all erected pipe work, pumps and valves immediately after erection and where possible before being built in.
   - Operating tests shall be conducted on valves.
   - The pump set shall be tested for satisfactory operation. The vibration and noise level shall be checked to be within specified limits.
3. Motors: Condition of winding insulation be tested and insulation values shall be restored to required level by suitable heating arrangements locally.
4. Hoists: The hoist and lifting tackle shall be tested to 125% of the safe working load. The Contractor shall arrange the test load.
5. Mixers, agitators, air blowers, etc. After erection, these shall be tested for its performance.
   - Electrical Panels Insulation
   - Test High Voltage Power Frequency test
   - Performance Test
6. Cables
   - Insulation Test
   - Continuity Test

- High Voltage Power Frequency Test
- Instrumentation

Performance of the instrumentation shall be checked as per the design requirements.

4.9. COMMISSIONING

4.9.1. Scope

At the time of commissioning, the Engineer-in-Charge will appoint his representative as commissioning engineer. The Contractor shall carry out commissioning tests in the presence of the commissioning engineer. Though the mechanical completion may have been checked and clarified by the site engineers, the commissioning engineer may verify any mechanical completion checks to satisfy himself that the plant is fit and sound, if such checks had not been witnessed by him. It will be the responsibility of the Contractor to make all arrangement for carrying out these tests. The evaluation of test results and decision passed by the commissioning engineer regarding the test results will be final and binding on the Contractor. Any additional tests or repetition of tests to establish satisfactory operation of any equipment shall be carried out by the Contractor at no extra cost.

4.9.2. Miscellaneous

Completion checks and commissioning tests on items not covered under above , shall be carried out by the Contractor as per the instructions of the Engineer-in-Charge.

4.9.3. Commissioning Date

No item of plant will be certified as commissioned by the Purchaser unless it has successfully passed all the tests called for under the Contract and the following documentation are duly complied and submitted in final formats in duly bound volumes.

a) A completion of all shop inspection results/reports of the plant/machinery with due attestation that the Plants have been manufactured to specified standards (6 copies)

b) All erection/construction quality control checks in appropriate approved formats for all installation works with attestation that installation has been carried out as per acceptable/stipulated standards (6 copies).

c) All "As built drawing" and O & M and Erection manuals. Soft copies of drawings and documents will furnished by the Contractor.

4.10. TENDER DRAWINGS

The following drawing shall be submitted by the bidder with tender:

1. Plant Layout with unit sizing
2. Process Flow Sheet with process design/calculations
3. Hydraulic Flow Diagram with hydraulic design/calculations
4. Process & Instrumentation Diagram
5. Single Line Diagram for all Electrical Installations with load calculations
6. Outline dimensional drawing
   a. Pumps
   b. Gates-Motorised/Manual
   c. Valves-Motorised/Manual
   d. Chlorinators
   e. Electrical Panels
7. Performance Curve for
   a. Pumps
   b. Aerators
   c. Blowers
8. Instrumentation - Catalogues for all the instruments

4.11. DRAWINGS FOR APPROVAL

The following mechanical drawings shall be submitted for approval including GA drawings, technical data sheets Quality assurance plan and other related documents to the Engineer In Charge for the approval and further action:

a. Knife gate valves

b. Non-Return valve
c. H.O.T./E.O.T. Crane
d. Gates
e. Manual and mechanical Coarse /Fine screens
f. Degritter
g. Primary and Secondary Clarifier
h. Diffusers
i. Air blowers
j. Submersible pumps
k. Chlorination system
   Sludge Dewatering units
l. If any as per technology selected

4.12. CONSTRUCTION DOCUMENTS

The Construction Documents are certified Drawings submitted by the Contractor to the Employer or Engineer-in-Charge during the course of the Contract for approval.

The Engineer-in-Charge may require the Contractor to submit for approval additional drawings if they are necessary to enable him to satisfy himself that the items are well designed, that they comply with the Employer's Requirements and that they are suitable for their intended purpose. These drawings shall form the agreed basis for the execution of the Works. If an approved drawing is revised, revised copies shall be submitted for approval as above and no such revised drawing shall be used for the purposes of the Contract until it has been approved in place of the earlier issue of the drawing.

Approval of drawings by the Engineer-in-Charge shall not be held to relieve the Contractor of his responsibilities under the Contract. Drawings should be got approved from the Dy. Director & Chief Manager and Industrial Safety before starting the site work.

Two nos. of `Approved copies of each drawing will be returned to the Contractor when approval is given if the Contractor so requests.

The Engineer-in-Charge will not permit construction to start on a part or section of the Works unless Construction Documents for that part or section have been approved.

4.13. AS-BUILT DRAWINGS

These drawings shall be complied by the Contractor and shall constitute a permanent record of the Works as executed. These shall include all such drawings, schedules, documentation and calculations as necessary for a complete understanding of the Work design, operation and maintenance.

A3 and smaller sized As-Built Drawings shall be provided on durable paper for reproduction by photocopier. As-Built Drawings larger than A3 shall be provided as a paper copy and also produced in the form of black lines on a durable translucent film from which further paper prints can be taken by others as required. In addition drawings shall be provided as AutoCAD Revision 14 software copy.

Text shall be provided in an industry standard work processing, spreadsheet or database format as appropriate.

4.14. INFORMATION REQUIRED ON AS-BUILT DRAWINGS

The As- Built Drawings shall consist of the fully up-dated versions of the approved Construction Documents incorporating any additional information which will assist the Employer in operating maintaining and if necessary modifying or extending the Works at a later date. These drawings should extend and supplement the information given in Operating and Maintenance Manuals.

4.15. OPERATING AND MAINTENANCE MANUALS

4.15.1. General

The Contractor shall compile operating, maintenance and overhauling instructions for

the whole of the Plant. The instructions shall consist of one volume of :

a. General descriptive text (including drawings for illustration) of the Works described section by section.

b. Complete operational instructions for the treatment plant. This shall be termed the Operators Manuals. It shall be aimed at the operational staff and shall be written in clear unambiguous text complete with drawings which necessary for clarification of any issues. The manual shall comprehensively detail what to do on a day to day basis and also what to do in the event of fault develop. It shall in addition provide a complete list of the process maintenance tasks the operator should carry out including the intervals between these tasks.

c. Essential Instructions for mechanical and electrical maintenance of the Plant. These instructions shall be short and concise and set out in consolidated schedule the inspection, lubrication, cleaning and any other type of servicing operations required. The Contractor shall prepare typical maintenance log sheets that the Employer can subsequently use for daily, weekly, monthly or other periodic maintenance and shall form record sheets of plant maintenance operations.

d. Instructions for use of skilled maintenance personnel in fault location, carrying out routine replacement, withdrawing, dismantling, overhauling, re-assembling and testing the various items of Plant.

e. Manufacturer's Technical Documentation subdivided into categories for:
   - civil
   - process
   - electrical
   - electrical building services
   - mechanical building services
   - instrumentation and control

f. Civil As-Built Drawings

g. Comprising the FDS and PLC code

h. Electrical As-Built Drawings: The electrical drawings shall be complete sets

including all information necessary for maintenance and spares replacement.

i. Electrical and mechanical building services As-Built Drawings: The drawings shall be complete sets including all information necessary for maintenance and spare replacement.

j. FAT records for the Plants and Works

k. SAT records for the Plants and Works

Each volume shall be subdivided (relating to areas of plant) into sub sections or sub volumes in order to ease the location of plant details. Each volume or sub volume shall be provided with a comprehensive index for the volume or sub-volume concerned and the O & M manuals as a whole.

Each volume shall be enclosed within A4 and A3 ring binders having tough grease resistant cover suitable for use on site and designed to permit the easy removal and insertion of the contents. The front cover and spine of each volume shall show details of the project, Employer, Engineer-in-Charge and a volume title.

Text shall generally be enclosed in A4 ring binder except where they accompany A4 text in which case they shall be folded. A1 drawings shall generally be folded and enclose in A4 box files. Where A1 drawings accompany text they shall be folded and enclosed in an A4 plastic wallet, one wallet per drawing.

4.16. SUBMISSION OF DOCUMENTS AND DRAWINGS

Eight (8) copies of each drawing and document shall be submitted by the Contractor to the Engineer-in-Charge for approval. The Engineer-in-Charge will return two (2) approved copies to the Contractor and retain six (6) for the Engineer-in-Charge's office and field use. The contractor, shall also arrange to get the approval on these drawings from the Dy. Director of Industrial Safety and health at his own cost.

The Engineer-in-Charge will signify his approval or disapproval of the Preliminary Phase Drawings within 15 calendar days of submission.

Construction Documents shall be submitted in accordance with the timetable set down in the Program.

The Engineer-in-Charge will signify his approval or disapproval of the Construction Documents within 15 calendar days of submission of each submission.

Draft copies of the O & M Manuals shall be submitted to the Engineer-in-Charge for his approval at least 56 calendar days prior to the commencement of Tests on Completion.

The Engineer-in-Charge will signify his approval or disapproval of the O & M Manuals within 28 calendar days of submission.

Draft As-Built Drawings shall be submitted 30 calendar days prior to the commencement of Tests on Completion.

The Engineer-in-Charge will signify his approval or disapproval of the As-Built Drawings within 15 calendar days of submission.

The Final As-Built Drawings shall be submitted prior to the issue of any Taking Over Certificate.

To remove doubt the submission dates referred to above shall be the dates on which the drawings and documents are received by the Engineer-in-Charge.

4.17. NOTICE OF OPERATIONS

The Contractor shall give full and complete written notice of all important operations to the Engineer-in-Charge sufficiently in advance to enable the Engineer-in-Charge to make such arrangements as the Engineer-in-Charge may consider necessary for inspection and for any the purpose. The Contractor shall not start any important operation without the written approval of the Engineer-in-Charge.

4 APPROVED MANUFACTURER/MAKE FOR MAJOR ITEMS

The bidders are to consider the following list of Approved Manufacturer/Make for Mechanical equipment as under:

Component	Manufacturer/Make
Gates	Jash / Batty
Mechanical Fine Screens	Jash / Huber / Johnson
Mechanical medium Screens	Jash / Huber / Johnson / Triveni/Headworks/
Manual Screens	Voltas / Geomiller / HDO / Batliboi / Triveni/Jash
Detritors	Voltas / Geomiller/ HDO / Batliboi / Triveni
Air blowers	Usha / Kay / SWAM / KPT/Everest/
Primary / Secondary Clarifiers	Voltas / Geomiller/ HDO / Batliboi / Triveni
Sludge thickener	Voltas / Geomiller/ HDO / Batliboi / Triveni/Alfa laval
Agitators	Voltas / Geomiller/ HDO / Batliboi / Triveni
Diffusers	Grindwell Norton / OTT system / Environmental Dynamics
Chlorination System	Metito / Pennwalt / RR Enterprises / Sumitra/
VFD	Allen Bradly / Schneider / ABB / Siemens
Motor (excluding	Siemens /ABB / Crompton /Kirloskar
Instruments (Excluding	Fischer Rose Mont / Toshbro / Forbes Marshall /
Ultrasonic flow meter)	Mikamchi / Alfa laval / Manas
Horizontal Pumps	Grundfos / Kirloskar /Johson /Jyoti / Mather & Platt
Submersible pumps	Grundfos / Kishor / KSB / Mather & Platt - EMU/Aqua
Knife Gate Valves	Jash / Fouress / Dezurick
Ultrasonic Flow meter	Siemense / Crohne Marshall / Forbes Marshall / Manas
DO measurement	Endress Hauser / Fischer Rosemont / Forbes Marshall /
Hoists EOT	Index / Elephant / Anupam / Speed
Chain Pulley Block Monorail	Hercules / Anupam / Smaco

VOLUME II-D

ELECTRICAL SPECIFICATIONS

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ELECTRICALSPECIFICATIONS

1. **Electrical Works:**

1.1 Codes & Standards:

The following codes and standards shall be applicable for continuous performance of all electrical equipment's to be supplied, delivered at site, erected, tested and commissioning. The electrical equipment's offered shall comply with the relevant Indian standards specifications. Fire insurance regulations, tariff advisory committee regulations, and particular to Indian electricity rules in all respect with all its latest amendments up to date.

For guidelines to the Tenderer, few of the Indian Standards are indicated below: -

1.	IS:116	-	Circuit breakers for AC System.
2.	IS:159	-	Busbar and Busbars connections.
3.	IS:3043	-	Code of practice of earthing.
4.	IS:10116	-	Code of practice for installation of switchgear.
5.	IS:10116	-	Code of practice for selection, installation and maintenance of fuse (up to 650 Volts).
6.	IS:3165	-	Potential Transformers.
7.	IS:3203	-	Climate proofing of electrical equipment's.
8.	IS:3427	-	Metal enclosed switchgear and central gear.
9.	IS:3419	-	Specification for fittings for rigid PVC non-metallic conduit.
10.	IS:3537	-	Gas separated relays.
11.	IS:3639	-	Fittings and accessories for power Transformer.
12.	IS:3837	-	Accessories for rigid steel conduits.
13.	IS:4064	-	Heavy duty Air Break switches and composite. Switch fuse units for voltage and exceeding 100V.
14.	IS:4064	-	Switch fuse units for Industries etc.
15.	IS:4237	-	General requirements for switchgears not exceeding 1000 Volts.
16.	IS:4615	-	Switch socket outlet.
17.	IS:5133 (Part-I)	-	Sheet steel boxed.
18.	IS:3070 (Part-I)	-	Lighting Are stores.
19.	IS:2034	-	L.T. capacitors.
20.	IS:192	-	Electric power switchgear for indoor and outdoor installation.
21.	IS:PUB 26	-	Circuit Breakers.
22.	IS:9535	-	Specification for conduits for electrical installation.
23.	IS:240 (Part-I & II)	-	For H.T. insulator of 33KV grade and above.
24.	IS:335	-	Insulating Transformer Oil.
25.	IS:374	-	Ceiling fans.
26.	IS:375	-	Marking and arrangement for switchgear boards main connections auxiliary wiring
27.	IS:415	-	Tungsten filament lamps.
28.	IS:692	-	Paper insulated cables.
29.	IS:694	-	PVC insulated cables and cords for power lighting.
30.	IS:722	-	Three phase watt hour meters with MDI.
31.	IS:732	-	Electrical wiring installation (up to 650V)
32.	IS:1087	-	Single pole tumbler switch 5 Amps.
33.	IS:1248	-	Direct reading electrical indicating instruments.
34.	IS:1255	-	Installation and maintenance of paper insulated power cables up to 33 KV.

35.	IS:1293	-	3 Pin lugs and sockets outlets.
36.	IS:1554	-	PVC insulated cables – heavy duty.
37.	IS:1567	-	Metal clad switches up to 100 Amps.
38.	IS:1651	-	Lead acid cell batteries.
39.	IS:1653	-	Rigid steel conduits for electric wiring.
40.	IS:1771	-	Industrial light fittings with accessories.
41.	IS:6600	-	Loading of oil immersed transformer.
42.	IS:6946	-	Reliable (flexible) non-metallic conduits for electrical.
43.	IS:7098 (Part-II)	-	Fox XLPE type cables.
44.	IS:5216	-	Guide for safely procedure and practices in electric work.
45.	IS:5578	-	Guide for marking of insulated conductors.
46.	IS:5792	-	11/22 KV drop out fuses.
47.	IS:5820	-	Pre-cast concrete cables covers.
48.	IS:5908	-	Method of measurement of electrical installation in building.
49.	IS:6381	-	Specifications for construction and testing of electrical apparatus.
50.	IS:1818	-	Isolation and earthing switches.
51.	IS:1886	-	Code practice for installation of transformers
52.	IS:1947	-	Flood lights.
53.	IS:2026	-	Transformers.
54.	IS:9242	-	Degree of protection provided for enclosure for switchgear.
55.	IS:9242	-	HRS cartridge fuse units up to 650 Volts.
56.	IS:2251	-	Code of practice for Danger Notice Plates.
57.	IS:2268	-	Code bell/buzzers.
58.	IS:2274	-	Code of practice for wiring installation (exceeding 650 Volts)
59.	IS:3854	-	Switches for domestic and similar purpose.
60.	IS:2312	-	Exhaust fans.
61.	IS:2309	-	Code of practice for lighting protection.
62.	IS:2418	-	Tubular fluorescent lamps for general lighting service.
63.	IS:2544	-	Porcelain post top insulators for BBW Class.
64.	IS:2509	-	PVC electrical conduits.
65.	IS:2516	-	A.C.Circuit breakers.
66.	IS:2667	-	Fittings for rigid steel conduits for electrical wiring.
67.	IS:2692	-	11/22 KV drop out fuses.
68.	IS:2575	-	Enclosed distribution fuse boards and cut outs for voltage up to 1000 V.
69.	IS:2705	-	Current transformer.

The entire electrical installation work shall be strictly complied with the codes, standards, rules and regulations framed under the Indian Electricity Act. Further it shall be strictly carried out as per the regulations and rules set out by “Tariff Advisory Committee and/or Fire Insurance Regulations”.

1.2 Terminal Points:

The Bidder shall get the HT Power Supply from MSEDC/ supply utility from the two different Tapping Point made available by MSEDC to fulfill power requirement of the proposed Sewage Treatment Plant.

1.3 Scope of Work:

The Scope of electrical works shall include design, manufacture, supply, delivery to site, inspection and testing at the manufacturer's works, erection/ installation, testing and commissioning of all the electrical equipment/systems required for the STP on turnkey basis, as specified in this Section and the enclosed drawings, so as to make the system complete in all respects. The brief description of scope is given below.

(a) Temporary arrangements to be made by the Tenderer for the power required for construction work and to operate existing raw sewage pumping machinery for bypass / disposal of sewage in adjacent Nala for construction phase or till regularized and functional power connection is obtained from MSEDC/ supply utility for proposed STP.

(b) Construction of 11/22 KV inbuilt sub-station as per approved drawing. Tentative location is identified in the proposed layout drawing enclosed however the exact location will be decided in consultation with MSEDCL / supply utility in charge / Engineer In-charge of AMC.

(c) Providing 11/22 KV SF6 Gas filled 3 Panel ring main unit (RMU) with one VCB & two isolator (motor operated) or as suggested by MSEDC/ supply utility, 11/22 KV SF6 Gas filled VCB Panel with one isolator, two VCB, 11 / 22 KV / 440V indoor transformer of required capacity. Capacity of transformer will be calculated on the basis of prevailing norms of MSEDC/AMC/any other authority, 11/22 KV cabling between RMU & RMU to VCB and VCB to transformer all within substation building.

(d) Wiring of substation building and provision of standard safety equipment's in the same as approved by the MSEDC and the electrical inspector/AMC.

(e) Incoming 11/22 KV supply cable to this substation shall be covered in the scope of work.

(f) The Tenderer has to obtain from MSEDC/AMC/any other approving authority, all necessary approvals right from the approval of scheme sanction of load to the releasing of power supply and bringing completion report from MSEDC/AMC. AMC shall help Tenderer in documentation to obtain such approvals, however the responsibility to achieve the same lies with the Tenderer. Tenderer will be fully responsible to obtain regularized and functional power connection from MSEDC for proposed STP within time frame stipulated in the Tender. No time extension will be granted on this ground.

(g) All necessary charges pertaining to power connection related to MSEDC authorities shall be borne by the Bidder.

(h) Provision of 1100 V grade XLPE insulated extruded inner and outer PVC sheathed aluminum conductor, armored cable of adequate size from the transformer up to PCC with APFC Panel up to the load point etc. complete along with the end termination with gland and crimping type of lugs.

(i) Provision of a complete indoor and outdoor cabling system. 1100 V grade, XLPE, aluminum conductor, armored cables shall be provided for distribution of power to various DBs/ panels and individual loads in the STP, while 1100 V grade, PVC insulated, extruded inner and outer PVC sheathed, stranded copper conductor, armored cables shall be provided for control and instrumentation. These cables shall be laid in trenches, trays, pipes/conduits, buried in ground, as required, depending on the plant layout. The entire cabling system shall be as per the approved drawings.

(j) Complete plant indoor and outdoor lighting system shall be provided by using Hybrid electricity e.g. solarpower, Wind power.

(k) Complete plant indoor and outdoor Earthing and lighting protection system comprising electrode pits and conductors shall be provided inside and outside the plant to ensure proper system neutral Earthing and safety Earthing. The entire Earthing and lightning protection system shall be as per the approved drawings and IS.

(l) LV capacitor bank, with control Panel consisting of automatic power factor correction (APFC) relay, shall be provided to improve the overall plant 'of' up to a maximum of unity.

(m) Local Start/Shop push button stations shall be provided near all motors.

(n) All the motors shall conform to the requirements of latest editions of application Indian Standards. The motors shall be squirrel cage, TEFC type and shall be rated for continuous duty. The winding insulation shall be of Class 'F' while the temperature rise shall be limited to that for Class 'B'. The degree of protection of enclosure shall be IP 54 for indoor motors and IP 55 for outdoor motors and IP 56 for outdoor motors located near water bodies.

(o) Complete electrical works within the terminal points comprising of the following:
- (i.) 3 Panel Ring Main Unit, 11/22 KV SF6 Gas filled with two Isolators.
- (ii.) 3 VCB Panel with Safety Relays.
- (iii.) 2 Nos. Transformers of suitable rating.
- (iv.) PCC with APFC.
- (v.) MCC Panels as per requirement.
- (vi.) Local Panels & Start Stop Push Button Stations.
- (vii.) Internal Illumination to the Lux Levels indicated in the Electrical Specifications.
- (viii.) External Illumination to the Lux Levels indicated in the Electrical Specifications.
- (ix.) Power & Control Cables.
- (x.) Earthing with Earthing Pits.
- (xi.) All the MCC Panels and PCC shall be integrated type using PLC Remote I/Os or Distributed System for integration of the plant electrical data on SCADA.

1.4 Detailed Specifications/ Requirements of Scope of Work

(a) Design, Manufacture, inspection and testing at works, supply at site erection, final check-up, painting, testing, and commissioning of the electrical equipment as detailed in the items with brief description shall form the scope of work of the successful Tenderer.

(b) The scope of work also includes civil work such as excavation, laying of sand and bricks on cables laid, closing the excavation, making Earthing pit chambers, foundation and pedestal for electrical equipment, grouting of cable tray supports in walls, making entries for cable conduits in walls and making good the surface to the original one, embedding concealed conduits, junction boxes, etc., in walls and ceiling and making good the surface, foundation for street lighting poles, providing covers, chequered plates on cable trenches, etc.

(c) Co-ordination with local authorities, such as MSEDC/AMC, Electrical Inspectorate the State Government, chief electrical authority, etc. for obtaining all the statutory approvals needed, preparing, submitting and obtaining approval of all electrical drawings and documents as well as obtaining approval of the electrical installation from these authorities shall also form a part the scope of the work.

(d) Preparation and submission of As-Built drawings on soft-copy installation, operation and maintenance manuals of the equipment supplied along with their catalogues shall also be furnished by the successful Tenderer.

1.5 System Design Parameters

The electrical equipment's/ items selected for this project shall be suitable for operation of technical parameters specified below:

a)	Incoming power supply	AC, 11/22 KV, 3 Phase, 50 Hz
b)	Plant power distribution voltage	AC, 415 V, 3 Phase, 4 Wire, 50 Hz
c)	Lighting and space heating	AC, 230 V, 1 Phase, 2 Wire
d)	DC alarm, control and protection	24 V, 2 Wire, DC
e)	AC control	AC, 230 V, 1 Phase, 2 Wire
f)	Potential transformer secondaries	AC, 110 V, 3 Phase, 50 Hz or as specified by MSEDC
g)	Ambient temperature	50^0 C
h)	System Earthing	Solidly earthed

i)	Voltage variation	± 10 % of rated voltage
j)	Frequency Variation	± 5 % of rated frequency
k)	Combined voltage and frequency variation	± 10%
l)	Fault Level	350 MVA (11KV), 40KA (415V) 6 KA (230V)
m)	Tap changing gear	On load tap changer

1.6 Standard Specifications of Electrical Works and Components

All the electrical work & equipment specifications will be as per the attached General Work Specification for electrical works specified in the following section.

a. Design Criteria

(i) Estimation of Load

The following assumptions are made to arrive at the maximum electrical demand of the water treatment plant.

a) Load Factor

i.	Motors	:	0.7
ii.	Auxiliary load (valve actuators, crane etc.)	:	0.9
iii.	Lighting load	:	1.0

b) Diversity Factor

i.	Motors	:	1.2
ii.	Auxiliary load (valve actuators, crane etc.)	:	1.5
iii.	Lighting load	:	1.2

c) Power factor of Motors : As per the Manufacturer's Catalogue

d) Efficiency of Motors : As per the Manufacturer's Catalogue

(ii) Equipment

b) All the indoor electrical equipment will be rated and sized for 45^{o}C design ambient temperature, while all the outdoor electrical equipment will be rated and sized for 50^{o} C design ambient temperature.

c) The capacity of the transformers will be calculated based on the total simultaneous maximum demand (calculated based on the load factors and diversity factors) plus 10% contingency. A transformer with the next higher standard rating recommended in the Indian Standards will be selected.The 100% standby transformer shall be provided.

d) All the power cables will be sized based on the continuous current rating of the load permissible voltage drop and short circuit current rating. The voltage drop will be limited to 2.5 % at rated equipment current rating.

e) The rating factors for variation in ground temperature, variation in ambient air temperature, grouping of cable, type of laying, depth of laying etc., will also be considered for cable sizing.

(iii) Illumination

The illumination levels to be considered for the design of lighting system for various areas as follow:

	Area	Illumination level (Lux)
1.	Office / Control Room	300
2.	Switchboard Room	250
	Area	**Illumination level (Lux)**
3.	Other indoor areas, if any	150
4.	Outdoor areas and roads	30
5.	Maintenance Factor – Outdoor area - Indoor areas	0.6 0.7

(iv) Earthing:

i. The material of Earthing conductor laid above ground or buried in concrete will be galvanized steel.

ii. The size of the Earthing conductor will be designed as per the Indian Standards / IEEE. The value of fault current will be calculated based on the transformer capacity, its impedance and the main supply system fault level. Fault current withstand time for sizing of earth conductor will be taken as three seconds. While sizing the buried earth conductor, a corrosion allowance of at least 20% will be taken.

iii. Main Earthing conduction outside and inside the building will be planned in such a manner that the equipment are connected to the Earthing system by two connections in a reliable manner.

(v) Protections

The following protections will be provided for various electrical equipment.

1. HV Substation
   a. VCB for transformer
2. LV switchboard
   a. Thermal overload and shot circuit protection features of MCCBs/ACBs for all feeders.
   b. Overload protection by thermal (bimetal) relays with single phasing preventer (SPP) for contactors for motor feeders.

(vi) Metering

The following metering will be provided on the LV switchboard:

1. LV Incomer
   a. Ammeter with selector switch
   b. Voltmeter with selector switch
   c. Kilowatt meter
   d. Power factor meter
   e. Kilowatt-hour meter
   f. Load monitor unit with MODBUS communication parts
2. LV Outgoing Feeders
   a. Ammeter with selector switch

(vii) Indicating Lamps

The following indications will be provided on the LV switchboard.

1) LV Incomer
   Supply 'ON' (Red, Yellow & Blue) or Legend R, Y, B
2) LV Motor Feeders
   Motor "ON', 'OFF" & 'Trip' indications (Red, Green & Amber).

(viii) General

a. The main LV switchboard is proposed with 'Form – 4' enclosure as per the Indian Standards. All indoor boards/panels and motors are proposed with a degree of protection of IP 54, while all outdoor equipment will be with a degree of protection of IP 55.
b. The method of starting of motors will be 'Direct-On-Line' (DOL) for motors with rating up to and including 5 HP, 'Star-Delta' for motor rating above 5 HP up to 30 HP , 'Soft Starter' for motor rating above 30 HP , and VFD' for motor rating above 75 HP.
c. LV power cables will be with stranded aluminum conductor, XLPE insulation, extruded inner and outer sheaths and galvanized flat/wire armoring, control cables will be with stranded copper conductor, PVC insulation, extruded inner and outer sheaths and galvanized flat/wire armoring.
d. Decorative type fluorescent lamp lighting fixtures will be used in the office/conference room, while industrial type mid-bay Magnetic Induction / LED /HPMV/MH lighting fixtures will be used in other indoor areas. For outdoor areas including roads, floodlight/street lighting fixture with Magnetic Induction / LED/ HPSV lamps along with G.I. octagonal poles are proposed.
e. All the electrical equipment, accessories and systems will confirm to the latest editions of the Indian Standards or other equivalent international standards.

b. Transformer

General:

The intent of this specification is to define the general requirement s for power transformers.

Standards:

The transformers shall comply with the latest edition of the following and other relevant Indian Standards

IS : 335	Insulating oil
IS : 1271	Classification of Insulating Materials
IS : 2026 (Part I)	Power Transformer - General
IS : 2026 (Part II)	Power Transformer - Temperature Rise
IS : 2026 (Part III)	Power Transformer - Insulation level and dielectric tests
IS : 2026 (Part IV)	Power Transformer – Terminal marking, tapping and connection
IS : 2099	High voltage porcelain bushing
IS : 3639	Power Transformer fittings and accessories
IS : 6600	Guide for loading of Oil Immersed Transformers

Construction:

The transformer shall be Indoor oil immersed type. Transformer tank shall be welded sheet steel construction and provided with gasketed steel cover plates, Base shall be suitably reinforced to prevent any distortion during lifting.

Base channels shall be provided with skids and pulling eyes to facilitate handling. All covers and seals shall be oil and air-tight and shall not be affected by mineral or synthetic oil action. The radiators shall be of fixed type.

All fasteners and bolts etc. shall be galvanized or zinc passivated. All surfaces to be painted shall be thoroughly cleaned, descaled, made free from rust and given a priming coat of rust resisting paint following by two finishing coats of approved shade, to withstand specified atmospheric conditions.

Unless otherwise stated the tank together with filter pipes and other fittings shall be designed to withstand without permanent distortion:

a) Full vacuum of 760 mm of Hg for filling of oil by vacuum.
b) Internal gas pressure of 0.35 kg/cm2 with oil at operating level.

Terminals and cable/marshalling Box:
Winding shall be brought out and terminated on bushings/cable box as specified in the data sheet. Cable box shall be sullied with cable lugs and glands. The neutral of the star connected winding shall be brought out a separate bushing terminal inside cable box.

All doors, covers and plates shall be 600 mm from floor level and provided with gland plate and cable glands as required. Top surface shall be sloped. An extra neutral bushing shall be provided for neutral grounding of transformer having a secondary voltage of 433 V. The natural bushing shall be mounted before bifurcation of the neutral, on the tank side to facilitate leading the earth conductor down to the ground level.

Marshalling box shall be provided as required.

Cooling:
Type of cooling shall be oil natural / air natural (ONAN)

Oil:
Transformer shall be supplied with first filling of oil and extra 10 % oil shall be a supplied non-returnable drum.

Accessories:
Accessories as specified in the parameters shall be included in the scope of supply. Conservator shall be complete with oil filling plug and cap, oil drain valve, purging device and plain oil level gauge in addition to magnetic oil level gauge.

Explosion vent shall be rotatable in all directions and provided with sight gauge and equalizer pipe connection. Bottom drain valve shall be of suitable diameter to drain off 90 % of the oil in ten minutes. Thermometer pocket shall be with mercury in glass thermometer (00-1200C).

Core and Winding:
Transformer shall be double wound, core type with cold rolled grain oriented silicon steel laminations perfectly insulated and clamped to minimize vibration and noise. Care shall be taken to insulate core-fastening bolts and to reduce losses and avoid hot points.

The insulation structure for the case to bolts and case to clamp plates shall be such as to withstand a voltage of 2000V for one minute. The complete case and coil assembly shall be dried in vacuum and shall be immediately impregnated with oil after the drying process to ensure elimination of air and moisture from the insulation. All parts of magnetic circuit shall be bounded to earth system. Winding of transformer shall be of copper and shall be designed to withstand the 22KV system dynamic and short circuit stresses.
Tapings and Control:
These shall be on high voltage side and connected to off circuit tap changing gear as specified in data sheet.

The tap changing arrangement shall change over taps on all the phases simultaneously. Under conditions of external short circuit, the tap changing equipment must be capable of carrying the same current as the windings.

Off circuit tap-changing gear shall have an external operating handle preferably mounted on the transformer side with locking arrangement and position indicator.

Noise:
The audible sound lever measured at 1 meter from the external surface of the transformer shall not exceed 250 db (A)

Earthing:
Transformer shall be provided with two main frame Earthing terminal on opposite sides, which shall be separate from the neutral terminal of star connected winding. Cable/Marshalling box etc. shall be separate from the neutral terminal of star connected winding. Cable/Marshalling box etc. shall be provided with one Earthing terminal in addition.

Performance Requirements:
The performance requirements for the transformer shall be as follows:

- Transformer shall operate without injurious heating at the rated KVA at any voltage within+10% of the rated voltage of particular tap.
- Transformer shall be designed for 110% continuous overloading capacity.
- Overloads shall be allowed within the conditions defined in the loading guide of the applicable Standards. Under these conditions, on limitations by terminal bushings, tap changers or other auxiliary equipment shall apply.
- The neutral terminal of windings with star connection shall be designed for the highest over-current that can flow through this winding.
- Every care shall be taken to ensure that the design and manufacture of the transformer shall be such as to reduce noise and vibration to the level obtained in good modern practice. The supplier shall ensure that the noise level shall not be more than 250 dB (A).
- For transformer with tapings, full power tapings shall be provided.

If the commissioning of the plant is likely to be delayed by the rejection of transformer, the Engineer reserves the right to accept the rejected transformer until the replacement of transformer is made available.

Transporting the rejected and replacement of transformer as well as installation and commissioning of both transformers shall be at the Contractor's cost.

Parameters for Transformer

1.0	**Site Conditions**		
1.1	Maximum ambient temp	:	@ 35^0 – 40^0C
1.2	Minimum ambient temp	:	15^0C
1.3	Relative Humidity	:	@ 98%
1.4	Altitude	:	4 to 5 M above MSL
1.5	Environment	:	Tropical
2.0	**Operating Conditions**		
2.1	Primary Voltage	:	11 kV
2.2	Earthing System		
	Primary	:	Not applicable
	Secondary	:	Solidly earthed

3.0	**General Data**		
3.1	Duty	:	Continuous
3.2	Type of cooling	:	ONAN
3.3	Installation	:	Indoor
3.4	Oil type	:	Mineral (as per IS 335)
3.5	Temperature rise		
	Oil	:	50^0C
	Winding	:	55^0C
3.6	Painting	:	Epoxy
3.7	Colour Shade	:	Shade 632 as per IS-5 (Admiralty Grey)
4.0	**Electrical Data**		
4.1	No. of windings	:	Two
4.2	Phase	:	3
4.3	Frequency	:	50 Hz $\pm$ 5%
4.4	Inter phase connection	:	Delta / Star
4.5	Vector group	:	Dyn-11
4.6	Insulation Class	:	A
4.7.	Winding insulation	:	Uniform
4.8	H.V. Phase sequence	:	UVW
4.9	Impulse voltage withstand Capacity	:	(1.2/50 u S) 75 kV
4.10	One minute power frequency Voltage withstand capacity	:	28 kV
5.0	**Specific Requirement**		
5.1	Rating	:	120% of total plant load
5.2	Voltage ratio	:	11 kV X 440
5.3	% impedance :		As per IS: 2026
5.4	off circuit tap changer	:	$\pm$ 5% in step of 2.5%
5.5	Overload capacity	:	20%
5.6	Terminal details		
	Terminal location HV	:	On one side
	Terminal location LV	:	Opposite to HV terminal
5.7	Connection details		
	Primary	:	Cable box
	Primary Cable Size/Type	:	Armored XLPE
	Secondary	:	Cable Box
6.0	**Accessories**		
6.1	Sampling Valve	:	Yes
6.2	Conservator	:	Yes
6.3	Conservator drain plug	:	Yes
6.4	Rollers (Bi-directional)	:	Yes
6.5	dial Type thermometer with Contacts	:	Yes
6.6	Silica Gel breather	:	Yes
6.7	Air release plug		
6.8	Drain cum bottom filter valve	:	Yes
6.9	Lifting lugs	:	Yes
6.10	Cross channels with towing lugs	:	Yes
6.11	Shut off valve for radiators	:	Yes

6.12	Thermometer pocket with Thermometer	:	Yes
6.13	Separate neutral bushing Outside terminal box	:	Yes
6.14	Top oil filter valve	:	Yes
6.15	Inspection cover	:	Yes
6.16	Disconnection chamber	:	Yes
6.17	Winding temperature indicator	:	Yes
6.18	Lugs and cable glands	:	Yes
6.19	Oil Gauge	:	Yes
6.20	Explosion vent:		Yes
6.21	Radiator	:	Yes

7.0 Tests:

The following tests shall be carried out as per IS: 2026

- Routine tests.
- 2KV withstand test for all wiring.
- Zero phase sequence impedance test.
- Temperature rise test.
- Short circuit test.

Certificates for type tests carried out in last three years on transformers of similar design shall be submitted for review.

8.0 Inspection

Inspection: Category A

c. Power Capacitors

General:

Power capacitor banks of suitable KVAR rating shall be provided across the main bus bar of PMCC with Automatic Power Factor Correction Relay (APFC) for maintaining the power factor of the installation at not less than unity.

The Contractor shall submit detailed calculations for arriving at the correct KVAR rating.

Standards:

Unless otherwise specified, the units shall conform to the following Indian Standards:

IS: 22534	:	Specification for Shunt Capacitors for Power Systems
IS: 5535 (PartII)	:	Shunt Reactors

Construction:

The capacitor shall be of All Polypropylene (APP) type consisting of elements wound from high purity soft annealed aluminum foil and layer of biaxial oriented polypropylene. The element must be assembled either in parallel or in series parallel combination for desired capacity and voltage ration with proper insulation. It shall be housed in a metal container. The leads shall be taken out through bushing and unit shall be hermetically sealed after fine vacuum drying and impregnated with highly purified nom PCB oil.

The capacitor shall be either with internal element fuse or external fuse with internal discharge resistance.

The capacitor bank shall comprise of suitable number of single phase units in series parallel combination. However the number of parallel units in each to the series stack shall be such that failure of one unit shall not create an over voltage on the units parallel with it. The complete bank with the accessories shall be metal enclosed, indoor floor mounted and free standing type. Each capacitor case and cubicle shall be earthed to a separate earth bus.

Each unit shall be fitted with a low loss discharge device to discharge capacitor to reduce the voltage to 50 V within one minute as per IS: 22534. The unit shall be capable to withstand satisfactorily an over voltage up to 110% of its rated voltage and 135% of rated KVAR including manufacturing tolerances.

Each capacitor unit shall be individually protected by HRC fuse rated for load current and interrupting capacity so that a faulty capacitor unit can be disconnected without causing the motor to be disconnected.

The capacitor bank shall be complete with all parts that are necessary for efficient operation. This shall include steel rack assembly, copper bus bars, copper connecting strip, foundation channel, fuse, fuse clip etc. The fuse breaking time shall be coordinated with the pressure built up within the unit to avoid explosion.

Parameters for Power Capacitor

1.0	Site Conditions		
1.1	Maximum ambient temp.	:	@ 35^0 – 40^0C
1.2	Minimum ambient temp.	:	15^0C
1.3	Relative Humidity	:	@ 98%
1.4	Altitude	:	4 to 5 M above MSL
1.5	Environment	:	Tropical
2.0	Output (KVAR)	:	To be decided by the Tenderer
3.0	Rated Voltage	:	415 V $\pm$ 10%
4.0	Rated frequency	:	50 Hz $\pm$ 5%
5.0	No. of phases	:	3
6.0	Location of capacitors	:	Indoor
7.0	Nature of control	:	By APFC relay
8.0	Type of capacitor bank	:	All polypropylene (APP)
9.0	Insulation level	:	2.5 kV (rms)

Tests:
All tests shall be conducted in accordance with the latest edition of IS: 22534 and as applicable for the controls. Type test certificates for similar capacitor units shall be furnished.

Inspection: Category A

d. LT Switch Boards and Control Cabinets

Main PCC

The main PCC shall be metal clad totally enclosed, rigid, floor mounted, air insulated, cubicle type for use on 415 V, 3 phase, 50 Hz system. The PMCC shall be single front, non-draw out type compartmentalized.

Each PCC shall consist of several compartments.

The equipment shall be designed for operation in high ambient temperatures and high humidity tropical atmospheric conditions. The equipment shall be for indoor installation. 10% spare feeders with minimum one (1) no. of each type and rating shall be provided in PCC, complete in all respects. PCC shall contend additional spare feeder for DG connection which shall carry the full capacity of plant load.

MCC/ Control Panel

The MCC/Control Panel shall be metal clad totally enclosed, rigid, floor mounted, air insulated, cubicle type for use on 415 V, 3 phase, 50 Hz system. The PMCC shall be single front, non-draw out type and non-compartmentalized type. MCC with double front construction may be accepted if substantiated by data where the size of sigle front cannot be accommodated in the Room.

The Local / MCC cum Control Panel shall have all controls mounted on the body and with only user required controls approachable from the outside. No live part should have direct access in the Panel.

The equipment shall be designed for operation in high ambient temperatures and high humidity tropical atmospheric conditions. The Sub PMCC/ Control Panel shall house the Intelligent Logic Controllers. The equipment shall be for indoor installation.

10% spare feeders with minimum one (1) no. of each type and rating shall be provided in MCC complete in all respects. All the Panels (LT) should be fuse less and should use MCB/MCCB/ACB as per application.

The DG incomer shall be design for the entire plant load in case of power failure, with electro-mechanical interlock with main incomer.

Standards:

The equipment shall be designed to conform to the requirements of:

IS: 25623 and IEC 439	Factory built assemblies of switchgear and control gear
IS: 4237	General Requirements for switchgear and control gear not exceeding 1000 volts
IS: 2147	Degrees of protection provided by enclosures for low voltage switchgear and control gear
IS: 375	marking and arrangement of bus bars
IS: 2959	AC conductors of Voltage not exceeding 1000 volts
IS: 4064 (Part II)	Air break switches and fuse combination units for voltage not exceeding 1000 volts
IS: 694 and IS: 25130	PVC insulated cables and aluminum conductors
IS: 12425	Direct action electrical indicating instruments
IS: 9224	Low voltage fuses
IS: 2516	Alternating current circuit breakers
IS: 2705	Current transformers
IS: 3156	Voltage transformers

Construction:

The structure of the panels shall be totally enclosed, free standing / wall / support mounted as applicable for the type of main or MCC, with the assemblies made up of requisite rigid welded structure frame made of structural steel sections and of dust and vermin proof construction with cold rolled sheet steel sections and of dust and vermin proof construction with cold rolled sheet steel of not less than 2 mm thickness or of pressed and former sheet steel of not less than 3 mm thickness.

The doors, covers, barriers etc. shall be made of minimum 1.6 mm thick steel. All Panel doors, removable covers, gland plates shall be provided with gaskets. The structure shall contain horizontal bus bars running throughout the length of the unit and be readily accessible.

Each vertical section shall be divided into the following well defined zones by metallic insulated barriers:

- Main bus bar chamber at top
- Unit chamber
- Cabling chamber at the right hand side or at the bottom of the unit chamber
- Vertical riser chamber behind unit chamber
- Horizontal wire way at top, in front of main bus bar chamber

The structure shall be mounted on a rigid base frame of folded sheet steel of minimum 3 mm thickness and 75 mm height.

The maximum height of floor mounting cubicle panels shall be 2500mm (maximum) and for wall-mounted Panel shall be 1500 mm.

The Panel shall be provided with a degree of protection of not less than IP 52 as per IS: 2147. Panel shall be extendable on both sides by addition of vertical sections.

Provision shall be made for permanently earthing the frame and other metal parts of the Panel through an aluminum earth bar running throughout the full length of the Panel at the bottom. It shall be possible to earth the Panel at two independent points through earthing terminals.

Metal Treatment and Finish:
All steel work used in the construction of PCC & MCC be given degreasing, derusting, phosphatising, and passivation treatment followed by (a) two coats of red oxide primer and two coats of final stove enamel paint of shade 631 of IS:5 or (b) epoxy powder coating.

Bus Bars:
The bus bars shall be air insulated and made of high conductivity, high strength aluminum complying with the requirements of grade E91E of IS: 50252. The bus bars shall be suitably braced with non-hygroscopic SMC supports, to provide a through symmetrical fault withstand capacity of LV side of transformer for one second. The neutral as well as the earth bar shall also be capable of withstanding the above fault level. Ridges shall be provided on the SMC supports to prevent tracking between adjacent bus bars. Porcelain insulator will not be accepted. The main horizontal bus bars shall be positioned at the top portion and suitable colour identification shall be provided. Suitable barrier shall be provided in front of the vertical bus bar against accidental contact. High tensile bolts and spring washers shall be provided at all bus bar joints. An earth bus bar joints. An earth bus of adequate site made of copper flat shall be provided at the bottom of the Panel.

Unit Module:
Each module shall be suitable for mounting a required number of power contactors, bimetal relay, auxiliary contactors, push buttons, isolator, ACB, MCCB, MCB, control fuses, main fuses, indicating lamps, meters, power and control contacts, terminal block cum secondary isolating contacts etc., to suit non-reversing, reversing and assisted start motor applications. Isolator, meters with selector switches, indicating lamps, push buttons & bimetal relay reset button shall be mounted on the module door.

The main and control contacts shall be self aligning type suitable for taking a mismatch up to +/- 4 mm.
The main power contacts shall be capable of withstanding a short circuit current.

The module shall be connected to the vertical bus bars by plug-in contacts. The contacts shall be between copper and copper both silver plated even if bus bars are of aluminum.

Each vertical Panel shall be fitted with a label on the front and rear. The PMCC as a whole shall also be fitted with a label indicating the switch gear rating and duty. Each relay, instrument, switch, fuse, contactor etc. shall be provided with a separate label. The AMC shall approve type and wording of all labels.

Air Circuit Breaker (ACB):
Circuit breakers shall be operated by a motor spring charging type of mechanism.

The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke.

Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charged the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor.

The charging mechanism shall be provided with mechanical indicators to show “charged” and “Discharged” conditions of the springs. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the “close” position.

The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB is released before the closing operation is complete, subject to the condition that there is no counter-impulse for tripping.
Means shall be provided to manually open and close the breakers slowly, when the operating power is not available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.
All operating mechanisms shall be provided with “ON”-”OFF” mechanical indication.

Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 255-110 % of the control voltage. Trip coils shall operate satisfactorily between 70-110 % the rated control voltage.

Moulded Case Circuit Breaker (MCCB):
MCCBs shall be of the air break, quick make, quick break and trip free type and shall be totally enclosed in a heat resistant, molded, insulating material housing.

MCCBs shall have an ultimate short circuit capacity not less than the prospective short circuit current at the point of installation.

MCCBs shall have a service short circuit breaking capacity equal to the ultimate short-circuit capacity.

Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism. Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.

The MCCBs shall be provided with the following features.

- Common trip bar for simultaneous tripping of all poles
- Shrouded terminals
- Time for clearing short circuit current of 20 sec.
- 2 NO + 2 NC auxiliary contacts

Miniature Circuit Breaker (MCB)

MCB shall be hand operated, air break, quick make, quick break type.

Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection.

Multiple pole MCBs shall be mechanically linked so that tripping of one pole simultaneously trips all the other poles.

The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this is not specified, it shall be Type C.

The short circuit rating shall be not less than that of the system to which they are connected.

Motor Starters:

Each feeder shall have two modes of operation – Manual Mode & auto Mode. In Manual Mode, the essential safety interlocks shall be provided with hardwire system. Also the starter shall have facility of Local/Remote Start/Stop in Manual Mode. In Auto Mode, the starter shall operate on PLC command.

Air break starter contactor shall be electro-magnetic type for uninterrupted duty as per IS: 2959 unless specified otherwise. The main contacts shall be of Silver or Silver Alloy. The insulation class for the coils shall be class 'E'. Each Contactor shall be provided with 2 NO + 2NC auxiliary contacts. In case these are not available in the main contactor an additional auxiliary contactor shall be provided.

Thermal overload relay with single phasing preventor shall be of three-element positive acting bi-metallic ambient temperature compensated type with adjustable setting. These relays shall be hand reset type. The hand reset button shall be flush with the front door of the control module and shall be suitable for resetting the overload relay with the module door closed.

Relay shall be either directly connected or CT operated as per manufacturer's recommendation depending on motor KW rating. Reset button shall be independent of start/stop push button.

Control/Selector Switches:

All control/selector switches shall be flush mounted on module door and shall be rotary, stay put, maintained contact type with phosphor bronze contacts. Ammeter selector switches shall have make before break feature.

The selector switches shall have four positions for reading three phase currents and fourth shall be 'OFF' position. The voltmeter selector switch shall have five position – three for the phase-to-phase voltage, the forth for phase to neutral voltage and fifth shall be 'OFF' position. Remote /Local / Off selector switches for motor feeders shall be lockable in 'OFF' position. Properly designated escutcheon plates clearly marked to show the operating position shall be provided with all switches.

Current Transformers (CTs):

Current transformers shall be cast resin wound primary or bar primary type and shall be able to withstand the thermal and mechanical stresses arising from the maximum short circuit and momentary duties of the equipment. The secondary rating of current transformers shall be 1A.

The polarity markings shall be clearly marked on the CTs and the lead termination of the terminal block.

The core laminations of the CTs shall be high-grade silicon steel. Magnetisation characteristics, performance calculation and protection settings of the CTs shall be provided.

The accuracy class for CTs shall be 1.0 and 5 P-20 for metering and protection purposes respectively. Where multi-ratio current transformers are provided, VA ratings of the current transformers shall be indicated, a label shall be provided, clearly indicating the connection required for alternative ratios.

These connections shall also be shown on Panel wiring diagrams. Identification labels shall be fitted giving type, ratio, output and serial numbers and duplicate rating labels shall be fitted on the exterior of the mounting chamber suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switch board.

Indicating Lamps:

Panel mounting type low power consumption LED type status indicating lamps suitable for specified voltage shall be used. Lamps shall be provided with suitable current limiting series resistors. Translucent lamp covers shall be provided to diffuse light.

Push Buttons:

Start/stop push buttons shall be suitable for Panel mounting and comprise of a contact element and actuator.

The contacts shall be of silver alloy of 10 A continuous current rating at 240V AC. Each push button shall be provided with 2 NO + 2 NC contacts. Colour of push buttons shall be as per relevant IS/standard code of practice. Emergency stop push buttons shall be lockable in operated position.

Push button knob for emergency stop push buttons shall be shrouded to prevent accidental operation.

Space Heaters:
Each individual cubicle shall be provided with space heaters to prevent moisture condensation and maintain cubicle temperature 50 C above the ambient.

The space heaters shall be located at the bottom of the switchboard and shall be controlled through a thermostat with an adjustable settings and a manually operated switch. For space heater 6 A DP switch and two HRC fuses shall be provided.

Each vertical Panel shall also be provided with 6A plug socket & switch for hand lamp connection.

Space heaters shall be provided only if the average humidity in the region is more than 250% for more than 3 months in a year.

Contactors:
Power contactors shall be air break type, having three power contacts and 2 NO + 2 NC auxiliary contacts conforming to IS: 2959. Contactors provided shall be AC 3 Duty type as per IS: 3947 part 4.

It shall be capable of making and breaking starting current of motors of corresponding rating. Auxiliary contacts shall be rated for at least 6 A and shall be break before make type. Insulation class of coil shall be minimum class B.

Contacts shall drop out at voltage down to 70% of rated coil voltage and pick up at 255% of rated coil voltage.

Switches:
Switches shall be air break type as per IS: 4047. The switch operating handle shall be front mounted and interlocked with the door such that the door cannot be opened when the switch in 'ON'. The live parts shall be shrouded with suitable insulating barriers so as to prevent accidental contact with the live parts after opening the module front door. Motor control switches shall be suitable for reliable and safe starting and stopping of 3 phase AC motors even under heavy starting locked rotor conditions. Switches shall be heavy duty, quick make and quick break type AC 3 duty. Switch contacts shall be silver plated and contact springs shall be of stainless steel. Switch handles shall have provision for locking in both open and closed positions. Mechanical ON-OFF indication shall be provided on the switches.

Indicating Meters(Analog / Digital):
Ammeters and voltmeters shall be of moving iron industrial type grade of accuracy class 1.5. The size of the instrument shall be 144 mm sq. for starter and fuse switch compartments. Ammeter with suppresses scale current rating shall be provided for specific requirements. Indicating instruments shall be mounted flush on the module doors.

Instrument dials shall be white with black numbers and lettering. Dials shall be parallax free. All indicating instruments shall have provision for zero adjustment outside motor cover.

Normal maximum meter reading shall be of the order of 60% of normal full scale deflection. Watt-hour meters shall be of the induction type and shall be provided with reverse running stop. One no. power factor meter shall be provided for the incoming feeder of PMCC.

Internal Wiring:

Internal wiring for control circuits shall be made with 650 V grade single or multistrand copper PVC wires. The minimum size of control wiring shall be 2.5 sq. mm copper for power & CT circuits and 1.5 sq. mm copper for other circuits. The wiring shall be terminated in the respective terminals with suitable crimp type sockets. There shall not be more than two wires connected to a terminal. Horizontal as well as vertical wire ways shall be provided. At the top, a horizontal wire way shall connect the inter Panel wiring.

Internal wiring terminal blocks shall be of 650 V grade with contacts of rating not less than 10 amps. They shall be of the screw type with barriers between adjacent contacts. The wire termination to the terminal block shall be of the screw type suitable for crimp type sockets.

Power Cable Termination:

Gland plates of adequate size & thickness shall be provided at the bottom of cable chamber to facilitate cable entry from bottom. Compression type gland shall be provided. Crimp type sockets made of tinned copper or aluminum shall be provided for terminating cables. Suitable shrouds shall be provided to prevent accidental contact with live outgoing terminations of other feeders while carrying out maintenance of one feeder. The individual cores of power and control cables shall be neatly dressed and supported at regular intervals inside the cable chamber, before connecting them to the relevant terminals. Termination kits for cable terminations shall be provided, as required.

Labels:

Labels shall be anodizedaluminum with white engraving on black background. They shall be property secured with fasteners.

Control / Auxiliary Power Circuits:

Control circuit voltage shall be 230 V AC achieved through suitably rated control transformer. Two (2) Nos. control transformers, each 100% rated shall be provided with selector switch and control buses. Auxiliary power supply voltage shall be 240 V AC, tapped from before the switch-fuse unit of the incomer with isolating switch and fuses.

All wiring for control & auxiliary power circuits shall be colour coded as follows:

AC circuits with	-	Red, Yellow or Blue determined by the phase, which the wire is associated.
AC phase wire	-	White
AC neutral	-	Black
DC circuits	-	Grey
Earth connections	-	Green

Engraved core identification ferrules, marked to correspond with the wiring diagram shall be fitted to each wire and each core of multi core cables terminated on the panels. Ferrules shall fit tightly on the wires, without falling off when the wire is removed. Ferrules shall be of white colour with black lettering. All wires forming part of a tripping circuit shall be provided with an additional red ferrule marked ‘T’.

Each wire shall be identified by a letter to denote its function followed by a number to denote its identity, at both ends. Unused cores of multicore cables shall be ferruled U1, U2 etc., at both ends and connected to spare terminals. Spare auxiliary contacts of electrical equipment shall be wired to terminals blocks.

Control Wiring Terminal Blocks:

Terminal blocks shall be of the 650 V grade, stud type of rating not less than 10A. Brass studs of at least 6 mm dia with fine threads shall be used and securely locked within the mounting base to prevent turning.

Each terminal shall comprise two threaded studs, with a link between them, washers, matching nuts and locknuts for each stud. Insulated barriers shall be provided between adjacent terminals.
Not more than two wires shall be connected on any one stud. Where duplication of terminal block is necessary, suitable solid bonding links shall be incorporated in the design of the terminal block.

Provision shall be made to insert terminal labels or shrouds between two successive insulating barriers.
Connections to the terminals shall be at the front. Terminals shall be numbered for identification and grouped according to function and engraved black-on-white labels shall be provided on the terminal blocks describing the function of the circuit.

Terminals for circuits with voltage exceeding 125 V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled.

Current transformer secondary leads shall be brought to terminal blocks, where a facility shall be provided for short circuiting and grounding the secondary. Terminal block shall be arranged with at least 100 mm clearance between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively.

All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type terminations. 20% spare terminals shall be provided in each terminal block.

Test Terminal Blocks:

Test terminal blocks shall be provided for secondary injection and testing of relay equipment. A suitable metering block shall be provided for the connection of a portable precision instrument to be operated when required, for specific plant testing purposes.

The terminal blocks shall be provided with suitable shorting links or alternatively shall be of the type suitable for use with a portable test plug-in-arrangement.

Earthing of Switchgear / Distribution boards:

Each switchgear / Distribution board shall be provided with an earth bus running along its entire length. The earth bus shall be located at the bottom of the board / Panel.

Earth bus shall be of copper. Earth bus shall be adequately sized to carry the rated symmetrical short circuit current of the associated board / Panel for one second.

Earth bus shall be supported to withstand stresses generated by the short circuits & momentary current of the associated switchgear / distribution boards.
Positive connections of all non-current carrying metallic parts and the frames of equipment mounted in the switchgear / distribution board to the earth bus shall be maintained through insulated conductors of adequate size.

All instrument and relay cases shall be connected to earth bus by means of 650 V grade, PVC insulated, stranded, and tinned copper, 2.5 sq.mm conductor, looped through the earth terminals of the case.

The scope of work will also include the rubber mat required to be spread in front of all the panels. The mat shall have a thickness of 12.5 mm and shall have dielectric strength suitable for the Panel voltage ratings.

Separate earting using copper strip and two earth pits with copper plates shall be provided for instrumentation.

Parameters for PCC & MCC:

1.0	Site Conditions		
1.1	Maximum ambient temp.	:	@ 35^0 – 40^0C
1.2	Minimum ambient temp.	:	15^0C
1.3	Relative Humidity	:	@ 98 %
1.4	Altitude	:	4 to 5 M above MSL
1.5	Environment	:	Tropical
2.0	Ratings	:	
2.1	Rated voltage , phase and frequency	:	415 V, 3 phase, 4 wire, 50 Hz
2.2	Type of construction	:	Single front-fixed type compartmentalized
2.3	Maximum system voltage	:	457 V
2.4	One minute power frequency withstand voltage	:	
	Power circuit	:	2500 V
	Control circuit	:	1500 V
	Aux. circuit connected to secondary of CT s	:	2000 v
2.5	Continuous current rating of bus bar under site reference ambient temperature of 50^0C.	:	To be decided by the Contractor on the basis of the plat load.
2.6	Short circuit withstand for bus bars and droppers	:	
	Short time (1 sec) at 415 V	:	to be decided by the Contractor based on the fault level available at HV side and the impedance of the transformer
	Dynamic rating	:	To be decided by the Contractor based on the fault level at LV side
3.0	Starters	:	
3.1	Type	:	Motors ≤ 5 kW – DOL Motors > 5 kW – Star-Delta Motors > 55 KW – Soft Starter/VFD
3.2	Contactor Rated Duty as per IS: 2959 and 25544	:	Uninterrupted
3.3	Utilization category as per IS : 2959 and 25544	:	AC3
4.0	Cable Entry	:	Top or Bottom

Tests:
The design of the switchgear / distribution board shall have been type tested in accordance with the relevant sections of IS: 25623. In absence of type test certificates, the following type tests have to be carried out by the Contractor free of charge to me AMC.

- Verification of short time current withstands and peak current withstand of main and vertical bus bars.
- Temperature rise tests on main bus bars, b\vertical risers, power contacts and control contacts.
- Routine test shall be conducted on the Panel in accordance with is: 25623.
- Dielectric tests.

Inspection: Category A Sub-Distribution Boards.

e. Motors

Materials, workmanship and standard: All the materials used in the manufacture of motors shall be of high grade free from defects and imperfection.

The motors shall be built to conform to the Indian Standard Specification as listed below along with other relevant codes.

IS : 325	:	Induction Motors
IS : 1231	:	Dimensions of 3 phase foot mounted induction motors
IS : 4691	:	Degrees of protection provided by enclosure from rotating electrical machinery.
IS : 4729	:	Measurement and Evolution of vibration of rotating electrical machinery.
IS : 6362	:	Methods of cooling of rotating electrical machines.

Workmanship shall be first class and workmen, skilled in their trades, shall do all work. Machining of fits and finish shall conform to the modern shop practice.

Type:
Squirrel cage, horizontal shaft mounting, induction motor suitable for Waste Water Treatment Plant environment shall be offered. The motors for indoor duty shall be TEFC with IP-44 protection. Motors for outdoor duty shall be TEFC with IP-55 protection.

Insulation:
Motors shall be provided with class F insulation with temperature rise limited to class B insulation. The insulation shall be given tropical and fungicidal treatment for successful operation of motor in hot, humid and tropical climate as per applicable standard. For motors for outdoor duty, account shall be taken of heating due to direct solar radiation.

Speed:
Speed shall not be more than 1500 RPM. The manufacture shall furnish the recommended standard and the economical speed.

Cooling:
Motors shall be cooled by self-ventilation only.

Bearings:

Motors shall preferably have grease lubricated ball or roller bearings. The bearings shall be adequate to absorb thrust produced by the motor and driven equipment assembly. Bearings shall be lubricated by grease injection from outside, in motor running condition without removal of bearing covers. Labyrinth seal shall be provided to prevent loss of grease and to protect entry of dust.

In case of oil lubricated bearings, a drain plug and oil level sight glass be provided.

Terminal Box:

Terminal box of the motor shall be suitable for top and bottom entry of cables and capable of being rotated through 3600 in step of 900. The box shall be of weatherproof spring washer, check nuts, cable glands and lugs. The terminal box shall have sufficient space for installation of termination kit. Separate terminal box shall be provided for space heater etc.

Overloads:

The motor shall have the standard short time overload capacity permitted by the applicable standard. The motor ratings shall be at least 15 % over the BHP required by pump / equipment at duty point or 10 5 above the maximum HP required by the pump / equipment in its entire operating range, whichever is higher.

Variation withstand capacity:

The motor shall be capable of producing rated output without reduction in life span when operated under either of the following variations in supply conditions:

- Variation of supply voltage from rated value + 10 %
- Variation of supply frequency from rated value + 5 %
- Combined voltage and frequency variation 10%(absolute sum)

The motor shall be capable of starting and accelerating the driven equipment with applicable method of starting without exceeding the temperature rise limit as 255% of rated voltage at motor terminals.

Noise and vibration:

The motor shall be designed to operate with least noise and vibration. Special precaution shall be taken for smooth running of the motor. The noise level must be within the limit of international standards.

Shaft:

The rotor shaft shall be forged to shape from open hearth carbon or alloy steel and heat treated to obtain high rigidity.

The shaft shall be designed to rotate without vibration and distortion at 25 % over the rated speed and shall have ample strength and stiffness to resist twisting on short circuit. The normal speed and the critical speed of the shaft shall be stated.

Fans:

For TEFC motors axial flow fans shall be mounted n rotor shaft for efficient circulation of air. Fans shall be of corrosion resistant die cast Aluminum or Polypropylene. They shall be suitable for rotation in either direction without affecting motor performance.

Lubrication System:

The bearing shall be equipped with all accessories and devices for lubricating the bearings while the motor is in service. Oil cooling / grease cooling arrangement shall be provided.

Number of Starts:

The motor shall be designed to allow the required number of consecutive starts for the application envisaged with at least 1 hot restart.

Space Heater:

The outdoor motors and indoor motors rated 30 KW & above shall be provided with space heater.

Balancing:

All rotating of the motor shall be balanced both statically and dynamically so as to run perfectly, smoothly vibration-free. Site balancing of the motor and driven equipment shall also be done during trial running before commissioning.

Earthing:

Two earth terminals shall be provided for the motors on base. One separate earth terminal shall be provided inside the terminal box.

Painting:

External parts shall be finished and produce a neat and durable surface which will percent rusting and corrosion. The surface shall be degreased and all rust, scales, sharp edges removed and treated with red oxide primer and two coats of finish paint as per shade approved by EIC.

Parameters for Motor:

1.0	Site Conditions		
1.1	Maximum ambient temp.	:	@ 35^0 – 40^0C
1.2	Minimum ambient temp.	:	@15^0C
1.3	Relative Humidity	:	@ 98 %
1.4	Altitude	:	4 to 5 M above MSL
1.5	Environment	:	Tropical
2.0	Application	:	Sewage Transfer Pumps / Wash Water pump / Air Blowers / Scraper / Booster Pumps
3.0	Type	:	Sq. cage induction type
4.0	System voltage phase, frequency	:	415 V, 3pH, 3 wire, 50 Hz
5.0	Starting method	:	DOL / Star-Delta / Soft starter / VFD
6.0	Starting current restriction	:	6 x FLC in DOL and 2 x FL C in S/D
7.0	Type of insulation	:	Class F
8.0	Space heaters	:	For motors rated 30 kW and above

Tests:

The following routine tests in accordance with IS: 325 of latest edition shall be performed in presence of the Engineer.

- Insulation resistance test
- Measurement of no load current and speed at rated voltage and rated frequency.
- Measurement of locked rotor current at reduced voltage or rated voltage and at rated frequency.
- High voltage test.
- Reduced voltage running up test at no load to check the ability of motor to run up to full speed at no load in both the directions of rotation with one third of rated line voltage applied to stator terminals.

The following additional test shall be performed to verify the performance, characteristics and guarantees. They shall be in accordance with IS: 325 of latest edition.

- Measurement of stator resistance.
- Temperature rise test
- Momentary overload in torque test
- High voltage test
- Over speed test

Each type and rating of the motors should have been type tested in accordance with IS: 325. In absence of type test certificates, type tests shall be carried out without any extra cost to the AMC.

Inspection: Category B

f. Power and Control Cables

HT Cable

Cable of 11/22 KV/ (Earthed) grade shall be armored & conform to IS: 70925 (Part II). The size of the cable shall be suitable for adequate electrical loading with multi-stranded. Compacted, circular shaped, aluminum conductors. The conductor screen and insulation screen shall both be f extruded semi-conducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion so as to obtain continuously smooth interfaces.

The metallic screen of each core shall consist of copper tape with minimum overlap of 20%.

The manufacture shall suitably design the semi conducting screen and shall clearly indicate the thickness and resistively of screed for both conductor and insulation. The thickness of this screen and resistively shall be as per requirement of relevant IS.

The eccentricity of the cores shall not exceed 10% and then 2%. Method of curing for cable shall be day curing / gas curing / gas curing / steam curing.

XLPE insulation shall be suitable for a continuous conductor temperature of 90^0C and short circuit conductor temperature at 250^0C.

The cable shall have distinct extruded PVC inner sheaths and outer sheaths of black color as per IS: 53251. The armoring shall be of galvanized steel as per relevant IS.

LT Cable

Cables for low & medium voltage and industrial heavy-duty application. Shall be multi core XLPE insulted PVC sheathed and armored of voltage grade 1100 V conforming to IS: 1554 Part I. Conductor shall be stranded Aluminum / Copper for power cable and stranded Copper of size 2.5 mm 2 for control cables.

Cable for internal wiring purpose in conduits shall be single core stranded copper conductor, PVC insulated conforming to IS: 694.

All cable shall be delivered to site as complete coils with wrapping in non-returnable drums and seals intact, accompanied by manufactures test certificate and indicating the date of test.

The length of cable on each drum shall be determined be determined by the manufacture considering the transport limitations from works to site.

The Contractor shall obtain AMC's approval for the drum length before packing cables on drums. No joints shall be allowed unless the actual length required is more than a drum length.

Construction of 650 / 1100 V grade cables:

The cables shall be of stranded aluminum / copper conductor, extruded inner and outer PVC sheath, flat / round galvanized steel armoured.

Cables up to 10 sq. mm conductor size have round steel wire armour. Above 0.00 sq. mm. size flat steel armour shall be used. For 31/2n core cables the current carrying capacity of the neutral conductor shall be 75 % of that of the main phase conductors.

The cables shall operate satisfactorily without any damage / deformation in shape and size at site conditions and at a continuous conductor temperature of 70^0C.

The cables shall successfully withstand the rated short circuit current for the duration specified by the manufacture without exceeding conductor temperature of 160^0C.

Cores shall be identified by different coloring PVC insulation. Following clour scheme shall be adopted.

Single Core	:	Red, Black, Yellow or Blue
Twin Core	:	Red, and Black
Three Core	:	Red, Yellow and Blue
Three & half Core	:	Red, Yellow, Blue and Black
Neutral of 31/2 Core	:	Black

For multi core cables, cores shall be numbered. Further spare cored shall be provided in control cables as follows:

Upto 5/C	:	No spare core
Above 5/C up to 9/C	:	1 spare core
Above 9/C up to 14/C	:	2 spare core
Above 14/C	:	3 spare core

Control cable cores shall be 3/C, 5/C, 7/C, 9/C, 14/C & 19/C
The cable sixes shall be selected based on the following criteria:

- Continuous current of the circuit
- Maximum voltage drops of 10% during starting and 3% during normal running condition of the equipment.
- Short circuit withstands time corresponding to system fault current and fault clearing time by the circuit protection.
- Various de-rating factors for ambient air temperature, type of laying grouping etc.

g. Lightning Arrestor

The lightning arrestor shall be nonlinear type station class suitable for non-effectively earthed, 50 HZ System, conforming to IS: 3070. The lightning arrestor shall consist of line to earth terminal stud, no. of spark gaps on series of linear resistors, the whole assembly housed in mechanically sealed porcelain bushing. Neoprene rubber gasket shall be provided between metal caps and porcelain.

Non-linear resistor shall be of silicon carbide block finished at both ends to ensure good electrical contact. Spring shall be provided to keep good electrical contact between terminals, non-linear resistor and spark gap, mounting brackets shall be hot dip galvanized suitable for installing lightning arrestor on structure.

Lightning arrestor shall be of hermetically sealed self-supporting construction suitable for mounting on structures. They shall have adequate thermal discharge capacity for switching surges, long duration surges and multiple strokes. The lightning arrestors shall be capable of withstanding the internal pressures developed during above discharge without operation of the pressure relief devices.

Arrestors shall be designed to withstand the seismic design co-efficient specified in IS. Arrestors shall be provided with pressure relief device, which will prevent shattering of porcelain in case excessive gas pressure builds up.

Outer insulators shall be of porcelain having adequate mechanical strength and rigidity for satisfactory operation under climatic conditions. Porcelain shall be finely glazed and shall be free from imperfections. All metal parts of the lightning arrestors shall be of non-rusting and non-corroding metal or if made of steel / iron, the same shall be galvanized or metalized. Bolts, screws and pins shall be provided with lock washers, key or equivalent locking facility.

Arrestors shall incorporate anti-contamination feature to prevent arrestor failure consequent to un-even voltage gradient shall be capable of discharging over voltages occurring during switching of unloaded transformers.

Spacers for gaps and valve elements or valve blocks shall be of ceramic material to provide robust construction and with excellent mechanical and electrical properties.

Arrestor shall be complete with insulation bases having provision for bolting to flat surface of supporting structure. Grading rings shall be provided on each complete arrestor unit for proper stress distribution as dictated by the voltage class. Arrestors shall be complete with line and earth side terminals with clamps and connectors as per requirement.

The complete assembled arrestor shall be subjected to routine and acceptance tests as per IS: 3070 part I, in presence of the Engineer. Type test report of similar type & rating of arrestor shall be furnished.

h. Specifications of Variable Frequency Drive

General References

The drive should be designed to meet the following specifications:

- NEMA ICS 3.1 – Safety standards for Construction and Guide for Selection, Installation and Operation of Adjustable Speed Drive Systems.
- IEC 146 – International Electrical Code.

Product Ratings

- **Input Power**
  The drive should be self-adjustable to accept an input supply voltage of AC, 3 phase & neutral of 415 V ± 10%, 50 C/s ± 5%.
- **Environment**
  Storage ambient temperature range: -10 to 50 degree centigrade.
  Operating ambient temperature range: 5 to 50 degree centigrade without derating.
- **Output Power**
  The output voltage should be adjustable from 0 to rated input voltage. The output frequency range should be adjustable from 0 to 100Hz. The inverter section shall produce a pulse width modulated (PWM) waveform using latest generation techniques.

- **Design Hardware**
  The drive hardware shall be employ the following power components
  - Diode or fully gated bridge on the input.
  - DC bus inductor on all ratings as required.
  - Switching logic power supply operating from the DC bus.
  - Phase to phase and phase to ground MOV protection.

- Gold plated plug-in connections on printed circuit boards.
- Microprocessor based inverter logic isolated from power circuits.
- Latest generation inverter section.
- Inverter section shall not require commutation capacitors.
- Customer Interface common for all horsepower ratings. Interface shall include an LCD digital display, programming keypad and operator keys option.
- Common control connection for all ratings.
- Optimized for 4 kHz carrier frequency at 44kW (60HP) or less, and 2 kHz at 55kW (75HP) and larger.
- Peripheral Interface to enable attaching common options.

Control Logic

The drive should be programmable or self-adjusting for operation under the following conditions.

- Operate drive with motor disconnected.
- Controlled shut down, when properly fused, with no component failure in the event of an output phase to phase or phase to ground short circuit and annunciation of the fault condition.
- Adjustable PWM carrier frequency within a range of 2-25 kHz. Selectable Sensor less Vector or V/Hz mode.
- Selectable for variable or constant torque loads. Selection of variable torque shall provide 115% of rated VT current for up to one minute. Selection of constant torque shall provide 150% of rated CT current for up to one minute.
- Multiple programmable stop modes including – Ramp, Coast, DC-Brake, Ramp-to-Hold and S-curve.
- Multiple acceleration and deceleration rates.
- All adjustments to be made with the door closed.

i. Power Conditioning

The drive should be designed to operate on an AC line which may contain line notching and up to 10% harmonic distortion. An input isolation transformer shall be required for protection from normal line transients and the K factor shall be 4.0 or less.

PF shall after rectification if required for lower frequencies not be lower than 0.95.

Features

Interface

The drive shall provide a removable Human Interface Module with integral display to show drive operating conditions, adjustments and fault indications. The display should be removable under power without causing a fault and shall be visible and operable without opening the enclosure door. The module also shall provide LED indication of drive direction and commanded direction. The display should be capable of remote mounting by means of cable connection up to 10 meters (33ft) from the drive and shall be capable of being used as a hand-held terminal.

Control Mode

Programming shall provide the ability to select sensor less vector or v/hz mode. The sensor less vector mode shall use the motor nameplate data plus motor operating data, such as IR drop, nominal flux current and flux up time. The volts per hertz mode shall be programmed for squared, cubed, straight line, preprogrammed or full custom patterns.

Current Limit

Programmable current limit shall be from 20% to 160% of constant torque rating. Current limit should be active for all drive states; accelerating, constant speed and decelerating. The drive shall employ PI regulation with an adjustable gain for smooth transition in and out of current limit.

Acceleration/Deceleration

Accel/Decel setting shall provide separate adjustments to allow either setting to be adjusted from 0 seconds to 3600 seconds. A second set of remotely selectable Accel/Decel setting shall be accessible with Control interface option. An adaptive current limit circuit shall be disabled in programming for fast acceleration of low inertia loads.

Speed Regulation

The programmable speed regulation modes shall include the following:

- Open Loop
- Slip Compensation with 0.5% speed regulation
- Droop – Negative Slip Compensation with 0.5% speed regulation
- Traverse Function
- Closed loop encoder feedback with 0.1% speed regulation
- Process PI control

Speed Profiles

Programming capability shall allow the user to produce speed profiles with linear acceleration/declaration or “S-Curve” profiles that provide changing accel/decel rates. S-Curve profiles shall be selectable for fixed or adjustable values.

Adjustments

The digital interface should be used for all set-up, operation and adjustment settings. All adjustments shall be stored in nonvolatile memory (EEPROM). No potentiometer adjustments shall be used. The drive shall provide EEPROM memory for factory default values.

Process Pi Control

The internal process PI regular shall have both proportional and integral gain adjustments well as error inversion and output clamping functions. The feedback shall be configured for normal or square root functions.

If the feedback indicates that the process shall be moving away from the set point, the regulator shall adjust the drive output until the feedback equals the reference. Process control shall be enabled or disabled with a hardwire input.

Transitioning in and out of process control shall be tuned for faster response by preloading the integrator. Protection should be provided for a loss of feedback or reference signal.

Fault Reset/Run

The drive shall provide up to nine automatic fault reset and restarts following a fault condition before locking out and requiring manual restart.

The automatic mode should be not applicable to a ground fault, shorted output faults and other internal microprocessor faults. The time between restarts shall be adjustable from 0.5 seconds to 30 seconds.

Skin Frequencies

Three adjustable set points that lock out continuous operation at frequencies which may produce mechanical resonance shall be provided. The set points shall have a bandwidth adjustable from 0Hz to 15 Hz.

Run On Power Up

A user programmable restart function should be provided to automatically restart the equipment after restoration of power after an outage. A maintained 2-wire start input shall be provided for this function.

Line Loss Restart

This programmable function shall select the reconnect mode of the drive after recovery from a line loss condition. The reconnect modes shall be – Last Speed.

Speed Search, Track Volts, or Use Encoder. Disabling this feature will force the drive to start from zero hertz.

Fault Memory

The last four faults as well as operating frequency drive status and power mode shall be stored at the time of fault. Information should be maintained in the event of a power loss.

Overload Protection

The drive shall provide Class 20 motor overload protection. Overload protection should be speed sensitive and adjustable for motors with speed ranges of 2:1, 4:1 and 10:1. A viewable parameter shall store the overload usage in percent. An alarm bit shall be used to adjust a process to eliminate an overload trip.

Auto Economizer

This feature automatically shall reduce the output voltage when the drive shall be operating in an idle mode (drive output current less than programmed motor FLA).

The voltage should be reduced to minimize flux current in a lightly loaded motor thus reducing kW usage. If the load increases, the drive shall automatically return to normal operation.

Terminal Blocks

Separate terminal blocks shall be provided for control and power wiring.

Flying Start

The drive should be capable of determining the speed and direction of a spinning motor and adjusts its output to “pick-up” the motor at the rotating speed. The flying start feature should be operable with or without encoder feedback.

Ride Through

The control logic should be capable of “riding through” a power outage of up to 2 seconds in duration.

Analog Output

An output signal should be jumper selectable for 0 – 10V DC or 0 – 20 mA which shall be user programmable such that it shall be proportional to one of 13 process parameters including output frequency, output current, encoder feedback, output power and other.

A programmable offset should be provided to allow modification of the analog output to obtain 2 – 10 V DC or 4 – 20 mA. Programmable gain adjustments for both upper and lower settings shall allow for system calibration.

Reference Signals

The drive should be capable of the following input reference signals:

- Digital pulse input
- Digital MOP
- Remote potentiometer
- Serial
- 0 – 10 V DC
- HIM (program/Control Panel)
- 4 – 20 mA

The remote potentiometer should be also programmable to be used as a trim pot for the 0 – 10V DC or 4 – 20 mA signals. Programmable gain adjustments for both upper and lower setting shall allow for system calibration. The analog inputs shall be programmable for normal, inverted or square be root operation.

Loss of Reference

In the event of loss of the 4 – 20 mA reference signal, the drive should be user programmable to the following:

- Fault and stop
- Alarm and maintain last reference within 10%
- Alarm and go to preset speed
- Alarm and go to minimum speed
- Alarm and go to maximum speed
- Active for Process PI reference or feedback

Digital I/O

Contact output ratings shall be 115V AC/30V DC, 5.0 Amp resistive, 2.0 Amp inductive. All four contacts shall be provided with programmable to 17 different conditions. Factory settings shall be as follows:

- Form A Run Contact
- Form C Fault Contact
- Form C Alarm Contact
- Form A At Speed Contact

Operator Devices

The drive shall provide an option for Start, Stop, and Jog. Reverse and Speed Control as an integral part of the Human Interface Module.

Control Interface

All control interface cards shall provide input terminals for access to fixed drive functions that include start, stop, external fault, speed, and enable.

Four additional inputs shall be to be programmed to one of 24 different input Modes for functions such as reverse, preset speed access, jog, second accel/decel time access, process trim, speed/torque, and local control selection.

Inputs shall be programmable to configure the drive for standard 3-wire, 2-wire, EC, 4-20 mA DC and serial operation requirements.

Remote I/O Communication

This be option shall provide a Single Point Remote I/O interface board. The board should be configurable for 1/4, 1/2, 3/4, or full rack with a baud rate of 57.6, 115, or 230k baud.

The Remote I/O board may be set up to control drive logic and speed reference commands and monitor drive status and process parameters.

j. Internal and External Illumination and Other Electrical Works

General:

Illumination system shall consist of lighting fixtures complete with fluorescent tubes / incandescent lamps / sodium vapour lamps. All materials, fittings and appliances used in the installation shall conform to the relevant IS specification and shall be anticorrosive painted for treatment plant area.

Illumination Levels:

The following minimum levels of illumination shall be provided in the respective areas:

Area	Illumination Level
Platforms and Chlorine house	
Offices, Laboratory	: 200 lux
Switch Gear rooms	: 150 lux

Area	Illumination Level
Transformer substation yard/ clarifier bridges	: 100 lux
Toilets, Staircase	: 70 lux
Plant Outdoor area	: 50 lux
Roads etc.	: 15 lux

Area Lighting/External Electrification

Scope

The scope of this specification covers design, manufacture, inspection of manufacturer's works and installation of MS/high Tensile Steel galvanized octagonal street light poles. The specifications of poles are as under: -

Specifications of Octagonal Poles:

This specification determines the requirements of the octagonal poles in respect of design, manufacture, testing and supply of galvanized poles, base plate and bracket arms for use in street lighting.

This specification covers tapered octagonal single piece columns of required mounting height.

High tensile steel round as well as octagonal poles of 3mm thickness with hot dip galvanized in the bath tub up to 9-11 meter. Single pole with minimum thickness of galvanizing as 36 micron. Contractor may use M.S. steel poles with 4mm thickness single pole of 9-11m. length with hot dip galvanized in the bathtub up to 12 mtr. single pole with minimum thickness of galvanizing 86 micron.

Galvanized base plate of special steel having thickness of 20mm is to be considered alternatively Bidder can quote for MS base plate with 25mm thickness.

Octagonal poles shall be of flanged type to be fixed on the foundation bolts.

Possible loading configurations for different types of octagonal poles are indicated in respective GA drawings.

The octagonal poles shall be designed for 180 km/Hr. maximum wind speed.

The pole shall be provided with a common base plate of suitable size.

Galvanized iron junction box of adequate size, 2.7mm thick (water tight – IP 66 grade) shall be provided for each street light pole. The box shall have arrangement to receive designed size and number of cables. The terminal strip selected shall be suitable for the same.

The box shall also be provided with a required rating/capacity MCB for controlling the individual lighting fixture. It shall be wired up in the respective phase. 3 x 25 sq. mm PVC insulated multi-strand copper wires shall run from the junction box to the lighting fixture. The sires shall run through the pipe. The wires shall be protected to avoid any damage at the entry point by providing rubber grommet. A suitable clamping arrangement shall also be provided. An arrangement for earthing to the pole shall be provided.
Two numbers of 50mm dia G.I. conduits shall be provided in the foundations from the directly buried main cable up to the junction box for incoming and outgoing cables with G.I. clamps of size 25 x 3 mm.

Suitable cement concrete foundation for the octagonal pole shall be designed by the successful Tenderer considering soil bearing capacity of 10 Tons/sq.mtr.

An earthing bolt (M6) shall be provided with a suitable nut to receive two number of 8 SWG G.I. earth wire.

General Standards
The methods and materials used shall comply with BSEN 10025 with yield strength of 355 Mega Pascal for octagonal pole shaft.

Hot dip galvanizing shall be in accordance with IS 2629-1966 except otherwise modified by provisions of this specification for poles and brackets.

Material
The steel used for manufacture of octagonal pole shaft and bracket shall be as per BSEN 10025 grade 355 Mega Pascal or equivalent and the material for the base plate, brackets, flange plates shall be as per IS 1062.

The steel used shall be welded, ageing resistant and suitable for hot dip galvanizing when such surface protection is required.

Manufacture
The octagonal pole shall be evenly tapered with single longitudinal welding from base to top. It shall be fabricated in one single section and shall be no circumferential weld joint.

Electrodes used shall be compatible with the grade of steel being used and have mechanical properties at least equal to those of the steel used. All welds shall comply with the following basic requirements: -

Base Plate
100% penetration between plates of all thickness. No fissures on inside or outside surface. No under cutting on the outside surface. Blowholes, spherical inclusions beyond standard minimum thickness shall be refused. Detectable angular inclusions shall not be acceptable.

Longitudinal Welds

60% penetration between plates of all thickness. No fissures on inside or outside surface. No undercutting on outside surface. No blowholes.

Galvanising

All components of the columns and brackets shall be hot dip galvanized after completion of fabrication. No further touching up, finishing or modification shall be done after galvanizing. The overall length of each section/bracket shall be immersed in one dipping operation.

The galvanizing coating shall be smooth, continuous and uniform. It shall be free from acid spots and shall not scale or blister nor be removable while handling or packing.

There shall be no impurities in the zinc nor additives to the smelter bath which could have a deleterious effect on the zinc coating.

Before pickling, all welding, drilling, cutting, binding etc. must be completed and all grease, paint, varnish, oil, welding slag etc. completely removed. All protuberances, which would affect the life of the galvanizing should be also be removed.

During pickling each article shall be completely immersed in one dip. Care shall be taken to ensure that the pickling solution is completely removed.

Weight of Zinc Coating

The weight of zinc deposited shall be not less than 86 microns.

Brackets

The bracket shall be hot dip galvanized after fabrication. The bracket shall be manufactured as per the GA drawing and with best workmanship. The bending of the pipes shall be without any kinks/visible marks. Arms shall be symmetrical.

Electricals

The octagonal pole shall be provided with a door flush with the pole surface without any projection. Required door reinforcement shall be determined by the manufacturer. Inside the door a suitable plate shall be welded for mounting 6A MCB and neutral link. Three core 2.5 sq.mm. copper wires shall be run for each luminaire individually.

Cable Laying

The cable laying shall be from supply point to the feeder pillar Panel and from feeder pillar Panel to street lighting poles.

The cable from supply point up to the feeder pillar shall be laid underground in excavated trench RCC pipe and HDPE pipe. The trench shall be at least 0.7 mtr. deep and 0.4 mtr. wide sand cushioning of 20mm shall be provided before laying the cable. The cable shall be protected with good quality bricks on all the sides. At road crossings, the cable shall be laid in 100mm dia RCC hume pipe of NP-2 class.

The cable from feeder pillars to the lighting poles shall be laid in suitable sized HDPE pipes buried at a depth of 0.7 mtrs. Loop of at least 1 mtr. shall be provided on either side of the pole.

Cables as far as possible shall be laid in complete, uncut lengths from one termination to the other.

Magnetic induction / LED light fittings/ HPSV/MH Fittings

The fixture for housing 150 WMagnetic induction / LED light fittings HPSV/MH SON (T) should integral street light lantern with semi cut off with prismatic bowl with single piece cast alum. Body nickel-chrome plated reflector with unbreakable acrylic cover and necessary control gear electronic 'ignitron' necessary wiring with choke condenser etc. erected on provided brackets.

This item is for supplying and erecting integral 150 Watt HPSV/MH/HPMV fixtures with semi cut off prismatic bowl, with unbreakable acrylic cover suitable for 150 Watt. HPSV lamp with necessary holder fuse, choke, condenser and control gear box. The lantern should be erected on the provided bracket on the pole. The fixtures should be tested for acceptance in manufacturer works in presence of AMC's representative with satisfying all the technical details as given in relevant IS. The fixtures should have following technical details and features.

The Street light fixture should be complete with all parts and accessories such as housing assembly facetted mirror, felt gasket, lamp holder, lamp holder bracket, toggle, lead for gear compartment, gear try, ballast, capacitor, ignitor, terminal block, pole clamp, unbreakable polycarbonate acrylic cover etc. It should have following features:

Light distribution pattern confirm to IS and BS specifications.

Facility for cut off/semi cut off light distribution as per CIE recommendations. Optimum lamp holder position with respect to the mirror system for use with various light resources.

Use of aluminium/stainless steel polymetal met acrylic cover. Universal geared tray incorporative ballast, condenser, ignitor, connector, suitable for flexible choice of light source, pre wired for operation.

A felt gasket impregnated with insecticides and water repellent chemical.

Simplicity in replacement of bowl assembly, optical unit and gear trey.
Single piece construction diacaste aluminium housing (Contractor/ manufacturer should mention the percentage of copper for corrosion resistivity MBV treated and hear resistance housing.
High purity, highly brighten anodized aluminium facetted mirror with special peet of blue for excellent optical control and protecting reflectivity and abrasion.

Electrited ceramic lamp holder confirming to the DEC/finger set.

Sticking bracket to hold the acrylic cover when it is open.

Hexagonal bracket for holding the mask arm gift effectively.

Stainless steel toggle hooks for clamping the acrylic cover over the canopy for prevention of entry of insects.
Aluminium lead for gear compartment.
Zinc plated and yellow passivated hard.
Skirted lamp holder as per IEC figure test.
Cassette type loading of the gear unit.

Pot optics reflector for the fitting.

Cast aluminium in one piece with facility of toe in angle.

Magnetic Induction/ LED/HPSV/MH Lamp (SON-T)

The Contractor will have to supply 150 watts SON (T) lamp which is operating on single phase 50 Hz 230/250 volts A.C. electric supply. They have to supply the approved makes as specified in this Tender. The sodium vapour lamps should be tested in presence of AMC's representative in the manufacturing work before dispatch.

Trench

Trench shall be of suitable width and 0.7 mtr. deep for laying provided L.T. cable and refilling the same with screened sand bed for 20 cms to embed the cable and bricks placed on both side and top all over the run and with excavated earth without stones or hard materials and making the surface proper with 15 cms. Crown on the top when more than on cable is to be laid in the same trench additional bricks should be used to form another compartment. After laying of the cable in above manner the trench should be backfilled with the excavated soil without hard stones and should be provided with 15 cm crown on top all over.

Area Light Control

1) All area lights inside premises are proposed to be controlled from one control pillar.
2) For metering the energy consumption, a separate 1 phase/3 phase energy meter shall be provided in the control pillar.
3) The cable between 6 way feeder pillar and the area light control pillar shall be laid by the agency.
4) For automatic ON/OFF operation of the area light automatic timer shall be provided with energy saving device.

Light fittings:

The lighting fixtures shall comply with the following requirements:

The fixture shall be suitable for operation on a nominal supply voltage of 240 volts, signal phase, 50 Hz with voltage variation of 10%. All fixtures shall be designed for minimum glare. The finish of all parts of the fixtures shall be such that no bright spots are produced, either by direct light source or by reflection. For multi lamp fluorescent fittings, the circuit shall be designed in such a manner to reduce the stroboscopic effect to a minimum.

The lighting fixture ballast shall comply with the following requirements.

- Fluorescent light fittings shall be of high power factor type and shall be supplied with control gear and all necessary accessories for mounting.
- The ballast shall be of the inductive and heavy duty type copper winding filled with polyester or equivalent. They shall be free from hum and protected from the atmosphere. The ballast shall have low power less. HPSV lamp ballasts shall be provided with taps. For multi lamp fittings a separate choke shall be provided for each lamp.
- Outdoor lighting for lagoon areas, screens &grit chambers and building periphery shall be carried out with sodium vapor lamp fixtures. All other indoor areas shall be illuminated by using fluorescent tube fixtures or high bay sodium vapor luminaries complete with reflectors. Office areas shall have decorative type fixture.
- All lighting fixtures shall be supplied complete with lamps and all necessary accessories for satisfactory operation. Lighting fixture reflector shall generally be manufactured from sheet steel or aluminum of not less than 20 SWG. They shall be readily removable from the housing for

cleaning and maintenance without disturbing the lamps and without the use of tools. The following type of lighting fixtures shall be supplied:

- Fluorescent lamp lighting fixture of standard channel mounted type, suitable for surface mounting, completely wired, complete with mounting accessories, control gear etc., and with 1 No.36/40 watt fluorescent tube.
- Industrial type fluorescent lamp lighting fixtures suitable for surface mounting, complete with internal wiring, mounting rail, vitreous enameled sheet steel reflector, control gear, mounting accessories and with 2 Nos. 36/40 Watt fluorescent tubes.
- Decorative type fluorescent lamp lighting fixtures suitable for surface mounting, complete with mounting rail and internal wiring, vitreous enameled sheet steel reflector, louver, control gear, mounting accessories and with 2 Nos.36/40 Watt fluorescent tubes.
- Industrial bulk head type fixture with 60 W incandescent lamp.
- Industrial fixture with VE reflector with 60 W incandescent lamp.
- 250/150/70 W color corrected outdoor heavy duty HPSV light fixture provided with clear heat resistant front glass with tropicalizing gasket and other accessories and lamp. The fixture shall have a cast aluminum housing.
- Each fixture shall be complete with a four way terminal block for the connection and looping of incoming and outgoing supply cable. Each terminal shall be able to accept two Nos... 2.5 sq.mm copper conductor cables and shall be provided with an earthing terminal suitable for 12 SWG GI wire.
- Incandescent lamp fixtures shall be well glass type, complete with a cast housing and reflector both of which shall be vitreous enameled. The fixture shall be suitable for satisfactory use in mildly acidic atmosphere.
- Lighting fixture starters shall be of safety type i.e., if the lamp fails to ignite at the first start, no further starting shall be possible without attending to the lamp. Starters shall have bimetal electrodes of high mechanical strength.
- The enamel finish shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading. On completion of manufacture, all surfaces of the fixture shall be thoroughly cleaned and digressed. The fixture shall be free from scale, rush, and sharp edges and burrs.
- All light reflecting surfaces shall have optimum light reflecting coefficient such as to ensure the overall uniform light output.
- The fixture capacitors shall be suitable for operation at 240 V + 10%, single phase, 50 HZ, with a suitable value of capacitance to correct the power factor of the corresponding lamp circuit to the extent of 0.925 lag. The capacitors shall be hermitically sealed preferably in a metal container to prevent see page of impregnating material and ingress of moisture.
- Lamp holders for fluorescent tubes shall be of spring loaded, low contact resistance bi-pin rotor type, resistant to wear and suitable for operation at the specified temperature without deterioration in insulation value, contact resistance or lamp hording quality.
- Lamp holders for incandescent lamps shall be GLS type.
- Louvers shall be of polystyrene egg box type. Appropriate captive type fixing devices shall be incorporated for securing the louvers.
- Emergency light fitting shall be 240 V self-contained 2 x 10 W fluorescent tube with built in Ni – cd battery having charging facility and six hours back-up time. The emergency light fitting shall be provided at strategic locations of each house / area.

Receptacle Units

Industrial type receptacle units of approved make of 5/15A, 240 V, 6 pin socket outlet with interlocked switches conforming to IS: 32554 and sockets conforming to IS: 1293 shall be supplied.

The units shall be suitable for mounting flush on stoveenameled sheet steel boxes generally conforming to IS: 5133 (Part I). At each floor/room of every building, 2 Nos., of such receptacle units shall be provided. 4115 V, 63 A, 4 pin power receptacles with switch shall be provided for welding sets. Welding sockets shall be provided at ground floor pipe gallery of filters and shall beefed from 415V PMCC. Welding socket shall be operated for maintenance purpose during plant shutdown when all the motor feeders form the PMCC are switched off.

Ceiling Fans:
Ceiling fan shall be suitable for 240 V, 1 phase, 50 Hz and shall be complete with standard mounting accessories such as suspension rod, top and bottom canopy, regulator, rubber reel etc.

The fan shall be of 1200 mm sweep and shall conform to IS: 374. Fans shall be provided in offices, control rooms, Laboratory and Store.

Exhaust Fans:
Impeller shall be with blades of aero foil design. Blades shall be mounted on stream lined hub. Impeller shall be mounted directly on motor shaft.

Casing shall be of heavy gauge construction properly reinforced for rigidity. It shall be provided with suitable support.

In case of vane axial fans, guide vanes shall be provided on the discharge side. Motor shall be totally enclosed and rated for 240V, 1phase, 50 Hz. The speed of the fan shall not exceed 1500 rpm.

Tests:
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.

a) 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.
b) Insulation resistance of each fixture shall be tested at 500 V DC and the insulation resistance so measured shall not be less than 2 megaohms between all current carrying parts and ground.
c) All luminaries provided with glass covers shall be subjected to thermal shock- proof test. This 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 1000 C and then plunged into cold water. No crack should develop.
d) Contractor shall ensure use of calibrated test equipment having valid calibration test certificates from standard laboratories traceable to National.

Inspection: Category C

Wiring for Illumination System:

General:
Wiring shall include switches, small power receptacles, lighting distribution boards complete with junction boxes, pull boxes, terminal blocks, glands, conduits & accessories and supporting & anchoring materials.

All materials, fttings and appliances used in the installation shall conform to the relevant IS specification and shall be suitable for application in Waste Water treatment plant

Type:
Wiring is to be done in the looping system without any jointing. Phase wires shall be looped in switch control points and neutral shall be looped at outlet points. For recess conduit system MS conduit and for surface conduit system GI conduit shall be used. Recess conduit system shall be used in office, laboratory, control room etc.:

Point wiring:
Point wiring shall include all works necessary to complete wiring of a switch circuit of any length from the tapping point on the distribution circuit to the following via switch with
- Ceiling rose and connector: for ceiling / exhaust fan points
- Back plate: for fluorescent fittings with down rods etc.,
- Socket outlet: for socket outlet points
- Lamp holder: for wall brackets, bulk head and similar fittings.

The following shall be included in point wiring:
- Switch board
- Ceiling rose or connectors as required
- Any special or suitable round block for neatly housing the connector and covering the fan hook in case of fan point.
- Wooden box, bushed conduit, porcelain tubing where cable passes through wall etc.,
- Metallic covering on conduit up to 1.5 m from floor.
- Earth wire from six-pin socket outlet point/fan regulator/fixture to common conduit earth wire system.
- All wood or metal blocks, boards and boxes, sunk or surface type for mounting fan regulator etc.
- All fixing accessories such as clips, rails, screws, pin plugs, wooden plugs etc., as required.
- Connection to ceiling rose, connectors, socket outlet, lamp holders, switch and fan regulator etc.,
- Looping the same switch board and inter connections between points on the same circuit
- Providing fish wire in conduits for recessed conduit works.

Load on Circuit:
Lighting circuits and small power circuits for sockets, exhaust fans/axial flow fans shall be separate. Each circuit shall not be loaded more than 60% of MCB rating. It shall, however, be ensured that in one switchboard, wiring of one circuit is only provided.

Size of Conductor:
The smallest copper conductor to be used for lighting circuits shall be 1.5 mm2 and for power circuits 2.5 mm2. Neutral conductor and earth continuity wire shall be brought to each switchboard situated in rooms and halls. These shall be terminated inside the switchboard situated connectors. The switchboard shall be of adequate size to accommodate one number 5 amps socket outlet and required Nos... Of piano key type control switches with spares for future use.

Conduit capacity:
PVC insulated cables conforming to IS: 694 – 1977 drawn in one conduit shall not occupy more than 60% of conduit capacity.

Rigid Steel Recessed Conduit

In this system of wiring, no bare or twist joints shall be made in through run of cables. If the length of final circuit / sub-main is more than the length of the standard coil, joints shall be made by means of approved mechanical connectors in suitable and approved junction boxes.

The chase in the wall shall be neatly made and in ample dimensions to permit the conduit to be fixed in the manner desired. In case of buildings under construction, conduits shall be buried in the wall before plastering. These shall be grouted and covered with 1:4 cement and mortar, neatly finished at the plane of the un-plastered brick work and cured. Under no circumstances finished plastered surfaces shall be allowed to be chased for the conduit work. Before taking up chasing on the wall, the routes shall be marked and got approved by the Engineer. The horizontal chase shall be avoided as far as possible. In case of exposed brick / rubble masonry work, special care shall be taken to fix the conduit and accessories in position along with the building work.

MS Conduit pipes shall be fixed by heavy gauge saddles secured to suitable wood plug or other approved manner at an interval of not more than one meter but on both ends of couples or bends or similar fittings. Saddles shall be fixed at a distance of 30 cm from the center of such fittings. The saddles shall not be less than 20 gauge for larger diameter of conduits.

All conduits after erection shall be tested for electrical continuity.

Fixing of standard bends or elbows in roof slab shall be avoided and all curves shall be maintained by bending the conduit itself with a long radius which will permit easy drawing of wires.

Suitable junction / inspection boxes according to requirement shall be provided to permit periodical inspections and to facilitate replacement of wires. Such boxes shall be located and arranged suitably so that are not in irregular positions. These locations shall also be specifically shown in the conduit layout of the shop drawings and approval shall be obtained before installation, however, number of such boxes shall be minimized. The boxes shall be mounted flush with the wall or ceiling. Minimum 65 mm depth junction boxes shall be mounted flush with the wall or ceiling and depth of boxes in other places shall be as per IS: 2667-1977.

All outlets such as switches, wall sockets, etc., shall be flush mounting type.

Inspection: Category C

Earthing

General

Earthing system for the plant shall be carried out in compliance with the requirements of IS: 3043 and the following specifications:

Pipe Electrode

GI pipe electrodes shall be of medium class, 40 mm dia and 3 m in length. Galvanizing of the pipe shall conform to relevant Indian Standard. GI pipe electrodes shall be tapered at the bottom and provided with holes of 12 mm dia drilled not less than 75 cm from each other and up to 3 m height from bottom. The electrode shall be buried in the ground vertically with the top not less than 200 mm below ground level.

Plate Earth Electrode

For plate electrodes, minimum dimensions of the electrode shall be 600 mm x 600 mm x 6 mm thick. Heavy duty CI/MS frame with cover shall be suitably embedded in the masonry enclosure. For instrumentation earth, the plate of same size but of copper shall be used.

Where-ever the hard soil/ roc is available at site at 1 to 1.5 meter below the ground level the CU- CU / GI- GI chemical bore earthing shall be used to maintain the earthing resistance.

Location

Normally earth electrodes shall not be situated less than 2 m from any building. Minimum two (2) Nos. of earth electrodes shall be provided for each building. Care shall be taken that the excavation for earth electrodes may not affect the column footing or foundation of the building.

The location of the earth electrode shall be such that the soil has reasonable chances of remaining moist, as far as possible. Entrances, pavement and roadways shall be avoided for locating the earth electrodes.

Earthing Lead Connection

In case of plate earth electrodes, the earthing lead shall be securely bolted to the plate with two bolts, nuts, check nuts and washers. In the case of the of pipe electrodes, they shall be connected by means of bolt, nuts, washers and cable socket. All connecting materials shall be GI construction. The earthing lead will be securely connected at the other end of above ground main earthing grid.

Equipment Earthing Connection:

Each transformer body and neutral, GOS & lightning arrestor shall be connected to separate earth electrodes by two separate distinct earth lids. LT motors, switchgear, distribution boards and other electrical equipment shall be earthed at two separate points and connected to earth electrodes through above ground main earthing grid (65 x 10 mm x GI Flat) and 65 x 10 mm GI flat risers (from earth electrodes to above ground main earthing grid).

Size of Earthing Conductor:

The earth strips shall be of galvanized steel and shall be of the following sizes:

Main earthing grid	:	65 mm x 10 mm
LT Switchgears / Switchboards / Capacitor Panels	:	50 mm x 6 mm
Motors, Lighting Distribution Boards	:	25 mm x 6 mm
Junction Boxes, lighting fixtures, PB stations, small motors,	:	12 SWG
Exhaust fans etc.		

The earthing system shall be designed in such a way that overall earth resistance is less than one ohm.

The soil resistivity shall be measured at site by the Contractor. If required, number of earth electrodes to be increased by the Contractor to achieve the required earth resistance.

Earthing Pit

Earthing pit shall be of minimum 1200 mm x 1200 mm. An inspection chamber of size 400 mm x 400 mm x 400 mm in cement concrete of 1:3:6, 50 mm thick for side walls and 100 mm thick for bottom, shall be provided. The chamber shall be provided with CI cover on MS frame. The cover shall be hinged to the frame and shall be with padlocking arrangement. The frame and cover shall be painted with anticorrosive paint.

Testing

The Engineer may ask the Contractor to carry out earth continuity tests, earth resistance measurements and other tests in his presence. The Contractor shall have to bear the cost of all such tests.

Lightning Protection

For tall structures & buildings, lightning protection system shall be provided as per relevant IS with horizontal & vertical air terminations, down conductors with test links and separate earth electrodes.

k. Specifications for Street Lighting System

Scope of Work

The street lighting for the road shall be designed as per IRC, I.S. Codes and specifications and National electric code. The street lighting shall be designed with average illumination (E.A.V) of 30 lux and minimum illumination of 12 lux and uniformity ratio of 0.4. For the junctions, the average illumination level should be kept move.

Scope of work covered under this Tender shall be supply of the necessary equipment, installation, erection, testing and commissioning of the Street Lighting system as per the drawings/specifications, but not limited to following: -

a) Supply, installation, testing and commissioning of outdoor feeder Panel to receive power from with CT & PT & metering section.
b) Supply, installation, testing and commissioning street light fittings with steel tubular pole, junction box earthing etc.
c) Supply, installation, testing and commissioning 1100-volt grade cables.
d) Getting the drawing and complete work approved from Electrical Inspector i.e. for all substation equipment.

Employer reserves the right to procure any item from above and free issues the same to successful Tenderer for installation for economical reason. Final decision will be conveyed after price Bid opening to the successful Tenderer.

Indian Standard Specifications

The particular specification for the work is as detailed hereinafter. These specifications shall be read in conjunction with the relevant Indian Standard, Chief fire officer's recommendations and the obtainable local practice as detailed in various regional handbooks of practice and the work shall be executed accordingly. Where the specifications in any of the standards are at variance with the Specifications detailed herein, the most stringent amongst them shall govern. Contractor shall ensure that execution of total work is in accordance to this.

Quality of Materials & General Standards of work

The nominated subcontractor under this Contractor commits himself to use first class material and assumes full responsibility for the quality of all material incorporated or brought for incorporation in the work. The work shall be executed in accordance with best engineering practice and as per directions of Consultants.

Water and Power for Construction

Please refer relevant clauses under "General Conditions of the Contract".

Scaffolding

All scaffolding and ladders required for the proper execution of the work shall be provided by the nominated subcontractor.

Measurements

The mode of measurements for shall be as per provisions of the relevant Indian Standards. The nominated subcontractor shall provide all the measuring tapes and other accessories necessary.

Tools and Plant

The Tenderer along with his Tender furnishes a list of tools, plant and machinery, which he intends to use on the works. The nominated subcontractor is obliged to use all the machinery mentioned in his list if Engineer consider it necessary.

Drawings by Nominated Contractor

The Nominated Contractor shall make following drawings and obtain approval from Engineer before starting the work

- Layout showing locations of light fitting, feeder pillar and cable distribution network and miscellaneous accessories
- General arrangement drawing & control wiring drawing of all equipment under his scope of supply and other shop drawings.
- Necessary drawings and approval of installation by Electrical Inspector and various statutory authorities.
- As built drawing after completion of work.

Testing

The Nominated Subcontractor shall carry out all required tests, at no extra cost, on different equipment as per specification in the presence of the Employer in order to enable the Employer to determine whether the plant and equipment comply with the specifications.

Guarantee

Equipment and the installation shall be guaranteed for a period of one year for defective materials or workmanship from the date, the plant and installation has been finally taken over. The Nominated Sub-Contractor shall rectify the defects or replace defective materials at his own cost during the guarantee period.

Approvals

The Nominated Subcontractor shall arrange to obtain necessary statutory approvals / drawing approval including following before starting the work: -

All statutory approvals from:

Electrical Inspector (PWD)

Electric Supply Company (MSEDC)

Workmanship

Good workmanship and neat appearance are the prerequisites for compliance with the various sections of these specifications. Work shall be carried out in accordance with the statutory rules and local regulations in force and conform to relevant I.E Rules and I.S. Specifications.

Tools and Spare Parts

The Contractor shall obtain himself all special tools and tackle required for erection and assembly of the equipment covered by the contract himself.

All other materials such as foundation bolts, nuts etc. required for the installation of the plant shall be supplied and included in the Contract.

Tenderer shall quote separately for spares recommended by him for two years operation of each type of equipment covered by these specifications.

Contactor

Contactors shall be of the electromagnetic type rated for uninterrupted duty as defined in applicable standards. Main contacts of contactors shall be of silver plated copper. Each contactor shall be provided with two NO and two NC auxiliary contacts. Insulation class of operating coils shall be class B or better. Operating coils of contactors shall be suitable for operation from the specified control supply system. Contactors shall be of the double break, non-gravity type. One number spare auxiliary contactor with 4 No. /4NC contact along with its coil completely wired up to the terminal should be provided.

Control and Selector Switches

Control and selector switches shall be:

a) Of the rotary type
b) Adequately rated for the purpose intended (Minimum acceptable rating is 10A continuous at 240V AC and 1A inductive break) 220V DC.
c) Provided with escutcheon plates clearly marked to show the positions.
Control switches for circuit breakers shall be provided with pistol grip type handles.

Push Buttons

Push button shall be:

a) Of the momentary contact, push to actuate type rated to carry 10A at 240V AC and 1A (inductive breaking) at 220V DC.
b) Fitted with self reset, 2 NO and 2 NC contacts.
c) Provided with integral escutcheon plates marked with its function.

'Start', 'Open', 'Close' push buttons shall be green in colour. 'Stop' push buttons shall be red in colour. All other push buttons shall be black in colour.

'Emergency Stop' push buttons shall be of the lockable in the pushed position type and shall be shrouded to prevent accidental operation. Key shall not be required for the operation of the push button.

Instrument Transformers

The current transformers shall be Epoxy moulded base mounted and comply the following features:

-
- Class I accuracy for metering and class 1 and 5 p 10 for protection with rated burden of 15/30 VA on secondary.
- Error limit to specific class of accuracy.
- Air or epoxy resin insulated with bar or wound primary.

Meters and Indicators

The meters and relays shall comply the following: -

- Digital type with Class-I accuracy compatible to PC.
- A, V meters 144 x 144 mm. square or square bazal flush mounting type with selector switches and back up fuses for A & V meters.
- Energy and demand meters to be tested by local supply co.
- Indicating lamps shall be LED type with fuses. Phase indicating lamps shall be colour coded.

Inspection and Testing

The L. V. Switchgears shall be subjected to factory inspection before finishing and dispatch unless inspection is waived.

The following tests are to be carried out and necessary certificates submitted: -

a) Routine certificate for MCCB's from manufacturer.
b) HV test at 2.5 kV for one minute.
c) Insulation resistance test with 1000V meggar with all switchgear in closed position.
   i) Phase to Phase : 2.6 meg. ohms.
   ii) Phase and Neutral : 1.5 meg. ohms.
d) Secondary wiring and apparatus should withstand 2000V for one minute.
e) Meters and relay calibrated and tested through secondary injection tests.
f) Continuity test
g) Operation test

LT Cabling

Scope

The scope under this section covers the following: -

1. 1100 V grade Power Cables.

Standards

The following standards shall be applicable amended up to date.

1. IS:1554-1964 - PVC insulated electric cables (heavy type)
2. IS: 1753-1967 - Aluminum conductors for insulated cables.
3. IS: 3961-1967 - Recommended current ratings for cables.

Power Cables

The cables shall comply the following: -

- 650/1100V grade with stranded aluminum conductors above 6 mm^2 and stranded copper conductors up to 6 mm2.
- Color coded PVC insulation applied over conductor by extrusion.
- PVC inner and outer sheathed applied by extrusion.
- Steel armouring between inner and outer sheathed.
- Size of cables to suit the duty and load section.

Installations

1. Power cable laying shall strictly be as under: -
   - In full length for each route without joints or splices.
   - Mark the routing on drawings and at site and got approved if the routes are not available on drawings.

   Cables laid underground shall be at depth not less than 750 mm. with sand bedding and protective bricks or tiles extending 75 mm. on either side and non-corroding cable identifications at 10 m. spacing in addition to route markers above ground at regular intervals, bends, and crossing.
   - Provide 150mm diahume pipes for road crossings.
   - Provide loops of minimum 500 mm. radium at each ends.
   - Cable should be bend to a radius of 15-20 times the diameter of the cables with a minimum of 8 diameters at space restrictions.

2. Control cables shall be laid on separate cable tray from the power cables. The power cable termination shall have the necessary double compression brass glands and Tinned copper crimping lugs.

Testing

Power cables shall be tested after installation using 500V insulation resistance tester and the following readings recorded: -

- Continuity on all conductors.
- Insulation resistance
  a) Between Conductors
  b) All conductors and ground.

Earthing

The following standards and rules shall be applicable: -

1. IS: 3043-1987: Amended up to date Code of practice for Earthing
2. Indian Electricity Act 1901 and Rules issued thereunder

Earthing Stations

The earthing stations required for establishing an equipment earthing grid shall consist of Galvanized Steel or copper pipe / plate into ground. The minimum depth, type of electrode, soil treatment shall be shown on drawings and in accordance with I.S. Code of Practice 3043-1966 complete with masonry chamber, watering pipe C.I. cover etc. The number of earthing stations shall be as shown on the drawings

Earthing of feeder pillar shall be done by 2 Nos. of 25 x 6 mm GI strip connected to earth stations as per enclosed drawing and IS-3043.

Earthing of lighting pole shall be done as per specification of pole and drawing enclosed.

Testing:

The following earth resistance values shall be measured with an approved earth meggar and recorded: -

1. Each Earthing Station
2. Earthing System as a whole (shall be less than one ohm)
3. Earth Continuity conductors.

Lighting Poles and junction box

Lighting Poles shall be steel tubular type as per drawing enclosed and as per bill of materials.

Lighting Poles shall be complete with fixing bracket and junction box as per enclosed drawing and bill of materials. Junction box shall be suitable for loop-in and loop-out of three cables of 4c x 25 sq.mm.

The lighting poles shall be coated with bituminous preservating paint on inside as well as on the embedded outside surface. Exposed outside surface shall be coated with two coats of metal primer.

The galvanized sheet steel junction box for the street lighting poles shall be completely weatherproof confirming to IP-55 made of 14 SWG sheet steel and provided with lockable door, fixing bracket and HRC fuse mounted on the fuse carrier and fuse base assembly.

Wiring from junction box at the bottom of the pole to the fitting at the top of the pole shall be included in the installation charges of the pole.

Earthing of the pole shall be carried out by 4# SWG GI wire as per enclosed drawing.

Lighting Fittings and Accessories

Scope of Specification:

This specification covers the design, material specification, manufacture, testing, inspection, delivery to site and installation & commissioning of lighting fittings and their associated accessories.

Codes and Standards:

The lighting fittings and their associated accessories such as lamps/ tubes, reflectors, housings, ballasts, etc. shall comply with the latest applicable standards as specified. Where no standards are available, the supply items shall be backed by test results, shall be of good quality and workmanship & any supply items which are bought out by the Contractor shall be procured from approved manufacturers acceptable to the Engineer.

Products

Lighting Fittings - General Requirements

i) Fittings shall be designed for continuous trouble free operation under atmospheric conditions as specified (in Sections B & C of project information) without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.
ii) The fittings shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps / starters etc.
iii) Connections between different components shall be made in such a way that they will not work loose by small vibration.
iv) For each type of lighting fitting the Contractor shall supply the utilization factor to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.
v) All fittings shall be supplied complete with lamps suitable for operation on a supply voltage and the variation in supply voltage.
vi) The fittings and accessories shall be designed to have low temperature rise. The temperature rise above the ambient temperature shall be as indicated in the relevant standards.
vii) All mercury vapour, metal halide lamp and sodium vapour lamp fittings shall be complete with accessories like lamps, ballasts, power factor improvement capacitors, starters wherever applicable, etc. These shall be mounted as far as possible in the fitting assembly only. If these cannot be accommodated inside, then a separate metal enclosed box shall be included to accommodate the accessories and in addition with a fuse and a terminal block suitable for loop-in, loop-out connections. Outdoor type fittings shall be provided with outdoor type weather-proof box.
viii) All fluorescent lamp fittings shall be complete with all accessories like ballasts, power factor improvement capacitors, lamps, starters and capacitors for correction of stroboscopic effect.
ix) Each fitting shall have a terminal block suitable for loop-in, loop-out and T-off connection by 250/440V, 1 core,PVC insulated Cu conductor cable up to 4 sq.mm in size unless otherwise specified. In hazardous areas, the termination at the fittings shall be suitable for 1100V, PVC, armored cables of sizes specified and terminals shall be of stud or clamp type. The internal wiring should be completed by the MANUFACTURER by means of stranded copper wire and terminated on the terminal block.
x) The mounting facility and conduit knock-outs for the fixtures shall be as specified.
xi) All hardware used in the luminaire shall be suitably plated or anodized and passivated for use in chemical industrial and power plants.

Earthing

i) Each lighting fitting shall be provided with an earthing terminal suitable for connection to the earthing conductor.
ii) All metal or metal enclosed parts of the housing shall be bounded and connected to the earthing terminal so as to ensure satisfactory earthing continuity throughout the fixture.

Painting / Finish

i) All surfaces of the fittings shall be thoroughly cleaned and degreased. The fittings shall be free from scale, rust, sharp edges and burrs.

ii) When enamel finish is specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mills for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.

iii) The housing shall be stove-enameled / epoxy stove-enameled-Vitreous enameled or anodized as indicated on flame-proof fittings is prohibited.

iv) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90° over □" dia mandrel.

v) The finish of the fittings shall be such that no bright spots are produced either by direct light source or by reflection.

Street Lighting Fittings

i. Street lighting fittings shall be suitable for mercury vapour lamps, fluorescent tubes or sodium vapour lamps and shall be of the cut off, semi-cut off or non-cut-off type as specified.

ii. The fittings shall be of the tope entry/ side entry /post top/ suspension type as specified.

iii. The means for attaching the fittings shall be designed to sit the weight of the fitting and shall ensure that the strength of the connection is adequate to withstand a wind speed of 150 Km/h equivalent to the following wind loads on the projected surface of the fitting in relation to its mounting height: -

Mounting Height	Wind Load
Less than 8 m	15 N/m^2
8 to 16 m	20 N/m^2
Above 16 m	24 N/m^2

iv. The size of threads, length of threads, socket bores of various types of fittings mentioned in 8.2 above shall comply with relevant standards specified.

v. The fittings shall be designed such that the glare value is controlled below an acceptable level. The light distribution patterns of cut-off, semi-cut off and non-cut-off fittings shall be as per relevant standards specified.

vi. The required control gear such as ballast and capacitor shall be provided integral with the fitting. The housing shall be of cast aluminum stove-enameled and provide with anodized, mirror or polished aluminum reflectors. The covers shall be of transparent acrylic sheet and neoprene gasket shall be provided for sealing the unit for outside atmosphere.

Lamp/Starter Holders

i) Lamp holders shall comply with relevant standards. They shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with in normal installation and use.

ii) Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamp holder shall not be exposed during insertion or removal of the lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp is in working position.

iii) Lamp holders for incandescent and mercury vapour lamps shall be of bayonet type up to 100W and Edison Screw type for higher Wattage lamps.

iv) Starter holders for fluorescent lamps shall conform to the standards specified. All material used in the construction of the holder shall be suitable for tropical use.

v) The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

Ballasts

i) The ballasts shall be designed, manufactured and supplied in accordance with the relevant standards. The ballasts shall be designed to have a long service life and low power loss.
ii) Ballasts shall be mounted using self-locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dusting, non-combustible enclosures.
iii) The ballasts shall be of the inductive, heavy duty type, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. Ballasts shall be provided with tapping to set the voltage within the range specified. End connections and taps shall be brought out in a suitable terminal block, rigidly fixed to the ballast enclosure. The ballast wiring shall be of copper wire. They shall be free from hum. Ballasts which produce humming sound shall be replaced free of cost by the CONTRACTOR.
iv) Separate ballast for each lamp shall be provided in case of multi-lamp fittings, except in the case of 2 x 20 watts fittings.

Starters

i) Starters shall have bimetal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool. Starters shall have brass contacts and radio interference capacitor.
ii) The starters shall generally conform to the relevant standards.

Capacitors

i) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.
ii) The capacitors shall be suitable for operation at supply voltage and shall have a value of capacitance so as to correct the power factor of its corresponding lamp circuit to the extent of 0.95 lag or better.
iii) The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnant and ingress of moisture.

Lamps

i) The fluorescent lamps shall be `Day-light colour' type unless otherwise specified and shall be provided with features to avoid blackening of lamp ends.
ii) Mercury or sodium vapour lamps shall be of high pressure, colour corrected type.
iii) The constructional features of gas discharge lamps for special applications as stated or for instant start fluorescent lamps if specified, shall be clearly brought out in the Bid.
iv) The lamps shall be capable of withstanding small vibrations and the connections at lead in wires and filaments/ electrodes shall not break under such circumstances.
v) Lamps / tubes shall conform to relevant standards and shall be suitable for supply voltage and frequency specified.

Spare Parts

i) Unit prices of the items shall be quoted together with catalogue numbers.
ii) The unit prices shall not however be limited to the above items. The CONTRACTOR may recommend additional spare items and quote the unit prices of the respective items.

Tests and Test Reports

Type tests, acceptance tests and routine tests for the lighting fittings and accessories covered by this specification shall be carried out as per the relevant standard for the respective fittings and their accessories.

The Manufacturer's type and routine test certificates shall be submitted for tests conducted as per relevant standards for the fittings and accessories. The TENDERER shall submit with his proposal copies of available test certificates of the fittings offered.

1.7 Area lighting:

(b) Complete outdoor area lighting shall be powered by hybrid electricity. The hybrid electrical system shall be as per MNRE/ MEDA specification with wind-solar combination, the Hybrid system project shall be granted through the government subsidy. The project feasibility report shall submitted for prior approval. Unit for Hybrid power generation shall be installed in plant area, which shall be controlled from lighting panels/switches installed in respective plant areas. The entire lighting system shall be as per the approved drawings with required Lux level as per IS. Lux level calculation should be submitted.

1.8 Specifications for Aero generators/ Wind-Solar Hybrid Systems

(i) The site should be free from the obstacles like tall trees, high buildings, electric transmission lines etc. within the radius of about 100 meters.

(ii) The site for installation of aerogenerators should, preferably, have annual average wind speed of about 15 kmph (4.17m/s) or above, at 20m height. The wind speed at a particular site has to be obtained from C-WET or any other agency using actual wind data collected by C-WET or by using standard software programme like Wind Atlasetc. The user agency /manufacturer has to provide latitude- longitude of the site and other parameters as needed for this purpose to the verifying agency.

(iii) Wind and solar resources should be preferably of complementary nature.

(iv) The foundations should be designed and constructed by taking into consideration the soil bearing capacity of the site.

(v) Generally aero generators should be avoided to be installed on the roof of a building and if it is installed on the roof of any building, the load bearing capacity, clearance/ obstruction from the nearby buildings, electrical wires etc. and other safety related aspects should be carefully examined by technical personnel.

1.9 Aero generators and Wind-Solar Hybrid Systems

(c) The scope of supply of aerogenerators/wind-solar hybrid systems will cover the design of system-configuration, manufacture/supply, testing, transportation, installation, commissioning and performance monitoring of the complete system comprising aerogenerator, SPV modules, batteries, inverters, control systems, tower, cables, necessary instrumentation for monitoring of the field performance etc. The manufacturers/supplier will also supply spares for three year trouble free operation, user's tools & tackles kit, and a copy of comprehensive users manual providing information on performance data, power curve, O&M and recommended Dos and Don'ts for trouble free operation of the system. It has been noted that the suppliers do not take care of repair/ maintenance of the systems. Both the parties should, therefore, make necessary provision in the Contract at the time of award of work so that trouble free operation of the system is ensured. The critical spare parts like inverter card etc. must be supplied by manufacture at the time of commissioning so that uninterrupted functioning of the system takes place.

1.10 Installation of Energy Meters

It has been noted that energy meter is installed only for the energy consumed from the systems by the load i.e. after the storage system (Battery). This does not give the information about the total energy generated by the system. It is therefore decided that one additional energy meter for each solar & wind system will be installed which will measure the total energy generated by the system.

1.11 Aero generators and Wind-Solar Hybrid Systems

(i) SNAs/manufacturers/beneficiaries may send bundled proposals along with Feasibility reports for deployment of the system in a "Project Mode" for different users such as Tribal Hostels, Primary Health Care Centers, Nursing homes Police Communication Centers, Anganvadis, Literacy Centers, Panchayati Raj Institutions including private individuals & corporate sector etc. In a bundled proposal, separate feasibility reports have to be submitted for separate projects/sites.

(ii) Proposals must accompany a written commitment of SNAs /other government bodies/ each beneficiary for meeting the remaining part of the project cost other than MNRE's CFA.

(iii) The manufacturers/SNAs will get prepared a feasibility report providing information as per **Annexure – VII** and after verifying the suitability of the site and system based on site visits considering the load requirements.The manufacturers/SNAs will submit the proposals to MNRE along with feasibility report.

(iv) The feasibility report will provide all technical details of aerogenerator, solar PV modules, batteries, inverter, control system, cables and tower etc. and other components covered under the project. In the case of battery storage, only tubular plate lead acid batteries will be permitted.

(v) There could be following modes of submitting the proposal to MNRE :

(A) Implementation through Manufacturers

The manufacturers will identify suitable beneficiaries, prepare a bundled proposal having a minimum cumulative capacity of 30 kW and a minimum number of 3 systems and submit to MNRE. Proposal with higher capacity (30 kW or more) with single beneficiary can also be considered. After examining the proposal, the Ministry will issue an "in principle approval" indicating the amount of subsidy for the project. The beneficiary in this route will necessarily have to go for financing through banks/financial institutions for meeting full/part of the cost of the project. The eligible subsidy would be released after the concerned manufacturer obtains the necessary documents regarding project completion report as per Annexure VIII and Project Monitoring report for at least three months period of the system as per the format given at Annexure IX from the Bank/Financial Institution and submits the same to the Ministry. The manufacturer will also ensure submission of quarterly monitoring reports as per the Annexure IX for at least one year of the operation.

(B) Implementation throughSNAs

The State Nodal Agencies could also submit proposals on a project mode to the Ministry (bundled proposal having a minimum cumulative capacity of 30 kW and a minimum number of 3 systems; proposal with higher capacity (30 kW or more) with single beneficiary can also be considered). In this case also, the Ministry would issue an approval in principle for the eligible subsidy.The eligible

subsidy will be released to the SNA for onward transmission to the concerned beneficiary after commissioning of the system and receipt of the prescribed documents regarding project completion report as per Annexure VIII and Project Monitoring report for at least three months period of the system as per the format given at Annexure IX . The SNA will also ensure submission of quarterly monitoring reports as per the Annexure IX for at least one year of the operation. The stipulation contained in the earlier scheme to provide work order by the State Nodal Agencies based on a competitive tender procedure will not be required as the beneficiaries/beneficiary institutions will be free to select the system from the list of the empanelled manufacturers following their own purchase procedure. An administrative charges @ 2% of CFA will be provided to SNAs at the time of final release.

The manufacturers may also bundle the proposals for beneficiaries, who do not wish to avail the Bank Loan and submit to Ministry through SNAs (with an advance copy to Ministry). The SNAs may forward the same to Ministry. The Ministry may consider issuing an approval in principle for the proposal, for such cases even if the SNA does not forward it after a reasonable time. The subsidy will be released to the Bank Account of the beneficiary after commissioning of the system and based on documents regarding project completion report as per Annexure VIII and Project Monitoring report for at least three months period of the system as per the format given at Annexure IX by a Designated Agency (DA) including the SNAs. The Ministry will empanel the Designated Agency in due course and suitable service charges will be paid to the services of such DA. The DA will also ensure submission of quarterly monitoring reports as per the Annexure IX for at least one year of the operation.

(D) Ministry may also consider the proposals in “Project Mode” directly from Govt. organizations based on the above mentioned modalities.

(vi) In all above cases, the manufacturers/SNAs/beneficiary **will complete the project within one year** after in principle sanction of the project is issued by MNRE.

Submission of quarterly monitoring reports, completion reports, audited Statements of Accounts

2 (i) After completion of the projects, the SNAs/manufacturers/DA/other implementing agency are required to submit project monitoring reports to MNRE as per the format given in **Annexure IX** on quarterly basis for at least one year. The manufacturers/SNAs/DAs/other implementing agencies are also requested to inform MNRE about difficulties, if any, faced by them and the proposed corrective actions.

3 (ii) The SNAs/manufacturers will also submit an audited statement of expenditure on entire project cost by the user as per format given in **Annexure - XI**.

3.1 Field Trials and Performance Evaluation of New designs/developments and proto types

4 **types**

5 Field trials and performance evaluation of new designs of wind pumps, small aerogenerator systems, hybrid systems and their sub systems, parts, components used in such systems and proto-types when developed under a R&D project or independently developed by a manufacturer through its own R&D efforts will be fully supported financially by the Ministry. Field trials and evaluation of such new developments will be fully supported by the Ministry in a project mode meeting all costs relevant to the project. In case of

systems/components developed by industry through their own R&D, the Ministry will meet the cost of the small wind energy system and cost of the relevant monitoring equipment and other expenses relating to the monitoring of the system. The remaining cost of the project will be met by the user organization. A maximum of 5 units of a system/sub system/ proto type may be tried out under this arrangement in a year.

6 **Aerogenerator/Wind-Solar Hybrid Systems**

7 (a) No release will be made alongwith the in principle approval.

8 (b) 100% CFA will be released after receipt of the required documents including project completion/commissioning certificate, performance monitoring certificate, audited statement of expenditure for the entire expenditure on the project as per the format given as **Annexure XI**.

8.1 Preform at for Feasibility Report for Aero generator/ Wind Solar Hybrid Systems

8.1.1 Title of the project and the details of the project site:

- Name of the organization:
- Address of site with Taluk/ distinct etc.
- Name of the contact person with telephone number, fax no. email etc.
- Type of establishment : Please provide brief details of the establishment.
- Category of the beneficiary : Profit making/ Not profit making

8.1.2 Wind and Solar resources data of the identified site:

Month	Air temperature	Dailysolar radiation horizontal	Atmospheric pressure	Wind speed *	Heating degree-days	Cooling degree-days
	^{o}C	$KWh/m^2/d$	kPa	M/s	^{o}C-d	^{o}C-d
January						
February						
March						
April						
May						
June						
July						
August						
September						
October						
November						
December						
Annual						
Measured at(Magl)						

*Please enclose the supporting details verifying the wind data(reportbyC-WET/otherinstitution)

8.1.3 Estimated Energy Requirement at the proposed site

TYPEOFLOAD	USAGETIMEHrs.	QTY.	PERDAYENERGY REQUIREMENT (kWh)

8.1.4 System Design Details.

Battery Bank Total Energy Consumption/day Voltage configuration Power factor Battery efficiency Depth of discharge Battery capacity Required Inverter Total Load Power factor Inverter efficiency Inverter capacity required

Final design configuration of the_____kW capacity wind-solar hybrid system:

a) Number, Capacity, specification and power curve of Aero generator proposed:

Aerogenerator
Capacity
Make & Model No.
Type Test report available: Yes/No
Does this model appear in MNRE empanel: Yes/No
Rated wind speed
Peak power
Start generating wind speed
Cut out wind speed
Survival wind speed Propeller
diameter
Propeller material & No. of blades
Generator
Weight
Voltage controller
Over speed protection
No. of machines

b) Number & specification of SPV Modules

SPV Modules
Capacity Make
Peak power per module
Weight
Dimension W x H x D
Temperature
Wind Load

Humidity
No. of SPV Modules

ANNEXURE-VIII

c) Details of various equipment/sub-systems

Monitoring of system and spares.

8.1.5 Methodology of project implementation.

8.1.6 Details of the estimated cost of the system:

Sl. No.	Item	Cost (Rs. in lakhs)
1.	Aerogenerators	
2.	Photovoltaic Panels	
3.	Cabling from SPV module to control center and cabling from Aerogenerator to control center	
4.	Invertors *** KVS	
5.	Tower & Erection material	
6.	Batteries **v/*** Ah	
7.	Photovoltaic Panels structure with fencing	
8.	Instrumentation (ammeter, voltmeter, energy meter, wind and solar monitoring equipment, Ah meter, battery level indicator)	
9.	Wind charge controller and solar photovoltaic charge controller	
10.	Ex-Work Cost Total (total of1 to 9)	
11.	Transportation	
12.	System, Design, Erection, Testing, Commissioning	
13.	Civil Work	
14.	Total (total of 11 to 13)	
15.	Grand Total (10+14)	

Proposed Sources of financial assistance.

Sl.	Details	Cost
(i)	MNRE support	
(i)	State govt subsidy, if any*	
(ii)	User share*	
	Total	

*Please enclose the necessary letters from the supporting agency/use

8.1.7 Project Implementation Schedule.

9 The project implementation schedule to be given indicating different stages of implementation with dates. The project has to be completed within one year from date of sanction of the project by MNRE.

9.1.1 PROFORMA FOR PROJECT COMPLETION REPORT OF AEROGENERATOR/WIND-SOLAR HYBRID SYSTEM

1.	**System Details**

	(a) MNRE Sanction No. and date:	
	(b) Capacity of the system (kW) Aerogenerator Component (kW) SPV Component (kW)	
	c) Name of Manufacturer/ Supplier	
	d) Commissioning Date	
	e) System's design (line sketch)	
	f) System's photograph (at least 5)	
2.	**Estimated Energy Requirement**	
	a) Type of Load	
	b) Usage time (Hours)	
	c) Quantity	
	d) Per Day Energy Requirement (kWh)	
3.	**Technical Details of the System Installed**	
	a) Aerogenerator Total capacity Capacity of single machine No. of machines Make & Model No. MNRE's reference number/ date of issue of inclusion in MNRE list Rated wind speed Rated Peak power UIN of each aerogenerator Generator Specification Voltage controller Over speed protection	
	b) SPV Modules Total capacity Capacity of each Module Nos. of SPV Modules Make Peak power per module Weight Dimension W x H x D Temperature Wind Load	
	c) Number and Place of Installation of Energy Meters	
	d) Battery Bank Total Energy Consumption /day Voltage configuration Power factor Battery efficiency Depth of discharge	

	Battery capacity required	
	e) Inverter **Total Load Power factor Inverter efficiency** **Inverter capacity required**	
	f) Balance of System (give details)	
	g) Details of spares provided	
4.	**Training Details**	
	a) Whether training provided by manufacturer/ Supplier to the user	Yes/No.
	b) Whether documents provided by manufacturer / Supplier to the user	Yes/No.
	c) Whether system is properly maintained by the user	Yes/No.
	d) Overall satisfaction of the user	

Signature . Signature .

Name Name . Designation .

Head of State Nodal Agency/Manufacture with seal

User Agency/Beneficiary.

9.1.2 PROFORMA FOR PROJECT MONITORING REPORT OF AEROGENERATOR/WIND-SOLAR HYBRID SYSTEM

1.	System Details	
	(a) MNRE Sanction No. and date:	
	(b) * TotalCapacity of the system (kW) * Nos/unit capacity of aerogenerator * Total Aerogenerator Capacity (kW) * UINs of aerogenerator * Nos of module/unit capacity of a module * Total SPV Capacity (kW)	
	c) Name of Manufacturer/ Supplier	
	d) Commissioning Date	

Performance Details

Month/Year	Aerogenerator		SPV		Total No. of Units (kWh) generated	Total No. of Units (kWh) consumed
	Average Wind Speed	No. of Units (KWh) generated	Average solar insolation	No. of Units (KWh) generated		

Are all the aerogenerators/SPV modules are functioning ?	
Whether system is properly maintained by the user	
Overall satisfaction of the user	
Satisfaction of Monitoring Team about the performance	
Any other information to be provided	

Signature .
Name
Head of State Nodal Agency/Manufacture
with seal

Signature .
Name . Designation .
User Agency/Beneficiary.

APPROVED MAKES

All materials to be used in the work shall conform to relevant Indian Standard Specifications and wherever available ISI marked material only will be used. All material procured shall be subjected to relevant tests specified in B.I.S. at the frequency specified therein from any Government recognized laboratory. **The Tenderer shall distinctly understand that it will not be their prerogative to insist on using a particular Make/Brand from amongst the approved ones. The final selection will have to be done with the approval of Engineer-in-charge.**

SL. NO.	MATERIAL, WORK	SUPPLIER, MANUFACTURER, VENDOR, AGENCY
1.	S.F.U. / breakers	L&T / Siemens / Schneider
2.	Distribution Boards	MDS / Siemens / Schneider / Hager
3.	Indicating Digital Meters	AE / Meco / L&T / Apex / Mimic
4.	Crimping Lugs / Glands of double compression type	Dowells / Jainson / Lotus
5.	Jelly filled Telephone Cables	Finolex / Universal / RPG
6.	Tag Block with Boxes	Krone
7.	Rossets	ITL / Tele Connectors India
8.	MCB / RCCB	MDS / Siemens / Schneider / Hager
9.	Main L.T Panels / PDB / LDB Panel	Incorporating L&T / Siemens / GEC / Schneider Switchgear Components & Manufactured by those who have CPRI test certificate,
10.	Switches and sockets	MDS / Schneider / Anchor, Cona
11.	PVC Copper Wires	Finolex / RR Kabel / LAPP/ PolyCab
12.	Motors	Siemens, ABB, Bharat Bijlee, Crompton, Kirloskar, Texmo, NGEF.
13.	Cable glands and Lugs	Dowell, Lotus, A.G. Electricals, Siemens.
14.	Cat-6 Lan wire	Lucent / LAPP / AMP
15.	PVC Pipe	Diamond / Precision (PPI) / Asian
16.	Lighting Fixtures	Wipro / Phillips / Crompton / Bajaj / GE
17.	Fans & Air-Circulators	Crompton / Bajaj / Almonard / Usha / Cinni / Rallies / Orient / Khaitan
18.	Distribution Transformer 11/22 KV / 433 V	Crompton, Kirloskar, Emco, Bharat Bijalee, Andrew Xule, Pactil, Voltamp
19.	11/22 KV VCB breaker & Panel	ABB, Schneider, Siemens
20.	Relays	ABB, Siemens, Schneider, L&T
21.	11/22 KV SF6 insulated 3 Panel / 4 Panel extensible type RMU	ABB, Siemens, Schneider, L&T
23.	Fuse base	Siemens, L & T, EE
24.	Control Cables	LAPP, Finolex, Polycab
25.	Batteries	Amar Raja, HBL Knife, Exide, Emco.
26.	11/22 KV End termination & straight through joint	Raychem, Xicon.
27.	Measuring Instruments	MECO, IMP, KEW, Rishiline (L&T), Conzerve
28.	Cables	
a)	PVC Insulated Cable for working voltage up to 1.1 KV as per IS : 694:1990	Finolex, Asian, Polycab, Torrent, Universal, Fortgloster, CCI
b)	XLPE – LT Cables as per IS:7098 Part – I : 1988	CCI, Asian, Finolex, Torrent, Polycab, Gloster

SL. NO.	MATERIAL, WORK	SUPPLIER, MANUFACTURER, VENDOR, AGENCY
c)	XLPE – HT Cables as per IS:7098 Part II – 1985	CCI, Asian, Finolex, Macro, Polycab
d)	PVC Insulated (HD) Cable up to 1.1 KV as per IS:1554 Part I – 1988	Torrent, Macro, Vardhaman, Finolex, CCI, Asian, Polycab.
29.	Air Conditioners	Samsung, LG, Voltas, Carrier
30.	Lamps HPMV/HPSV Metal Hallide Lamps & Accessories	Vallient, Fixolite, Bajaj, Philips, Wipro
31.	MCB/ELCB/RCCB/HRC/	Indo Asian, MDS, Datar, Hagger
32.	T.W.Boards& Blocks	Double folding polished board from plant shall be one piece. Block up to 8" X 10" shall be in two pieces
33.	T.Switch S.P. or 2 way S.A. to I.S.A.	Porcelain base with bakelite cover Khosla, Keycee, Anchor, Roma
34.	Three pin socket 5A to 15A	Porcelain base with bakelite cover Khosla, Keycee, Standard, Anchor, Roma
35.	Ceiling rose	Khosla, Keycee, Ellora, Oshan, Modern.
36.	Submersible Pump Motor Set	Kirloskar, Mather and Platt, Modi, KSB, Kishor, Flowmore, ABS, Grundfos, Flygt
37.	Ring Main Unit/HT, switch and fuse unit	MEI, South Andrew Yule or MSEDC approved
38.	C.T./P.T.	MSEDC approved
39.	Auto Transformer Starter	MEI, Kilburn, JMP, Siemens, Andrew Yule, GEC, KEC.
40.	Trivector Meter	MSEDC approved
41.	Measuring instrument	AE, MECO, FE, Rishiline (L&T), Conzerve
42.	Current Transformer	AE, Gilbert & Maxwell, IMP, Siemens, SEGC (C.S.) or MSEDC approved
43.	PVC Conduits, PVC Pipes, HDPE Pipes	Garware, Finolex, Shakti, Circlearc, Popular, Prince.
44.	G.O.D. Switches and Dropout fuse outfit	Kiran, Pactil, Atas or MSEDC approved
45.	Chain Pully Block	Elephants, Herculas, WMI
46.	Lugs	Dowels, Lotus, AG Electricals
47.	Chlorinator	Panwalt, Shree Mitra Purification
48.	Motor Protection Relays	Universal, Thresold, E.E., L&T, Minilac, Siemens, C.S. Telemechanique, Scheineder
49.	MCB & MCB, D.B.	MDS, Siemens, EE, Telemechanique
50.	ELCB	Datar, MDS, Telemechanique, Siemens, EE
51.	PVC Wires, Copper Aluminum Conductor, Flexible Cables	V-Plast, Delta, Spacecab, HMT, Finolex, Polycab, Lapp
52.	Cable Glands	HME, EEW, MSEDC Approved
53.	HC Fuse Distribution Board	CPL, EE, Ess-ess, Stenly, KEW, Kalki, EE, Standard
54.	Air/Oil Circuit Breakers (HT/LT)	ABB, Andrew Yule, Siemens, L&T, GEC, Soutern, BHEL, Telemechanique, Scheineder
55.	Energy Meters	Jaipur or MSEDC approved
56.	Capacitors	GEC, KhatauJunkar, Crompton, L&T, Momaya, Madhav, Epcos or MSEDC approved.
57.	Steel Tubular Poles	Indian Electric Poles, Bombay Tubes, Nityanand,

SL. NO.	MATERIAL, WORK	SUPPLIER, MANUFACTURER, VENDOR, AGENCY
		Rajan Tubes, Bajaj
58.	GI Pipes/Poles	Zenith, Tata, Bharat, Jindal, Suryaprakash
58.	Terminal Box, bracket, Junction Box, Control pillar	ELM, United, DVK, Locally fabricated as per AMC's approved drg./specifications
59.	Street Lighting luminaries	Bajaj, Wipro, Crompton, Philips, Wipro, GE
60.	Chokes/ignitors	Bajaj, Wipro, Crompton, Philips, GE-Apar, ECE, Indo-Asian
61.	Power contactors	L&T, Siemens, Telemechanique, Scheineder
62.	Lamps	Bajaj, Crompton, Philips, Cema, HMT, Electron, Mysore, Solarson
63.	Rotary/select or switches	L&T, Siemens, Kaycee, EE, Tecknic
64.	Post top lantern	Philips, Crompton, Glolite, Bajaj, Parimal, Tulip, Keselec, ECE, Genlec, ELM, Wipro, Indo-Asian
65.	Street light controller/ Timer	L&T, (TSQ 100) 24 Hrs. dial, ELM
66.	ASCR Conductors	MSEDC Approved
67.	Alternators	Kirloskar, Jyoti, NGEF, AVK-SEGC, KEL, Caterpiller, Stamford, CG Newage Elect. Ltd
68.	Diesel Engines	Kirloskar, Greaves Cotton, Cummins, Ashok Leyland, Cater Piller, Super Nova
69.	Cable jointing kit	Raychem, Xicon, Benson, Mahindra (Push on) M Seal.
70.	Pole Paint	Jenson & Nicholson, Asian (S+M), Nerolac,
71.	Fluorescent Fixtures	Bajaj, Crompton, Philips, GEC, Wipro, Glolite
72.	PLC	Allen Bradley, Mitsubishi, Messung
73.	Pressure gauges	H.Guru, Gluck, M Guru
74.	Analysers	Forbes Marshall, Endress& Hauser, Yokogawa
75.	Level Switch / Level indicator	Levcon, Revathi, Fitzer. S.B.Electro-Mechanical
76.	Flow meter – magnetic / ultrasonic	Endress& Hauser, Fisher Rosemount, Forbes Marshall.
77.	Compressor	Ingersoll Rand, Elgi.
78.	MCC	Interlec, Positronocs, Jay Switchgear, Chavare Engineering, L&T, Siemens, ABB, Schneider, Crompton.
79.	VFD	AB, Nord, Mitsubishi, Siemens
80.	Soft Starter	ABB, Scheineder, Siemens, Innovative Tecchnomics
81.	SCADA	Rockwell (RS-View), Ellipse, Wonderware, Intellution
82.	Electrical	Pratibha Electricals, Spark Electricals, Prakash Electrical, Leena Power Tech. Engineers (Pvt.) Ltd., A.S. Electricals, Chavare Engineering, Joycee Electricals, Turn Key Electricals, Ganesh Electricals, Vicky Electricals, Theji Electricals.
83.	Air Blowers	Everest Transmission, Kay International, Swam Pneumatics

List of Makes and Manufacturers for Diesel Generator set

Sl.No.	Name of the Equipment	Name of Manufacturer
1.	Engine	Caterpillar/Cummins/Perkins/ Wartsila
2.	Alternator	Stamford,Leroysomer
3.	AMF cum Synchronizing Relay	Woodward's/ComAp/DeepSeq
4.	PushButtons	Tecknic/L&T/Siemens
5.	Battery	Prestolite/Exide
6.	Relays	ALSTOM/L&T/Schneider/Enercon
7.	AirCircuitBreaker&MCCB&Isolators	L&T/ABB/Siemens
8.	Contactors	Siemens/ABB/Legrand
9.	Time Switch	Siemens /Legrand
10.	DigitalMeters	AE/CONZERV/Secure
11.	Power& Control Cables	Universal / Nicco/ RPG / Finolex/ Polycab
12.	Terminations	Dowell/Braco
13.	Pipe	Tata/Zenith/Apollo

2. TECHNICAL SPECIFICATIONS FOR DIESEL GENERATING SET

2.1 GENERAL SCOPE OF WORK:

The scope of work shall cover the supply, installation, testing and commissioning of 1 No. Suitable rating to run the entire process, Diesel run generator with prime output capacity and its associated equipments including civil foundation works complete with parallel operation for the SUPPLY utility is to be erected for AMC SPS, The work shall be carried out as per the latest applicable IS, IER, CPCB Norms and Code of Practice. Necessary statutory approval / no objection certificate / clearance if any required from the competent authority shall be obtained by the contractor at their own cost.

2.2 INTRODUCTION:

The suitable rating of DG Set with prime output capacity are required to be supplied with acoustic enclosure as per CPCB norms. DG set with acoustic enclosure shall be installed outside the building with skid mounting in an independent foundation. The location shall befinalized in consultation with Manager (Engineering), SUPPLY. Associated Electrical control panel of the DG set can be located inside the acoustic enclosure or outside the acoustic enclosure as per manufacturer standard. In case, Electrical control panel has to be installed outside the acoustic enclosure, location of room to house Electrical control panel nearest to the acoustic enclosure shall be decided in consultation with the ExecutiveEngineer, SUPPLY.

a) The above sets shall automatically start one after the other upon mains power failure, run up to full speed within 6 seconds of power failure. The set shall be provided with a multiple start mechanism with indication of alarm for “failed to start” condition. A Tachometer switch shall be provided to control the start mechanism and also for the “run” indications.

b) The acoustic treatment shall ensure a maximum sound pressure not more than 75 dB (A) at 1 Mtr. from the acoustic enclosure in free field condition, while running on partial or full load. This condition shall be applicable to the engine exhaust noise levels also. A vertical type “Critical” silencer shall be fitted on the exhaust pipe after the flexible coupling to reduce the exhaust noise. The pipe shall be thermally insulated with ceramic insulation and covered overall with aluminumjacketing.

2.3 DESIGN DATA AND TECHNICAL SPECIFICATION

2.4 DIESEL ENGINE:

Scope: This section covers engine rating, standard components of a diesel engine including exhaust pipe.

a) Engine Rating :

The engine shall be of standard design of the original manufacturers. It should be 4 stroke engine, radiator cooled, naturally aspirated/turbo charged diesel engine developing suitable BHP for giving a power rating as per ISO 8528-Part-
1 in KVA at the load terminals of alternator running at 1500 rpm at ambienttemperature of 40 Deg C, for height at 1000 Meter above MSL and at 50% RH. The engine shall be capable for delivering specified Prime Power rating at variable loads for PF of 0.8 lag with 10% overload available in excess of specified output for one hour in every 12 hours. The average load factor of the engine over period of 24 hours shall be 0.85 (85%) for prime power output. The testing procedure shall be as per standards mentioned above.

The engine shall conform to ISO: 8528-Part 1/ISO 3046/ BS 5514 and as amended upto date.

b) Necessary test certificate for the engine noise and emission level as per CPCBguideline shall be furnished.

c) Engine shall be fitted with following accessories subject to the manufacturer’s design;
   (i) Dynamically balanced fly-wheel
   (ii) Necessary single bearing / close coupled and guard for alternator and engine.

(iii) Air cleaner (dry/oil bath type) as per manufacturer standard
(iv) An electronic governor to maintain engine speed at all conditions of load.
(v) Base fuel tank of minimum capacity of 990 liters.
(vi) Dry exhaust manifold with suitable exhaust residential grade silencer to reduce the noise level
(vii) The following display shall be provided at control panel:-
(a) Start/stop key switch
(b) Lube oil pressure indication
(c) Water temperature indication
(d) RPM indication
(e) Engine Hours indications
(f) Battery charging indication
(g) Low lube oil trip indication
(h) High water temperature indication
(i) Over speed indication
(viii) All moving parts of the engine shall be mechanically guarded in such a manner that a human finger cannot touch any moving part.

d) Governor:

Electronic governor of class A1 as per ISO 3046/BS 5514 with actuator shall be provided as per standard design of manufacturer. Governor shall be a self-contained unit capable of monitoring speed.

e) Lubricating Oil System:

Necessary priming pump for the lube oil circuit as per recommendation of manufacturer shall be installed, to keep bearings primed.

f) Exhaust piping:

The work includes necessary cladding of exhaust pipe using not less than 50 mm thick glass wool/mineral wool/rock wool, density not less than 46 km/m sq. and aluminium cladding (0.80 mm thick) for the complete portion. The exhaust pipe work includes necessary supports, foundation etc. to avoid any load & stress on turbo charger/exhaust piping. The exhaust pipe support structure shall b e got approved by Manager (Engineering), AMC before execution.

g) Optimum Silencer Location:

Location of the silencer in exhaust system has very definite influence on both reduction of noise and back pressure imposed on the system. The preferred silencer locations are given in the Table below, where L is length of the total exhaust system measured from exhaust manifold in meters. Please note that locating the silencer as peroptimum silencer location is mandatory. For high rise buildings, suitable arrangements have to be provided.

OPTIMUM LOCATION OF SILENCER (IN METERS)

	In-line Engine	'V' Engine
Best	2L/5	(4L – 1.5)/5
Second best	4L/5	(2L – 4.5)/5
Worst Location of silencer	L/5 or 3L/5 or at tail end of exhaust piping	(3L – 10)/5 or at the tail end of exhaust piping

h) Exhaust stack height: In order to dispose exhaust above building height, minimum exhaust stack height should be as follows:-

(i) For DG set upto 1000 KVA H = h+0.2 x / KVA

Where = Height of exhaust stack
H = Height of build ing

(ii) Care should be taken to ensure that no carbon particle emitted due to exhaust leakage enters and deposits on alternator windings and on open connection.

i) Cooling System:
   a) System should be designed for ambient temperature of 40 deg. C
   b) Water softening / de mineralizing plants should be used, if raw water quality is not acceptable.
   c) Coolant should be used mixed with additive (in suitable proportion) as per recommendation of OEM/Manufacturer for various engine models.
   d) Radiator fan flow should be free from any obstruction.

j) ALTERNATOR:

Scope: This section covers technical requirement of the alternator.

a) SYNCHRONOUS ALTERNATOR: Self excited, screen protected, self regulated, brush less alternator, horizontal foot mounted in single/double bearing construction (specify one only) suitable for the following:

Rated PF : 0.8 (lag) Rated voltage : 415 volts Rated frequency : 50 Hz No. of phases : 3
Degree of Protection : IP-4x

Ventilation : Self ventilated air cooled Ambient Temperature : 40 deg C maximum Insulation class : F/H
Temperature Rise : Within class F/H limits at rated load

Voltage Regulation : +/- 1% Voltage variation : +/- 5%
Overload duration/capacity : 10% for one hour in every 12 hours of continuous use

Frequency variation : As defined by the Engine Governor (+/- 1%) Excitation : Self excited system
Type of AVR : Electronic

Alternator should be with permanent magnet generation.

Standard : IS-4722 & IEC: 34 as amended upto date.

b) Fault tripping: In the event of any fault e.g. over voltage/high bearing temperature/high winding temperature or an external fault, the AVR shall remove the excitation voltage to the alternator. An emergency trip shall also be provided.

c) Standards: The alternator shall be in accordance with the following standards as are applicable:

(i) IS-4722/BS": 2613/1970 the performance of rotating electrical machine.
The performance characteristics of the alternator shall be as below: Efficiency at full load 0.8 P.F.
For DG set efficiency shall not less than 93.5%.

k) BATTERY/ELECTRICAL SYSTEM:

Battery capacity and copper cable sizes for various engine capacity should be as indicated in the table below. Cable sizes shown are for maximum length of 2 m. If length is more, cable size should be selected in such a way that voltage drop does not exceed 2 V.

l) FOUNDATION:

Genset with acoustic enclosure: A PCC foundation (1:1/2:3, - M-30 grade) of approximate depth of 300 mm is required so as to provide leveled surface for placement of the acoustic enclosure. About 300 mm foundation height shall be above ground level and shall be provided by contractor. The length and breadth of foundation shall be at least 250 mm more than the size of the enclosure. In case manufacturer's recommendations require more depth/width etc. than manufacturers recommendation shall be followed.

m) ACOUSTIC ENCLOSURE:

a) As per CPCB norms, restriction has been imposed for new DG sets upto 1000 KVA for noise level. Therefore, should be type tested at the climatic conditions specified in para.(q) through one of the authorized laboratory.

n) DAILY FUEL SERVICE TANK:

Free Standing Capacity of daily fuel tank shall be suitable to run the plant for next 24 Hrs after power failure, complete with fittings and accessories including fuel pump of suitable capacity as per the manufacture standard. A pipe line shall be laid from the fuel tank to engine/acoustic enclosure.

The Pump shall be controlled in such a way that the pump switch on itself automatically in case the level controller fails in the DG sets.

o) GENERAL DESIGN GUIDELINES:

a) To avoid re-circulation of hot air, durable sealing between radiator and canopy is must.

b) Exhaust piping inside the enclosure must be lagged (except bellow).

p) SPECIFICATIONS FOR ACOUSTIC ENCLOSURE:

a) The construction should be in such a way that it prevents entry of rain water splashing into the enclosure and allow free & quick flow of rain water to the ground in the event of heavy rain. The details construction shall confirm to the details as under.

b) The enclosure shall be fabricated out of the CRCA sheet of thickness not less than 1.6 mm on the outside cover.

c) The hinged doors shall be made from not less than 1 6 SWG (1.6 mm) thick CRCA sheet and will be made air tight with neoprene rubber gasket and heavy duty locks.

d) All sheet metal parts should be processed through 7-tank process. e) The enclosure should be powder coated.

e) The batteries should be accommodated in the enclosure in battery rack.

f) The canopy should be provided with high enclosure temperature safety device.

g) The enclosure shall be provided with suitable size and No. of hinged type doors along the length of the enclosure on each side for inspection, operation and maintenance purpose. Sufficient space will be provided inside the enclosure on all sides of the DG set for inspection, easy maintenance and repairs.

h) The canopy should be as compact as possible with good aesthetic look. j) The complete enclosure shall be of modular construction

i) The forced ventilation shall be as per manufacturer design using either engine radiator fan or additional blower fan(s). If the acoustic enclosure is to beprovided with forced ventilation then suitable size of axial flow fan with auto start arrangement should be provided. The forced ventilation arrangement shall be provided with auto stop arrangement to stop after 5 minutes of the stopping of DG sets if necessary as per manufacturers design.

j) The acoustic enclosure should be suitable for cable connection/connection through bus-trunking. Such arrangements on acoustic enclosure should be water proof and dust-(proof conforming to IP-65 protection).

q) INSPECTION AND TESTING:

a) The successful tenderer will arrange staff/fuel for test run at his cost.

b) DG set testing shall necessarily carried out at factory / manufacture premises in presence of representative of SUPPLY.

c) For testing, following procedure will be followed:
All major items / equipments i.e. engine & alternator in assembled condition, associated electrical control panels etc. shall be offered for inspection and testing at factory / manufacturers works. The successful tenderer shall give a notice of minimum two weeks for carrying out such tests. The Engineer- in-charge / or his authorized representative of AMC shall witness such inspection & testing at mutually agreed date. The cost of the representative's visit to the factory will be borne by TENDERER.

d) The department also reserves the right to inspect the fabrication job at factory and the successful tenderer has to make arrangement for the same.

e) DG set will be tested on load at KW rate. During testing, each of the DG sets covered under scope of work, shall be operated for a 2 hours on rated KW following one hour on 10% overload after continuous run of the 2 hours. During testing all controls/operations safeties will be checked and proper record will be maintained. Any defect/abnormality noticed during testing shall be rectified. The testing will be declared successful only when no abnormality/failure is noticedduring the testing. The DG set will be cleared for dispatch to site only when the testing is declared successful by authorized representative of SUPPLY.

r) SITE TRIAL RUN / RUNNING-IN-PERIOD:

After successful testing of the DG set, a trial run at available load will be carried out for 18 Hours for three continuous days (6 hrs each day) at SUPPLY site. The DG set will be operated and a log of all relevant parameters will be maintained during this period. The arrangement of staff for trial run and diesel during such period will be made the successful tenderer. The DG set will be said to have successfully completed the trial run, if no break down or abnormal/unsatisfactory operation of any component of the entire installation included in the scope of work of the contractor, occurs during this period. After the DG set has operated without any major break down/trouble, it shall be taken over by the SUPPLY subject to guarantee clause of this contract. This date of taking over of the DG set, after trouble free operation during the trial run/ running- in period, shall be the date of acceptance / taking over.

s) AUTO SYNCHRONIZING CUM AUTO LOAD SHARING MV PANEL

Provision for Auto Synchronizing Cum Auto Load Sharing MV Panel for Front access, Free Standing, dust and vermin proof, Indoor switch board suitable for 415V,
3Ph, 4Wire,50Hz fabricated from 2mm thick CRCA M.S sheet with hinged, gasket and lockable doors having structural reinforcement with suitable angle/Flat section,

3mm thick gland plates, lifting hooks, including power coated paint finish of siemens gray texture shade over metal surface cleaned and treated with seven tank process with interconnection shall be provided.

Any other items left above and necessary for each design, manufacturing erection and commissioning shall be the responsibility of the tenderer. However any of such items if required shall be mentioned in the technical bid itself and no such request will be entertained in future.

- DG Incomers shall fitted with

1No – Suitable rating Amps. TP Microprocessor based EDO ACB (O/L, S/C, E/F) each fitted with

1 – Suitable rating Amps 4PMotorised MCCB for Neutral isolation.

1 – Digital Multi function meter

1 – Set of --CTs.

1 – Composite AMF cum Synchronizing Relay having the following Metering & Protection

a) Generator Measurements:

U, I, HZ, KW, KVAR, KVA, PF, KWH, KVAHr.

b) Mains Measurement:

U, I, HZ, KW, KVAR, PF.

c) Protection:

3 Phase integrated generator protections (U+F).

IDMT over current + short current protection.

Overload protection. Reverse power protection. Earth fault protection.

3 Phase integrated mains protections. Vector shift protection.

All binary / analog inputs free configurable for various protection types. Additional 160 programmable protections.

1 – Set of CTs for AMF cum Synchronizing Relay.

GUARANTEED PARTICULARS

The tenderers shall furnish the following guaranteed particulars for Rated KVA DG sets along with the offer.

a) Name of the Manufacturer:
b) Trade Mark / Brand Name:
c) Specific Fuel Consumption:

Specific Fuel Consumption @ 100% load ……..……..……g/ kW.Hr
Specific Fuel Consumption @ 80% load ……g/ kW.Hr
Specific Fuel Consumption @ 75% load ……g/ kW.Hr
Specific Fuel Consumption @ 50% load …… ….g/kW.Hr
Tolerance
Fuel Consumption in Liters
Fuel Consumption in liters @ 100% load ……..L/Hr.
Fuel Consumption in liters @ 80% load ……..L/Hr.
Fuel Consumption in litess @ 75% load ……..L/Hr.
Fuel Consumption in liters @ 50% load ……...L/Hr.
Tolerance considered
Density of Fuel considered ……Kg/L
Alternator Efficiency considered ……%
Lube Oil Consumption of Engine
Lube Oil Consumption @ 100% load ……..L/Hr
Lube Oil Consumption @ 75% load ……..L/Hr
Lube Oil Consumption @ 50% load ……..L/Hr
Lube Oil Consumption @ 25% load ……..L/Hr
Recommended lube oil
Lube oil change period …….....Hrs.
Minimum acceptable lube oil temperature ……..Deg C at start
Lube Oil Priming pump
d) Any other relevant Particulars:

List of Makes and Manufacturers

Sl. No.	Name of the Equipment	Name of Manufacturer
1.	Engine	Caterpillar / Cummins / Perkins / Wartsila
2.	Alternator	Stamford, Leroysomer
3.	AMF cum Synchronizing Relay	Woodward's / ComAp / Deep Seq
4.	Push Buttons	Tecknic / L & T / Siemens
5.	Battery	Prestolite / Exide
6.	Relays	ALSTOM / L & T/ Schneider / Enercon
7.	Air Circuit Breaker & MCCB & Isolators	L & T / ABB / Siemens
8.	Contactors	Siemens / ABB / Legrand
9.	Time Switch	Siemens /Legrand
10.	Digital Meters	AE / CONZERV / Secure
11.	Power & Control Cables	Universal / Nicco / RPG / Finolex / Polycab
12.	Terminations	Dowell / Braco
13.	Pipe	Tata / Zenith / Apollo
14.	Insulation Material	U.P. Twiga / Kimmco / Lloyds / Borosel
15.	Structural Steel	Tata / Vizag Steel / Jindal
16.	Fuel Pump	Rotodel / Kirloskar or equivalent
17.	Water Pump	Kirloskar / Grundfoss
18.	Synchronizing Panel	L & T / Siemens / Priya Electrical / Ellin/ Lotus / Power Gear
19.	Bus Trunk	Stardrive / Priya Electrical / Ellin / Lotus

Makes of the equipment offered shall be limited to the above. However, while offering alternatives, the make shall be selected justifying the quality and economy.

3. SPECIFICATION FOR INSTRUMENTATION WORKS

3.1 Instrumentation works for STP & SPS

Control Philosophy:

The following control philosophy for the different unit operations in the STP. The plant should be capable to auto control depending upon the level in the Raw Sewage Sump (Wet well) with a provision of manual operation / override. For transfer of wastewater into the downstream treatment units, the interlocking will be done depending upon the level of wastewater in the sump.

a) Raw Sewage Pumps:
Raw Sewage Pumps operation shall be in auto. Ultrasonic Type Level Transmitter shall be provided for auto start/stop of pumps. The arrangement shall be such that under no condition, dry run of pump occurs. Also adequate number of pumps shall start/stop based on levels in the sump. By interfacing this to PLC, the PLC should generate configurable alarms.

b) Flow Measurement:
Ultrasonic open channel / pipe meter to be provided to measure and transmit the flow reading to the central SCADA through PLC. Ultrasonic flow measuring devices shall be installed on outlet and bypass pipelines.

c) Process Basin:
Process Basins (Primary & Secondary) shall have:

- PLC based automation system with application software based on Rockwell hardware or equal to control all pumps, valves, blowers, VFD, decanters, limit switches and probes as per Tenderer's design including I/Os with 20 % spares, power supplies, UPS.
- HMI Panel to comprise up-to-date standard PC with monitor, printer, mouse, internet connection, RS-view, RS-links (gateway version), entire process and operator software with dynamic flow charts, pictures, screens, alarms, historical trends, reports etc.
- Automation system to monitor continuously in each tank the followings:
  a. Incoming Sewage volume
  b. Process quantity
  c. Discharge quantity
  d. DO-level
  e. Temperature
  f. Oxygen Uptake Rate
  g. Energy requirements
  h. Blower speeds
  i. Equipment operation hours

d) Chlorination system:
Auto switch-over facility of chlorinator to filled toner shall be provided. Chlorine Leak Detector shall be provided to detect chlorine gas, which shall initiate the audio-visual alarm in case of chlorine leakage.

e) All Sumps:
All the sump pits shall be provided with individual capacitance type level switch for cutting off the pump in case of low sump level. Audio-visual alarm in case high level in the sump. Auto start for the pump shall be provided with design level in the tank.

f) All Valves:
All pneumatically / electrically for process system shall operate through the PLC/Control Panel.

g) Dosing Systems:
All Chemical solutions shall Auto Stop in case of low level in dosing solution tank with Alarm

3.2 SCADA (Supervisory Control & Data Acquisition):

The STP shall be designed for automatic operation through PLC and SCADA based system with HMI interface. Provision shall be made for each facility to operate process unit manually, if for any reason the need arises. The control system shall be selectable to either "Off", "Manual" or "Automatic" modes. In the "off" mode, power failure shall be annunciated but no further action shall be taken. Annunciation shall be provided on the central HMI. Gas generation and utilisation shall also be monitored through SCADA

Pressure Measurement

Pressure Indicators shall be provided at the individual discharge of all pumps / blowers / compressors/gas holder/chamber.

Alarms

Audio-visual alarms shall be activated on the following conditions.

i) "Low-Low" Level in Inlet Sump
ii) "High-High" Level in Inlet Sump
iii) High DO level in Bio Reactor/basin& Blowers ON or Low DO level and required number of blowers not operating.
iv) Other alarms as required by the Tenderers technology, which should be identified and stipulated, by the Bidder including alarms for tertiary treatment if adopted by the Tenderer.

3.3 Technical Requirements for PLC & Control Unit / Desk

The treatment plant instrumentation shall be linked to a PLC. The conceptual PLC- operating plant philosophy & technical Requirements is as follows.

The objective of the PLC is to provide control function for total plant operation as descried above.

i) Record Data of listed drives / parameters in plant – i.e. operating hours per day etc.
ii) Record and provide Trending of critical parameters as listed below.
iii) Provide Alarm of faults / breakdowns.
iv) The data record and trending data, alarms from the PLC should go to a printer which should record the information as follows:
    a. Alarms as and when it takes place with time and detail of fault.
    b. Data record of drives – to be automatically printed on a daily basis at a given time – say 1200 hrs. However a facility should be provided to take a status print out at any required moment using a manual signal – this signal can be given from a pressure sensitive keyboard.
    c. Trending data of the listed parameters to be available as follows;
        - for the past 25 hour period.
        - for the past 24 hour period
        - for the past 7 day period

    d. The Trending data should be printed automatically for past 24 hr period at a given set time every day-say 1200 hrs and the record for the past 25 hrs, 24 hrs. and 7 day be available by giving a signal from the pressure sensitive keyboard.

The PLC shall give the following type of alarms:

a. Normal Alarms

All alarms are software alarms – to be printed on the printer, accompanied with an audio-visual alarm for a definite time, however whenever there has been an alarm of any tube there shall be a facility which will enable to give a normal audio – visual alarm also when the plant is under operation in an "attended" mode-i.e. there is an operator.

This audio-visual alarm facility is to be disabled when the plant is under "non attended" mode.

b. Emergency Alarms

Emergency audio / visual / telephonic alarm is to be activated in case of an emergency fault in the "non attended mode". (The Emergency faults are to be listed by the Tenderer as per their control philosophy for the process).

3.4 PLC Specifications:

a. The PLC shall have adequate I/O per card.
b. There shall be 10% spare I/O of each type.
c. Retentivity shall be 100% to save the recorded data and saving the programmed logic, other attributes connected with system for power & system failure.
d. Change in programme / modifications to programme shall be possible by a portable lap top computer.

3.5 Plant Operation Modes

The plant shall be operated in three modes;

a. Automatic Mode – i.e. when there is no operator required for the plant, and all sections of the plant are to operate only in the auto mode only.
b. Non Automatic (Manual) Mode- i.e. operator normally will be required for all operations.
c. Semi Automatic Mode – i.e. for certain component/module requiring manual operation when auto system is not functioning. Provision shall be made for isolation of each automatic mode locally.

Control Unit

a. The PLC, printer, Panel display instruments, all drive units, VDU, Alarm accept buttons, data print signed buttons etc shall be connected to the Computer.
b. All accessories including furniture, desk, storage cupboards, modem for fax and internet, chairs, air-conditioner and other connected housekeeping shall be provided.

3.6 Computer:

Desktop Computers (2 Nos.) of HP/Lenovo/Sony or equivalent make of following configuration shall be provided:

Intel Core i5/i7 (2.2 GHz, 8GB DDR3 RAM, 500 GB SATA HDD, 17" Digital/
lcd Display, 8 X DVD-RW Drive, Multimedia Kit, UPS, HP Laser A3 Size Printer or HP All in One, Internet Port (100 MBPS to 1 GHz) with latest Software like Windows 7 Professional etc.

VOLUME II - E

OPERATION AND MAINTENANCE

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O & M

1. OPERATION AND MAINTENANCE

1.1. GENERAL

This section applies to the specifications of materials used for operation and maintenance, the workmanship, period for routine maintenance, specifications for the acceptable quality of treated water, maintenance of records, and responsibilities during operation and maintenance period.

The Contractor shall operate and maintain the entire Aurangabad sewerage system including Collection System, Sewage treatment plant, outfall, Sewage pumping stations, Rising Main, instrumentation system,

communication system, the PLC systems, all ancillary buildings, campus area, roads and ancillary civil structures along pipeline and road for the entire period specified in the Contract.

1.2. 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 Employer's Representative prior to commencement of the operation and maintenance period and must be incorporated in the O&M manual. Without being limited by this clause, during O&M 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.

1.3. ACTIVITIES DURING O&M PERIOD

1.3.1. 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 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:

- The AMC will evaluate the proposals based on life cycle cost of proposed technology.
- The Operation and Maintenance for 1st five years shall be compulsory and the operation and maintenance for subsequent stages of 5 years shall be given on the performance in the 1st stage.
- The Contractor shall operate and maintain the collection system, Pumping Station, Rising Main, sewage treatment plant, Outfall, Ring Main under this Contract for the period specified in this Contract.
- The Operation and Maintenance of sewerage system shall be done as per Chapter No. 8 **"MAINTENANCE OF SEWERAGE SYSTEM" of CPHEEO** of Government of INDIA.
- The Operation and Maintenance of STP and Pumping Station shall be done as per Chapter No. 23 "**TREATMENT PLANT OPERATION AND MAINTENANCE" of CPHEEO o** Government of INDIA.

a) Collecting sewage from all the zones, pumping stations and treatments with quality of effluent sewage as specified or as directed by the Employer's Representative

b) Providing the required staff, but not less than the minimum specified numbers/ level, during operation and maintenance period and additional staff as per requirement during periodic maintenance and in emergencies.

c) Ring main laid in the desired area should be maintained, repaired, replaced as per requirement.

d) Providing all required consumables required for functioning of plant and equipment except for and power charges.

e) Maintenance of pump houses, sewage treatment plant, administrative buildings, STP campus, renovated buildings and their campuses, staff quarters and their surroundings, etc.(all works constructed in this Contract) in neat and clean condition.

Entering into AMC contracts with system / equipment suppliers, as necessary. It is mandatory to enter into an agreement for a 10 year maintenance contract with the PLC and SCADA system supplier or the authorized system integrator, whosoever has executed the work for this project.

g) Maintenance of the lighting fixtures and the lighting system of all areas and replacement of all non-functional lighting fixtures within 24 hours.

h) Maintaining;

- Repair history of all mechanical, electrical and instrumentation control equipment in pumping stations, sewage treatment plant, Outfall, sewage pumping main and communication instruments;
- Logbooks through PLC system;
- Every day power availability, input voltage and current, frequency, power factor, kWh meter readings and kW reading for Substation at STP and clear water pump house;
- Daily log of operations of all the important equipment such as screen chamber, grit chamber, STP electrically actuated valves, etc., with time tag;
- Daily start–stop operation of pumps with every hour readings for operating voltage, amperage and power factor;
- Hourly readings of pressure on the manifold, flow rate in manifold and integrated quantity of water;
- Hourly levels of sumps;
- Influent and effluent water quality test results on Do, BOD, TSS, residual chlorine levels, etc. (every 6 hours);
- 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;
- Observations made during patrolling of the pipeline and roads.

In addition to maintenance of above logbooks the Contractor is required to maintain one inspection book at each pumping station and STP. The complaints entered in the complaint register must be investigated and remedial measures must immediately be taken.

i) Providing required spares and maintaining adequate inventory of required accessories or equipment itself for repair of system so that the electrical, mechanical, instrumentation and control system, pipe and pipe appurtenances and surge system and the communication system can work efficiently as per the guarantees given or minimum required efficiencies asked for in the Contract, without any additional costs to department. 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.

j) Providing manpower for the required repairs of all facilities along with the manpower and materials for repair of the roads, buildings and campus area utilities.

Maintaining the drinking water supply facilities in pump house building, STP campus and all its units.

l) Maintaining stores for the electrical, mechanical and instrumentation and control equipment as well as that for the chemicals and laboratory consumables at the STP. The maintenance of stores will include but shall not be limited to:

- Loading / unloading of materials received and issued for works;
- Proper arrangement of material in stores to ensure its safety and easy availability;
- Maintaining store areas in a neat and tidy condition;
- Keeping records and accounting for the incoming materials,
- 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.

m) Daily patrolling of the raw sewage and raw sewage main from pumping to STPS and to identify and report the damages / defects of road, road embankment, pipe and pipe appurtenances, CD works en-route structures.

n) Periodic and routine maintenance as per the manufacturer's recommendations and recommended schedules, as well as emergency (breakdown) maintenance as and when required. Maintaining a fleet consisting of at least one JCB or other equivalent or superior hauling machine, sufficient inspection/patrolling vehicles and material hauling vehicles and any other vehicles/ machinery/ equipment for adequate and timely repairs and/or for routine/ periodic maintenance/ patrolling of the system.

o) Periodic routine maintenance of structures/buildings of intake pumping station and others built in the Contract, campus areas of treatment plant and pumping station(s). 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.

p) Providing transportation facilities between various areas.

q) 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.

r) Submission of monthly report generated through SCADA output including energy and chemical Consumption at STPS.

s) Co-ordination with other contractors and/ or agencies responsible for the execution, operation and maintenance of the sewage system and collection within AMC area and en-route villages, including the O&M contract for the AMC. .

t) Providing all machinery like JCB, generator, drain pumps, crane, welding machine, etc., as required for proper and timely maintenance activities.

Insurance: The Contractor shall, without limiting his or the Employer's obligations and responsibilities, insure;

I. The work together with material and plant for in Corporation therein, to the full replacement cost (term "cost" in this context shall include profit).

II. 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.

III. 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 O&M until the date of completion of O&M in respect of the facility or any section or part thereof as the case may be.

IV. Any amount not insured or not recovered from the insurer shall be borne by the Contractor

1.3.2. EXPERIENCE AND QUALIFICATION OF STAFF

For all operation and maintenance works, the Contractor shall provide skilled staff, which has adequate qualifications and sufficient experience of similar works. CV of General Manager, Shift-in-charge, Plant Supervisors will have to be got approved from the Employer. The following Table describes the minimum levels of staffing, and their minimum qualifications and experience in similar works, theta the Contractor will be required deploy for carrying out the O&M functions:

Table : Minimum Requirements for Staff and Qualifications at each zone

Sr.No	Designation	Qualification	Experience	Nos.
A. General Staff (common for the whole project)				
1.	General Manager	Graduate Engineer (Civil)	10 years	1
2.	Electrical Engineer	Graduate Engineer-Electrical	5 years	1
3.	Foreman-Electrical	Diploma /ITI	5/10 years	1
4.	Foreman-Mechanical	Diploma/ITI	5/10 years	1
5.	Wireless Communications Operator	Diploma in wireless communications or equivalent	5 years	2
6.	Foreman Instrumentation	Diploma	5 years	*1*
7.	Instrumentation Technician	ITI Instrumentation	10 years	*1*
8.	Helpers	10th Pass	-	4
Total of A				12

Sr. No.	Designation	Qualification	Experience	Shift-1	Shift-2	Shift-3	Total
				8 am-4pm	4pm-12	12-8am	
B. Collection System for all Zones							
1.	Shift-in-charge	Graduate (Civil.) OR Diploma (Civil.)	5 years 10 years	2	2	2	6
3.	Helpers	8th Pass	-	4	4	4	12
4.	Security Guards	8th pass	-	--	--	--	--
	Attendant	-	-	1	-	-	1
		Total		*7*	*6*	*6*	*19*
Total of B.				***19***			
C. Pumping stations and Sewage Treatment Plants for all zones							
1.	Plant Supervisor	Graduate Engineer-Mech /Elect /Civil/ M.Sc.(Chemistry)	7 years	3	-	-	3
2.	Shift-in-charge	Diploma (Elect/Mech.)	5 years	3	3	3	6
3.	Electrician	ITI (Elect.)	5 years	3	-	-	3
4.	Chemist	BSc-Chemistry	5 years	3			3
5.	Lab Assistant	Diploma in Lab Tech.	3 years	6	-	-	6
6.	Helpers	8th pass	-	12	12	12	36
7	Security Guards	8th pass	2 years	7	7	7	21
8	Gardener	8th pass	2 years	6	-	-	6
		Total		43	22	22	87
Total of C.			***87***				

Note:

1. The above requirement is minimum. The Contractor will arrange extra work force when required so as to smoothly run the operation and maintenance including preventive maintenance, repairs etc. and general cleanliness of the installations.

2 The above staff strength is exclusive of leave reserve required for different category of staff. The Contractor shall ensure availability of the personnel given in the above table for all seven days in a week.

3. The Contractor shall make appropriate arrangements for maintenance of items like road work, buildings, arboriculture, patrolling and maintenance of civil structures, vehicle operations and other activities defined to fulfill its obligations under O&M Contract.

1.3.3. PUMPING STATIONS

(i) Operation of plants as required, including provision of required manpower for routine operation of pumping station.

(ii) eriodic upgrading, as required, of the initial impellers and wearing rings by replacement with the intermediate impellers and wearing rings, and subsequently with the final impellers and wearing rings, for the clear water pumping station (replacement impellers and accessories to be provided as a part of the Contract).

(iii) Maintaining the pumping station PLC, including hardware and software along with all instruments, in proper working condition. The downtime of the control system shall not exceed 2 hours. During the downtime, the Contractor shall continue to operate the pumping station in manual mode using the local panel controls and the readings from local instruments.

(iv) Routine and periodic maintenance of the entire control system and instruments as per the manufacturer's recommendations.

(v) Replacement of damaged control, communication cables, and power supply cables.

(vi) Repair or replacement, as required, of all instruments such as flow meters, pressure sensors, pressure gauges, level sensors, float level switches, temperature scanners, vibration sensors, noise meter, data loggers along with all other equipment. The down time of any individual instrument as referred above shall not exceed 24 hours.

(vii) Periodic site calibration of all measuring/metering equipment at every 6 months minimum or as recommended by the manufacturer. The calibration at the manufacturer's works/ independent laboratory shall be carried out only in case of major failure of the instrument.

(viii) Preparation and submission of daily and monthly customized reports, produced from the local SCADA system

(ix) Repair or replacement, as required, of damaged electrical equipment/ parts for proper functioning of electrical system.

(x) Maintenance of the cooling and lubricating systems.

(xi) Routine maintenance of the pumps/ motors as per recommendation of the manufacturer.

(xii) Replacement of bearings, damaged impellers and other damaged parts so that the operation of pumps ensures the guaranteed efficiencies with desired noise and vibration levels.

(xiii) Routine and periodic maintenance of the EOT cranes as per the manufacturer's recommendations.

(xiv) Breakdown maintenance of all electrical, mechanical, instrumentation and control equipment, EOT crane, etc.

(xv) Re-painting of the exposed mild steel components of pipe line, ladders, railings etc. in the pump house in the 3rd and 5th year of O&M to keep them in good shape.

(xvi) Maintaining the surrounding areas of the pumping stations free from shrubs, weeds, grass and other unplanned vegetations.

(xvii) Routine monitoring of substation equipment and taking preventive measures as required

(xviii) Routine maintenance of VFD as per manufacturer's recommendation.

(xix) Keeping the hourly records of:

- Status of pumps
- Current
- Voltage
- Frequency
- Active and reactive power
- Water level at suction reservoir
- Suction and delivery gauge readings
- Rate of flow
- Pump head
- Keeping daily records of:
    - Total number of hours of operation
    - Total quantity pumped
    - Total energy(kWh) consumption

(xx) Specific requirements of pumping station maintenance are as listed in the following Table :

Table Maintenance Schedule for Pumping Stations

Activity	**Frequency**
Removal of clogged materials from screens (only for raw water pumping plant)	Daily 6 times
Temperature of WTI/OTI w.r.t ambient temperature	Daily 4 times
Oil level in the conservator	Daily
Oil level in the bushing	Daily
Temperature of RTD, BTD in motors w.r.t. ambient temp.	Daily
Watering garden around plant, if provided	Daily 4 times
Checking of disconnectors' operation	Weekly
Operation of crane for all motions	Weekly

Activity	Frequency
Cleaning of level sensors	Weekly
House keeping plant and its surroundings (Includes removal of dust, dirt, cobweb etc)	Daily
Checking vibration and noise level of pump sets	Daily
Fully closing and opening of sluice gates and valves	Monthly
Submission of report on maintenance to Employer	Monthly
IR and PI values of motors	Monthly
Condition of silica gel in breather and replacement(if required)	Monthly
Replacement of bearings	Within a day of breakdown
Replacement of bulbs, lamps etc	Within a day of breakdown
Tightening of gland	When leakage increases beyond acceptable limit
Greasing, oiling	As per manufacturers recommendation
Attending breakdowns	As and when it occurs
Preparation of list of spares for satisfactory operation	Half-yearly
Transformer oil sample checking	Half-yearly
Inspection of switchboard, cable box, etc.(i.e. visual inspection, tightness of nuts and bolts, IR values, earthing contacts, checking tightness of terminal block, etc.)	Halt-yearly
Measurement of earth resistance	Yearly
Checking of relays/ alarm (trough secondary injection)	Yearly
Condition of gasket and replacement (if required)	Yearly

(xxi) Disposal of screened material.

(xxii) Providing all consumables such as grease, oil, stationery, water for gardening, etc.

(xxiii) Providing office furniture for operating and maintenance staff.

(xxiv) Providing safety accessories such as gloves, shoes, first aid box etc.

(xxv) Ensuring safety of plant and equipment.

(xxvi) Furnishing required information to Employer.

(xxvii) Any compensation charges levied by MSEB towards low power factor, overloading or any other such penalties will be borne by the Contractor.

(xxviii) Contractor will be given a minimum of 15 days advance notice by the Employer's Representative for changing the impellers when required.

1.3.4. SEWAGE TREATMENT PLANT

i) Operation and maintenance of all the Sewage treatment process facilities from inlet chamber to treated water reservoirs/sump

ii) Providing required manpower for routine operation of all the process units, compressor room, HV/LV switchgear room, PLC control, all motors and valves in the system, and laboratory.

iii) Maintaining the PLC, including the hardware, software and all instruments, in good working condition. The downtime of entire control system shall not exceed 2 hours. During the downtime, the Contractor shall continue to operate the sewage treatment plant in manual mode using the local panel controls and the readings from local instruments

iv) Routine and periodic maintenance of the entire control system and instruments as per the manufacturer's recommendations.

v) Replacement of damaged controls, communication cables and power supply cables.

vi) Repair or replacement, as required, of all instruments such as flow meters, pressure transmitters, pressure gauges, level sensors/transmitters, float type level switches, on-line pH meters, on-line turbidity meters, on-line residual chlorine meters and laboratory instruments along with all other equipment. The downtime of any individual instrument as referred above shall not exceed 24 hours.

vii) Periodic site 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.

viii) Preparation and submission of daily and monthly customized reports produced by the local SCADA system.

ix) Provision and maintenance of all consumables for printing without any additional costs to the Employer.

x) Inspection of each STP at least once in a year after complete dewatering for damages caused to the moving parts, steel structures, and the RCC structure. Subsequently the repairs, cleaning and disinfection must be done.

xi) Maintaining all STP in good and proper operating condition irrespective of the inflow and outflow rates, except for filters under repair or periodic inspection.

xii) Maintenance of the STP beds and under drainage system in good and proper operating condition including providing gravel and sand as required.

xiii) Weekly lubrication of all gears of reduction motors, motorized valves, gates and other parts of the system.

xiv) Periodic operating and checking check all valves and gates for their manual and electric operation. Operation of valves must be checked from local control console, switchgear and through PLC system. Any defect observed must be made good.

xv) Ensuring environmentally friendly disposal of sludge at approved site(s), within a radius of 30 kilometers from the sewage treatment plant.

xvi) Operation and maintenance of all circuits and buildings associated with the treatment works.

xvii) Breakdown maintenance of all electrical, mechanical and instrumentation equipment.

xviii) Routine monitoring of substation equipment and take preventive measures (as required)

xix) Routine maintenance works of lighting and earthing system.

xx) Re-painting of the exposed mild steel components of pipeline, ladders, railings etc. in the plant to keep them in good shape.

xxi) Maintaining the surrounding areas of the STP free from shrubs, weeds, grass and other unwanted vegetation.

xxii) Providing safety accessories, e.g. gloves, shoes, first aid box, etc.

xxiii) Ensuring fire and safety equipment.

xxiv) Minimum 15 days stock of all the consumables shall have to be maintained to ensure that quality of water does not suffer. The Contractor will use chemicals to ensure their most economic consumption and minimize wastage.

1.3.5. 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 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.

1.3.6. 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 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.

1.3.7. COLLECTION SYSTEM

Sewer inspections and maintenance should be planned. The whole sewerage systems should be marked on a plan and divided into sections and areas, which are placed under a maintenance gang. The maintenance gang preferably consists of a supervisor or mate with at least 6 skilled sewer men. The area under each gang will depend on the size of the sewer depth to which it is laid, the spacing of manholes, the condition of sewer line (whether surcharged or not) whether cleaning is being done by manual labour or by mechanical sewer

machines etc. In case, house gully traps are to be maintained, special gang of one or two persons will clean these traps regularly in a phased or planned manner is necessary.

The work of each sewer maintenance gang would consist of the following:

a) Check manhole condition for deposition of silt, new connections done, damaged walls or steps, manhole covers, clogged vertical pipes in drop manholes etc. While the cleaning of the manhole, pipes etc., will be undertaken by the gang, repair etc. may be reported to be handled by a separate construction gang of mason and helpers. It is preferable that the repair gang comes out on the work when the sewer cleaning or maintenances gang is working , so that brick bats, debris mortar etc., which fall in the manhole are removed there and then. This will cause a major blockage if the same is allowed to flow into the sewer line, which usually occurs when repairs are done separately. In such cases a couple of sewer men should be deputed to clean the manhole of the debris immediately after repair work is completed.
b) Check the sewer line between two successive manholes for silting and flow conditions and remove the deposited silt and
c) Check for any harmful and extraneous matter entering into the sewer line so that further investigation for the cause and location can be determined.
d) Check air release valves in rising or force mains sluice gates or stoppage in the sewer lines, overflow arrangements etc.
A record of daily work done by the gang and also a record of work done on the sewer lines should be maintained so that chronic spots may be investigated and remedial action taken.

1.3.8. SEWER CLEANING EQUIPMENT AND PROCEDURE

Sewer cleaning works require usual implement like pick axes, manhole guards, tripod stands danger flag, lanterns, batteries, safety lamps, lead acetate paper, silt drums, ropes, iron hooks, hand carts plunger rods, observation rods, shovels etc.

In addition, sewer cleaning work calls for the following special equipments and devices like a portable pump set running on either diesel or petrol engine, manila rope and cloth balls, sectional sewer cleaning rods, a sewer cleaning bucket machine, a dredger, a roding machine with flexible sewer rods and cleaning tool attachments such as augers, corkscrews, hedgehogs and sand cups, scraper, and hydraulically propelled devices such as flush bags, sewer balls, wooden ball and sewer scooters sewer jetting machine, gully emptiers and pneumatic plugs.

1.3.8.1 HYDRAULICALLY PROPELLED DEVICES

The hydraulically propelled devices take advantage of the force of impounded water to effectively clear sewers. Efficiency depends on the hydraulic principle that an increase in velocity in a moving stream in accompanied by a greatly increased ability to move entrained material. The transporting capacity of water varies as the sixth power of its velocity.

1.3.8.2 VELOCITY CLEANERS (JETTING MACHINES)

The high velocity sewer cleaner makes use of high velocity water jets to remove and dislodge obstructions, soluble grease, grit and other materials from sanitary, storm and combined sewerage system. It combines the functions of a roding machine and fully emptier machine. Basically it includes a high pressure hydraulic pump capable of delivering water at variable pressure upto about 80 kg/cm2 through a flexible hose to a sewer cleaning nozzle. The nozzle has one forward facing hole velocity breaks up ad dislodges the obstructions and flushes the materials down the sewer. Moreover by varying the pressure suitably. The nozzle itself acts as a jack hammer and breaks up stubborn obstructions. (A separate suction pump or air flow devices may also be sued to suck the dislodged material).

The entire equipments is usually mounted on a heavy truck chassis with either a separate prime mover or a power take off for the suction device. The high pressure hose reel is also hydraulically driven. The truck also carries fresh water tanks for the hydraulic jet and a tank

for the removed sludge and the various control grouped together for easy operation during sewer cleaning. The manufacturers operating and servicing manuals should be carefully followed by best results in the use of the machine.

1.3.9. PIPELINE

The rubber gaskets/rings, nut and bolts, etc., to be used shall be as per the specifications given for the respective items.

After each repair the damaged coating of pipes must be repaired and, if in trench conditions, the trench must be filled with approved soil, well compacted to its original density, up to the existing ground level.

Stretches along pipe alignments where cover is washed out or removed due to other reasons must be rehabilitated so that the minimum cover required is always maintained.

All cracks in pipe supporting structures, valve chambers and their edges must be raked, filled and made good with cement sand mortar 1:2.

The repairs may include but not limited to items: -

a) Repair of leaks, damaged portion of road, embankment, pipe and pipe appurtenances, CD works and en-route structures identified during patrolling.

b) Emergency repair(s) of burst(s) for maintaining regular supplies.

c) Operation of all motorized valves quarterly to check its proper functioning electrically as well as for manual operation. Maintenance of all valves in leak less condition. Quarterly inspection of expansion joints, surge protection equipment/system, insulating joints and repairs if required. Contractor shall submit quarterly reports of all such activities done.

d) Maintenance of inventory for repair of pipe leak(s) and burst(s), valves (air valve, sluice valves, butterfly valves), expansion joints, surge protection devices, anti-corrosion devices or any other pipe appurtenances or equipment(s) installed.

e) Quarterly lubrication of all motorized gear boxes along the alignment.

f) Maintaining the valve chambers along the pipeline in clean and dry conditions.

g) Maintaining portable generating set for operation of valve actuator and dewatering of scour valve chambers and dewatering in case of burst/repair of pipe.

h) Maintaining the soil cover on the pipe damaged due to rains, runoff or any to other reason.

i) Repair of damaged coatings during maintenance operations.

j) Maintaining clean conditions at saddle and ring girder supports and oiling/greasing of all supports.

No sewage water losses are admissible in the collection system.

1.3.10. PUMPING STATION, TREATMENT PLANT AND ALL OTHER BUILDINGS

The Contractor shall carry out ordinary repairs to buildings during the O&M period. The repairs may include but not limited to the following items:

(i) Easing of doors and windows, monsoon repairs to roofs, attention to drains, rain water spouts, attention to plinth protection.

(ii) External white or color wash, external or internal painting, internal distempering, renewal of approach roads within the campus.

The frequency of repairs must not be less than as specified below:

Sr.No.	Nature of Repair	Frequency of repair for Residential Buildings	Frequency of repair for other Buildings
1	External finishing (color washing) after attending minor repairs such as damage to plaster, etc.	Once in a year	Every two year
2	Internal finishing (distemper / painting) after attending minor repairs such as damage to plaster etc	In 3rd and 5th year of O&M	In 3rd and 5th year of O&M

Repairs to other administrative buildings must be carried out during May to June except for white and color washing work, which should be done in September and October after monsoon in residential buildings.

Following repairs prior to onset of monsoon are essential:

1. Any faults in the electric installation, leakages, earthing, exposed wire ends and any hazards on this account to the users/inmates of the buildings, should be taken care of suitably; wiring, which is damaged or outlived, should be replaced.
2. Damaged sanitary lines should be replaced and choked lines cleared.
3. Proper drainage of the area around the building should be ensured to avoid stagnation of rain water/ house effluent, in order to prevent malarial conditions. Where courtyards exist in the buildings, their drainage into the outer drains should be ensured. Any choked drains should be cleared properly.
4. Leaking roofs should be attended to immediately with suitable repairs/ treatment, as the case may be. The rain waterspouts should also be cleared of blockages, etc. The roof should be swept clean of leaves, debris, etc., if any.
5. The plaster on outer walls of the building, which is exposed to weather, should be repaired before rains in order to prevent dampness inside. Where plinth protection has been provided, it should be checked and the damaged portions, if any, should be repaired before rains.
6. Damaged flooring should be repaired/ replaced as per requirement, in order to prevent dampness inside the rooms, etc., during rains.
7. Periodic repairs of damaged floors, door/window fittings, water taps, water coolers, furniture, desert coolers, electric circuits, must be taken up on complaints using the material of same quality as used during construction to ensure trouble free communication.

1.3.11. OPERATIONS AND MAINTENANCE MANUAL

The comprehensive manual shall be submitted 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:

1. 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.
2. 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 O&M period.

3. Frequency of spares used in maintenance of valves (air-valve, sluice valves and butterfly valves), expansion joints, and equipment installed for surge protection and protection against corrosion must be recorded for updating the contents of the manual.
4. Records of trouble shooting points and details of events causing trouble (breakdowns) during maintenance of inlet chamber, chemical mixing unit, flash mixer, clariflocculator, filter bed(s), sludge thickener and drying beds, pre-chlorinato, decanter, Air Blowers, gas Generation facility and any other part of the treatment plant must be maintained and used for updating the contents of the manual.
5. 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.
6. Records of locations and type of damages observed during maintenance of road which are of recurring nature must be used in updating the manual.
7. 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 for 12 months.
8. Records of the raw sewage water quality, as monitored during very day of the O&M period, must be maintained and handed over after the expiry of Contract period. The chemical requirement in the worst conditions of operation must be identified and incorporated in the manual.. Record keeping must be sufficient so as to assist in forming a relationship between the chemical dosages required for treatment with respect to the raw sewage water input quality.
9. The provisions in the manual must incorporate every aspect of good industrial 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.
10. The manual so prepared must be updated after the end of every year of operation and maintenance, giving effect to the experience gained and the observations made by the Department during the maintenance period.
11. At the time of handing over after completion of O&M period, all the equipment, including standby equipment, must be in good working order.

1.3.12. SERVICE LEVEL BENCHMARKS

Separate Management contract of Operation and maintenance of system shall be executed before issuing the commissioning certificate where service level benchmark specific to project shall be established along with the penalties for not being able to achieve these benchmarks.

1.3.13. PENALTIES FOR FAILURE TO ACHIEVE THE FUNCTIONAL GUARANTEES

In case of failure to deliver the required effluent quality, liquidated damages shall be imposed for such failure to meet the performance criteria, as described in the following. The Employer will be entitled to recover any such damages from the monthly progress payments to be made to the Contractor in the month in which the failure occurred, or at any time thereafter from the subsequent monthly progress payments.

1.3.13.1 Power Consumption in Pumping Stations:-

The expected power consumption shall be calculated every month on the basis of the characteristic curves submitted by the Contractor along with the offer and the actual duty conditions for the month (calculation can be done on hourly basis). It will be compared with the actual power consumption and if the consumption is higher than the expected consumption, after taking into account the tolerances, liquidated damages shall be recovered from the Contractor at the rate of two times of the charges for the extra power consumed and paid to MSEB.

Application of liquidated damages for excess power consumption will not be subject to any upper limit.

1.3.13.2 Quality of Treated Water: -

Water will be provided within the permissible chemical and bacteriological parameters and, in general, there should be no lapse in it. The treated sewage water will be checked for required quality parameters.

In case the permissible parameters are not achieved

(i) In case of lapses in more then two occasions in a calendar month, liquidated damages will be applied at the rate of 0.5% of the Contractor's monthly charges for O&M for each day of lapse.

(ii) In case there are lapses in two consecutive days, liquidated damages will be applied at the rate of 1.5% of the Contractor's monthly charges for O&M.

(iii) In case the Contractor has continuous lapses beyond two days, liquidated damages will be applied at the rate of 5.0% of the Contractor's monthly charges for O&M for each day of lapse. In such case, the Contractor will be notified and the Employer will have the option of making the necessary inputs to control and improve the supply. All costs for such improvement, including 10% for overhead and administration, will be charged to the Contractor, along with the penalty for the lapses.

1.3.14. FACILITIES TO CONTRACTOR

The Contractor will be permitted to use the premise and quarters developed under the Contract for use by his staff during operation and maintenance to the extent agreed and approved by the Employer's Representative.

1.3.15. 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 on a monthly basis in the Schedule of Prices, shall include all costs for carrying out all O&M responsibilities, except for the following items for which the Employer will bear the cost:

(i) The cost of electric power consumed, which will be paid directly to MSEDCL by the Employer

1.3.16. FORMAT

Suggested formats to be followed for proper recording of pumping and treatment plant operations are given below. The format can be finalized during execution stage.

A. PLANT DATA

Pumping Station:

Date:

Time Hrs	Voltage V	Frequency Hz	Speed Rpm*	Energy meter kWh	Flow Cu.m	Head (m)	Signature
1							
2							
3							

Time Hrs	Voltage V	Frequency Hz	Speed Rpm*	Energy meter kWh	Flow Cu.m	Head (m)	Signature
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
			Total =				

B. PUMP OPERATION

Pumping Station:

Date:

Time Hrs	Pump no								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									

Time Hrs	Pump no								
20									
21									
22									
23									
24									
Total hours of operation									

Mark ‘X’ if pump is not available

Indicate Starting and Stopping time

C. PUMP DATA

Pumping Station:
Pump No.
Date:

Time Hrs	Voltage (V)	Current	Suction gauge reading* (m)	Water level in sump (m)	Delivery gauge reading (m)	Total head (m)	Signature
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							

* For Horizontal pumps only

D. POWER STATEMENT

Pumping Station:

Month:

Date

Date	Theoretical power consumption (kWh)	Allowances	Actual Power consumption (kWh)	Difference	Signature
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					
31.					

Signature of Contractor No. of Corrections Executive Engineer

E. MONTHLY REPORT

Pumping station:

Month and year

	Pump no									
	1	2	3	4	5	6	7	8	9	10
Number of hours of operation										
Vibration mm/sec										
Noise level dBA										
Total quantity pumped ml										
Energy consumption kWh										
Total no of hrs of power failure										
Total no of pump set hrs not available										
Reason for non availability of pump set										
Action taken for rectification										
Non availability of any other equipment and reason										
Action taken for rectification										

Signature:

FORMAT 1

Daily Report on Operation and Maintenance of _____ MLD Sewage Treatment Plant

At_____

Prepared by: **[Name of Contractor]**

Report For: **[Date]**

A. Consumption Records						
Sr. No.	Item	Meter Reading or other records		Daily Quantity	Average per m^3 of raw water	Remarks
		At 6:00 hrs of reporting day	At 6:00 hrs of previous day			
A.1	Raw water quantity received at plant inlet					
A.2	Alum, Chlorine Quantity or any other chemical consumed					
A.3	Electrical Power consumed					

B. Quality Records							
Particulars		At 6:00 hrs	At 12:00 hrs	At 18:00 hrs	At 24:00 hrs	Average	Remarks
B.1	Dissolved Oxygen						
B.2	T.S.S of raw sewage						
B.3	PH Of Raw sewage						
B.4	PH of treated water						
B.5	DO in treated water.. etc.						

C. **Operational**					
Sr. No.	Unit	From hrs.	To hrs.	Total time	Remarks
C.1	*				
C.1.1	*				
C.1.2	*				
C.2	*				
C.2.1	*				
C.2.2	*				
C.3	Other Units				
C.3.1	…… Downtime				
C.3.2	…… Downtime				
C.3.3	…… Downtime				

* Process units as installed by contractor

Signed by: _____

Designation: _____

On behalf of Contractor: _____

FORMAT 2

Monthly Report on Operation and Maintenance of _____ MLD Sewage Treatment Plant

At_____

Prepared by: **[Name of Contractor]**

Report For: **[Month]**

A. Consumption Records						
Sr. No.	Item	Reading on last date of month	Reading of month	Quantity daily month	Average per 1000 m^3 of raw water/day	Remarks
A.1	Raw water quantity received at plant inlet					
A.2	Chlorine Quantity consumed					
	For pre-chlorination					
	For post-chlorination					
A.3	Alum Quantity consumed					
A.4	Electrical Power consumed					

B. Quality Records					
Particulars		Average during month	Maximum during month	Minimum during month	Remarks
B.1	As above in daily report				
B.2					
B.3					
B.4					

C. Operational				
Sr. No.	Unit	Total time during month	Average daily	Remark
C.1				
C.1.1				
C.2				
C.2.1				
C.3	Other Units			
C.3.1	…… Downtime			
C.3.2	…… Downtime			
C.3.3	…… Downtime			

* Process units as installed by contractor

Signed by: _____

Designation: _____

On behalf of Contractor: _____

VOLUME II-F

QA & QC

VOLUME II - F

QUALITY ASSESSMENT AND QUALITY CONTROL

TABLE OF CONTENTS - VOLUME II F,

PREAMBLE

The “Volume II F : Quality Assessment and Quality Control” are to be read for the purpose of pricing in conjunction with "Volume-I : Conditions of Contract" of the Tender Documents containing instructions to Tenderer and General Conditions of Contract; “Volume IIB : Civil Specifications”, “Volume IIC : Mechanical Specifications”, “Volume IID : Electrical Specifications”, “Volume IIE : Operation and Maintenance”, Volume IIF : Quality Control and Quality Assurance” and “Volume-III : Financial Bid” of this tender.

The prices quoted in the “Volume III: Financial Bid” shall be all inclusive value for the work described including all costs and expenses which may be required in and for the execution of the work described together with all general risks, liabilities and obligations set forth or implied in the document on which the tender is based.

All works shall be carried out strictly as per detailed specifications whether actually specified or not. If not specified, work shall be carried out as per directions of Owner/Engineer-in-charge.

The total amount entered in the Volume III: Financial Bid document shall be written in ink and shall be entered both in figures and words.

Specifications of items of work are described in Section D for each item of Volume III: Financial Bid shall read this in conjunction with other technical specifications and specific technical requirements and quote accordingly.

The tenderer can ask for clarifications, if any, by giving their queries in writing on or before pre bid meeting. Verbal queries shall not be considered.

1. QUALITY ASSURANCE AND QUALITY CONTROL

1.1. GENERAL

Some of the tests and procedures related to the specific works related to this Contract are laid out here and shall be applicable for this Contract. They shall be in general as an additional stipulation to the QA/QC manual and will not reduce the requirements stipulated in the Manual. The various tests stipulated below will be conducted on the following frequencies and the test report format and other details will be followed as per the QA/QC Manual.

1.1.1.Civil Engineering Works:

1.1.2.Supply of Material

The tests on the construction material received on site shall be carried out as follows:

Procedures for Testing Materials on Site

CEMENT			**QC-M-01**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Normal consistency	TC-M-01-01	One for each source and when called for by the Engineer	On receipt of material at site and before using as directed by the Engineer. Test certificate to be produced to the Engineer before use.
2	Fineness	TC-M-01-01		
3	Setting time – Initial / final	TC-M-01-01		
4	Compressive strength - 72 hrs, 168 hrs, 672 hrs.	TC-M-01-01		
For sulphate resistant cement as per IS-12330 OPC 43/53 shall conform to IS 8112/ 12269 and both 56 and 90 days strength shall be tested.				

SAND			**QC-M-02**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Sieve analysis	TC-M-02-01	One test for 15 m^3	On receipt at site and test certificate to be produced to the Engineer before use.
2	Fineness modulus	TC-M-02-01	One test for 15 m^3	
3	Deleterious constituents	TC-M-02-01	One test for 15 m^3	
4	Bulking test	TC-M-02-01	One test per Source	

WATER FOR CONSTRUCTION WORKS			**QC-M-03**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Alkalinity and acidity as per IS-3025	TC-M-03-01	Once per source of supply and when called for by the Engineer	Before use of water from that source
2	Solids	TC-M-03-01		

BRICKS			QC-M-04	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength	TC-M-04-01	One test per 50,000 bricks or part thereof	On receipt at site
2	Physical properties	TC-M-04-01		
3	Water absorption test	TC-M-04-01		

SIZE STONE			QC-M-05	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Water absorption test	TC-M-05-01	One test per source and when called for	On receipt at site
2	Dimension check	Lab format	As directed by the Engineer	
3	Type of rock	Lab format		

COARSE AGGREGATE FOR CONCRETE			QC-M-06	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Aggregate Impact or Los Angeles Abrasion Value as per IS-2386 Part-IV	TC-M-06-01/1 TC-M-06-01/2	One for each source of supply and when called for by the Engineer	On receipt of material at site
2	Soundness as per IS-2386 Part-V	TC-M-06-02		
3	Alkali Aggregate Reactivity as per IS-2386 Part-IV	Lab Format		
4	Flakiness Index	TC-M-06-03		
5	Gradation by wet sieve analysis	TC-M-06-04		
6	Water Absorption	TC-M-05-01		
When required, the Contractor shall furnish the mix design along with material properties at least 15 days in advance.				

SOIL/EARTH/SUB-GRADE MATERIAL			QC-M-07	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Swelling index IS 2720 part XL	TC-M-09-01	Two sets for 3000 m^3 or part thereof	On receipt at site
2	Liquid limits and plasticity index	TC-M-09-02		
3	Deleterious material IS 1498	Lab format		
4	OMC and MDD Test	TC-M-09-03		
5	Chemical properties	Lab format		
6	Grain Size Distribution Graph (by wet sieve analysis)	TC-M-09-04		
7	Void ratio gradation	Lab format		
8	Soaked CBR test (optional)	TC-M-07-01	Two sets for 3000 m^3 or part thereof and as directed by the Engineer	

GRANULAR SUB-BASE MATERIAL			QC-M-08	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	California Bearing Ratio Test	TC-M-07-01	As required	On receipt at site
2	Material combinations	Daily log		
3	Moisture content as per IS-2270	TC-M-07-02	1 test per 250 m3 or part thereof	Prior to compaction
4	Fineness value BS 812 Part III	Lab format	As required	On receipt at site
5	Soundness of material	TC-M-06-02		
6	Air voids content	Lab format		
7	Gradation by wet sieve analysis	TC-M-06-04	1 test per 200 m3 or part thereof	
8	Atterberg limits	TC-M-09-02		
9	Deleterious constituents	Lab format		
10	OMC and MDD	TC-M-09-03		
The Contractor shall furnish the GSB design mix along with material properties and test results at least 15 days before laying GSB at site.				

MATERIAL FOR WBM			QC-M-09	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Aggregate Impact Value	TC-M-06-01/1	One test for 200 m^3	On receipt at site
2	Grading by wet sieve analysis	TC-M-06-04	One test for 100 m^3	
3	Flakiness Index and Elongation Index	TC-M-06-03	One test for 200 m^3 of aggregate	
4	Atterberg limits of binding material	TC-M-09-02	One test for 25m^3 of binding material	
5	Atterberg limits of portion of aggregate passing 425 micron sieve.	TC-M-09-02	One test for 100 m^3 of aggregate	
6	Water Absorption Test	TC-M-05-01	Initially one set of 3 representative specimen for each source of supply and subsequently, when warranted by changes in the quality of aggregate	
7	Soundness Test	TC-M-06-02	One for each source of supply and when called for by the Engineer	On receipt at site and when absorption value is more 2%

METAL FOR BM / DBM / BC / SURFACE DRESSING / MSS / PRE-MIX CARPET			QC-M-10	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Aggregate Impact Value	TC-M-06-01/1	One test for 50 m^3 of aggregate or part thereof	On receipt at site and before using in the hot mixing
2	Flakiness Index and Elongation Index of aggregates	TC-M-06-03		
3	Water absorption of aggregates	TC-M-06-06	Initially one set of 3 representative specimen for each source of supply and subsequently, when warranted by changes in the quality of aggregate	
4	Stripping value	TC-M-11-01		
5	Gradation by wet sieve analysis	TC-M-06-04	As directed by the Engineer for individual component and for combined coarse, fine aggregate and filler.	

METAL FOR BM / DBM / BC / SURFACE DRESSING / MSS / PRE-MIX CARPET			QC-M-10	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
6	Soundness Test	TC-M-06-02	One for each source of supply and when called for by the Engineer	On receipt at site and when absorption value is more than 2%
For DBM and BC, the Contractor shall furnish the material properties and proposed job mix formula at least 20 days in advance.				

BINDER FOR WBM			QC-M-11	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Atterberg Limit Test	TC-M-09-02	One test for 100 m^3 of binding material	On receipt at site

FINE AGGREGATE FOR DBM/BC			QC-M-12	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Passing 2.36 mm sieve and retained on 75 micron sieve	Daily log	As directed by the Engineer	Before use
2	Deleterious matter	Daily log	Visual observation of lot before use	

BITUMEN			QC-M-13	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Grade of bitumen as directed/defined (Penetration Test)	TC-M-10-01	Two samples per test subject to all or some tests as directed by the Engineer	On receipt of material at site before unloading from the truck
2	Ductility Test	TC-M-10-02		
3	Flash and Fire Point Test	Lab format		
4	Viscosity Test	Lab format		
5	Softening Test	Lab format		

1.1.3.General Civil Engineering Works:

The general civil engineering works will be subjected to a check frequency as follows:

Table : Procedures for Testing General Civil and Structural Works

Embankment Formation			**QC-G-01**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Moisture content as per IS-2720	TC-M-09-03	One test for each 250 m^3 of soil	In-process
2	Field density test as per IS-2720	TC-M-09-03	5-10 density tests for each 1000 m^2 compacted area, or as directed by Engineer	
3	Compaction	Daily log	As per required number of passes	While compacting

Excavation/Backfilling			**QC-G-02**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Layout, slopes of excavation, benching and over-burden	Daily log	As directed by the Engineer	After excavation
2	Sub-soil water, shoring and strutting	Daily log		
3	Bottom levels and compaction	Daily log		
4	Soil classification	Daily log		
5	Backfilling and compaction	Daily log		After backfilling

Concreting			QC-G-03	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-516	TC-G-01-01	One test for 1-5 m^3 of concrete Two tests for 6-15 m^3 of concrete Three tests for 16-30 m^3 of concrete Four tests for 31-50 m3 + one set every 50 m^3 of additional concrete work.	Test samples to be taken while pouring. Testing to be done as specified in Contract.
2	Slump test per IS-1199	TC-G-01-02	Random checks throughout concreting as directed by the Engineer	Before pouring concrete
3	Inspection of steel reinforcement placement and bending, and formwork	Daily log	Before pouring concrete	Before pouring concrete
4	Concrete Pour Report	TC-G-01-03	When pouring is done	Immediately after pouring

Mortar			QC-G-04	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-2250	TC-G-01-01	One sample for every 2 m^3 of mortar subject to a minimum of three samples for a day's work	Test samples to be taken while before mortaring. Testing to be done as specified in Contract.
2	Consistency as per IS-2250	TC-G-02-01		

1.1.4.Pipe Line and Water Retaining Works:

The general pipe line works and water retaining works will be tested as follows:

Table : Procedures for Testing Pipeline Works and Liquid Retaining Structures

Earth Bedding			QC-P-01	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Moisture content as per IS-2720	TC-M-09-03	One test for each 250 m3 of soil	In-process
2	Field density test as per IS-2720	TC-M-09-03	One test for each 100 m^2 of compacted area	

Concreting			**QC-P-02**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-516	TC-G-01-01	One test for 1-5 m^3 of concrete Two tests for 6-15 m^3 of concrete Three tests for 16-30 m^3 of concrete Four tests for 31-50 m3 of concrete + one set every 50 m^3 of additional concrete work.	Test samples to be taken while pouring. Tests to be done as specified in the Contract.
2	Slump test per IS-1199	TC-G-01-02	Random checks throughout concreting period as directed by the Engineer	Before pouring concrete
3	Steel reinforcement placement and bending	Daily log	Before pouring concrete	Before pouring concrete
4	Concrete Pour Report	TC-G-01-03	When pouring is done	Immediately after pouring

Mortar			**QC-P-03**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Compressive strength as per IS-2250	TC-G-01-01	One sample for every 2 m^3 of mortar subject to a minimum of three samples for a day's work	Test samples to be taken while placing. Tests to be done as specified in the Contract.
2	Consistency as per IS-2250	TC-G-01-02		

Completion of Pipeline Laying and Jointing			**QC-P-04**	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Hydrostatic test for NP pipes	TC-P-04-01	One test for defined stretch	On completion of stage
2	Hydrostatic test for pressure pipes	TC-P-04-02	One test for defined stretch	On completion of stage

Completion of Manhole/Valve Chamber			QC-P-05	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Leakage Test	TC-P-05-01	100% inspection	On completion of stage

Completion of Liquid Retaining Structures			QC-P-06	
Sl. No.	**Type of Test**	**Test Report Format No.**	**Frequency of Test**	**Timing of Test/ Inspection**
1	Water tightness for underground structures	TC-P-06-01	One test per structure	On completion of stage
2	Water tightness for elevated structures	TC-P-06-02	One test per structure	

1.1.5.Materials, Plant and Equipment:

1.1.5.1. EXTENT AND PROCEDURE FOR SUBMISSION FOR PRE CONSTRUCTION TESTING AND REVIEW DATA:

All goods and materials to be incorporated into the Works shall be new, unused, of the most recent or current models, and shall incorporate all recent improvements in design and materials.

The Contractor shall place orders for the material and the equipment only after approval of the Employer's Representative. The Contractor shall submit the detailed drawings from the approved manufacturer and the procedure of submission, review and revision shall be as specified in different clause of tender document.

1.1.5.2. WORKS TESTS

These shall be as per applicable IEC/BIS standards unless otherwise detailed in the technical requirements. The results of all works tests shall be recorded and submitted to the Employer's Representative no later than the date of delivery of ex-works.

1.1.5.3. SCOPE OF INSPECTION

The test equipment, meters, instruments, etc. used for testing shall be calibrated at recognized test laboratories at regular intervals and valid certificates shall be made available to the Employer's representative at the time of testing. The calibrating instruments used as standards shall be traceable to International standards.

All type (as applicable), routine and acceptance tests shall be conducted in the presence of Employer/ Employer's Representative / Third Party Inspector on all the equipment as per latest applicable IS/IEC at no extra cost. Any modification / revision in the equipment as required by the Inspector shall be carried out by the Contractor without any extra cost. All such costs / fees for revisions / modifications shall be deemed to be included in the prices of supply of equipment as quoted by the Contractor. Typical type test reports for other equipment shall be submitted by the Contractor for approval by Employer.

1.1.5.4. DISPATCH

The Plant / accessories shall not be shipped / dispatched unless shipping release from Employer / Employer's Representative is issued subsequent to acceptance of test results.

1.1.5.5. PACKING AND SHIPPING

Any items liable to be damaged in transit shall be effectively protected and securely fixed in their cases. All cases shall be marked to show where slings should be placed.

All cases shall be clearly identified giving particulars of manufacturer's name and type of equipment. All identification marks on the outside of cases shall be waterproof and permanent. All electrical equipment shall be adequately sealed and desiccating agents shall be used where necessary to prevent damage from condensation. All equipment shall be packed and protected, bearing in mind that it will be shipped to a harsh environment, that a considerable period may elapse between its arrival on site and it's unpacking and that covered storage may not always be possible.

All wood and other materials used in packing cases shall be insect free. Adequate protection and precautions shall be taken to exclude termites and other vermin, noxious insects, larvae or fungus from the packing materials or plant. All contents shall be clearly marked for easy identification against the packing list.

The Contractor shall protect all steelwork before shipment, to prevent corrosion and / or damage. Bundles of steel sections shall be properly tied together by an approved method and care shall be taken to ensure that they are robust and that they can be handled easily during shipment.

Bolts and nuts shall be double bagged and crated for shipment. Crating of dissimilar metals is not acceptable.

Packing cases where used, shall be strongly constructed and in no case shall timber less than 25 mm in thickness be used. The contents of packing cases shall be securely bolted or fastened in position with struts or cross battens. Cross battens supporting weight in any direction shall not rely for their support on nails or screws driven lengthwise into the grain of the wood, but shall be supported by cleats secured from inside.

1.1.5.6. LABELS

All equipment / components / parts shall be provided with labels or name plates, giving a description of the equipment, together with information regarding the rating, nominal voltage, nominal current and the like under which the item of plant in question has been designed to operate. The labels shall be permanently attached in a conspicuous position. Where this is not practicable, such labeling shall be provided on packaging to the Employer's Representative approval.

Labels shall be made of non-rusting metal. Labels shall have white letters on black or dark blue background. The lettering size shall be 6 mm for panel designation and minimum 3 mm for device labels. The label inscriptions shall be subject to the Employer's approval.

Each item shall be clearly and permanently labeled on the outside of its container with its description and purpose. When several items are packed in one case, a general description of the contents shall be given on the outside of the case. Spare parts shall not be shipped in the same cases as components, which are used for erection. The cases shall be clearly labeled to indicate that they contain spare parts or tools and each spare part tool or appliance shall be clearly marked with its size and purpose.

1.1.5.7. QUALITY ASSURANCE

The Bidder shall submit in the bid an outline of the quality assurance practices that will be applied to all aspects of the manufacturing, installation and commissioning process.

The Contractor shall submit a detailed Quality Assurance Manual, which conforms generally to the requirements of ISO 9002. Approval to proceed with manufacture of equipment within this Contract will not be given until this Quality Assurance Manual and drawings of the equipment / systems has been received and approved by the Employer's Representative. Delays to the Contract completion date due to non-compliance with this requirement will be the Contractor's responsibility.

Major features of the Quality Assurance Scheme practiced by the Contractor and detailed in his Quality Assurance Manual shall include:

a) The Contractor has defined all staff responsibilities and the QA systems operating within the organization for the purpose of ensuring adequate quality of the end product
b) Regular and systematic programs of testing are carried out for all incoming raw materials.
c) Regular calibration checks are carried out on all measuring equipment used in the manufacturing operations
d) All production operations and test functions are properly documented and available to any relevant member of the Contractor's workforce.
e) All checking activities, test results, etc. are recorded on appropriate standardized forms and these are verified, certified, recorded and filed in a systematic manner.
f) A detailed inspection and test plan is prepared for the whole manufacturing operation.
g) Statistical analyses are carried out regularly on appropriate test results to confirm that all processes are performing within the specified tolerances
h) Adequate procedures are planned for corrective action in the event that quality checks show that performance is not satisfactory.
i) The Contractor has a senior officer with the authority to resolve matters of quality to the satisfaction of the Employer's Representative.
j) The Contractor has adequate facilities under the control of properly trained staff to perform the quality control duties.

The Contractor shall inform the Employer's Representative about the likely dates of manufacturing, testing, and dispatching of any material and equipment to be incorporated into the Permanent Works. The Contractor shall notify the Employer's Representative for inspection and testing, at least twenty-eight (28) days prior to packing and shipping and shall supply the manufacturer's test results and quality control certificates. The Employer's Representative will decide whether he or his representative will inspect and test the material / equipment or whether he will approve it on the basis of the manufacture's certificate.

The following inspection and test categories shall be applied prior to delivery of the equipment, of various categories as indicated in the technical specifications for each type of the equipment:

Category A: -The drawing has to be approved by the Employer's Representative before manufacture and testing. The material has to be inspected by the Employer's Representative or a third party inspecting agency approved by the Employer's Representative at the manufacturer's premise before packing and dispatching. The inspection charges of the agency will be borne by the Employer. Initially the Contractor will deposit the inspection charges and same shall be reimbursed by the Employer's Representative. The Contractor shall provide the necessary equipment and facilities for tests and the cost thereof shall be borne by the Contractor.

Category B: - The drawings of the equipment have to be submitted and approved by the Employer's Representative prior to manufacture. The material has to be tested by the manufacturer and the manufacturer's test certificates are to be submitted and approved by the Employer's Representative before dispatching of the equipment. Not withstanding the above, the Employer's Representative, after examination of the test certificates, reserves the right to instruct the Contractor for retesting, if required, in the presence of the Contractor's representative.

Category C: - Samples of the materials and/or equipment shall be submitted to the Employer's Representative for pre-construction review and approval in accordance with the provisions of Sub-Clause mentioned tender document. Following approval by the Employer's Representative, the material may be manufactured as per the approved standards and delivered to the Site.

1.1.5.8. CONDITIONS FOR SUPPLY AND INSPECTIONS:

For material/equipment under Category "A" and "B", the Employer's Representative will provide an authorization for packing and shipping after inspection.

The testing and approval for dispatching shall not absolve the Contractor from his obligations for satisfactory performance of the System.

The Employer or his duly authorized representative shall have access to the Contractor/Manufacturer's premises at suitable time to inspect and examine inspections (including testing for chemical analysis and physical properties) the material and workmanship of the material, plant and equipment during manufacture. The Contractor will be responsible for obtaining permission for such at the manufacture's premise if he is himself not the manufacturer as if he was himself the manufacturer. The testing will be carried out by the Contractor/Manufacturer 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. The Contractor shall forward to the Employer 3 Nos. duly certified copies of the Test Certificates and Characteristics Performance Curves for all Equipment.

If any material or any part of the works fails to pass any inspection/test, the Contractor shall either rectify or replace such materials or part of the works and shall repeat the inspection and/or test upon giving a notice. Any fault or short coming found during any inspection or test shall be rectified to the satisfaction of the Employer's Representative without any extra cost before proceeding with further inspection or wiring of that item. Any circuit previously tested, which may have been affected by the rectifications work shall be retested.

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.

Neither the Inspection / Testing of the material or any part of the works, nor the attendance by the Employer's Representative(s), nor the issue of any Inspection Test Certificate shall relieve the Contractor from the responsibilities under the Contract.

The Test Equipment, Meters, Instruments etc., used for testing shall be calibrated at Recognized Test Laboratories at regular intervals and valid certificates shall be made available to the Employer's

Representative at the time of testing. The calibration instruments used as Standard shall be traceable to National/International Standards. The calibration certificates for the test instruments shall be produced for Employer's Representative consent in advance of testing and if necessary instruments shall be recalibrated or substituted before the commencement of the test.

1.1.5.9. CATEGORY OF INSPECTION

The categorization of the various material, equipment and plant for purpose of inspections is as below. However this list can be altered and additions or subtractions done or categories changed in due course during the implementation of the Contract by the Employer's Representative.

1.1.5.9.1. Mechanical and Instrumentation Work

Sr. No.	Items	Category of Inspection
A)	**Mechanical Works**	
1.	Sewage pumps	Category A
2.	Sluice Valves with / without Actuators	Category A
3.	Butterfly valve with the actuator	Category A
4.	Non-Return Valves	Category A
5.	Pipe work above 300mm	Category A
6.	Sluice gates	Category A
7.	E.O.T Crane	Category A
8.	Air vessel and Pressure Filter	Category A
9.	Air compressor	Category A
10.	Chlorinator	Category A
11.	Motor above 90kW	Category A

Sr. No.	Items	Category of Inspection
12.	Motor below 90kW	Category B
13.	Cooling water pumps	Category B
14.	Lubricating water pumps	Category B
15.	M.O.T Crane	Category B
16.	Blower	Category B
17.	Metallic bellows, Expansion Joints and Dismantling joints	Category A
18.	Air washers	Category B
19.	Air Valves	Category B
20.	Drain and dewatering Pump sets	Category B
21.	Pipe Work 300mm and below	Category B
22.	Exhaust Fans	Category B
23.	Portable Fire Extinguisher	Category B
24.	Air Conditioners	Category B
B)	**Instrumentation Works**	
1.	Instrument Control Panel for RWPS comprising of PLC system, digital indicators, digital flow indicator and integrator, alarm annunciator, pushbuttons etc.	Category A
2.	Instrument Control Panel for CWPS comprising of PLC system, digital indicator, alarm annunciator, pushbuttons etc.	Category A
3.	Instrument Control Panel for Water Treatment Plant along with PLC System.	Category A
4.	Local SCADA Systems (Integrated testing with PLC system) for RWPS and for CWPS.	Category A
5.	Temperature scanners	Category A
6.	Flow switches	Category A
7.	Digital panel meters	Category A
8.	Conductivity level switches	Category A
9.	Control panel for surge protection system	Category A
10.	Filter consoles	Category A
11.	Full Bore Electromagnetic Flow meters	Category A
12.	Clarifier and dosing control panel	Category A
13.	Pressure Switches	Category B
14.	Differential pressure switches	Category B
15.	Ultrasonic type level measuring systems	Category B
16.	Ultrasonic flow meter	Category B
17.	Float type Level Switches	Category B
18.	Instrumentation and Control cables	Category B
19.	Battery and Battery Charger Panel	Category B

Sr. No.	Items	Category of Inspection
20.	Surge Protection Devices	Category B
21.	Radar type level meter	Category B
22.	Pressure transmitter	Category B
23.	Flow indicator and integrator	Category B
24.	Alarm Annunciator	Category B
25.	Motorised Actuators for valves	Category B
26.	Chlorine dosing control panel	Category B
27.	Open channel flow meter	Category B
28.	Turbidity meters	Category B
29.	Residual chlorine meter	Category B
30.	PH meter	Category B
31.	Laboratory instruments and equipment	Category B
32.	Pressure Gauges	Category B
33.	Portable temperature monitor	Category B
34.	Portable sound level meter	Category B
35.	Portable vibration meter	Category B

1.1.5.10. ELECTRICAL WORKS

Sr. No.	Items	Category of Inspection
1.	HV Outdoor Current Transformer	Category A
2.	HV Outdoor Switch Disconnector/ Isolator	Category A
3.	/HV Outdoor Lightning Arrester	Category A
4.	Gantry/ Structure for Switchyard/ Transmission Line	Category A
5.	Transformer (including OLTC, RTCC panel)	Category A
6.	MV and LV Capacitors and APFC Panel	Category A
7.	HV, MV and LV switchboards	Category A
8.	LV Variable Frequency Drive	Category A
9.	Reactance Starter for MV motors	Category A
10.	Battery and Battery Charger and DCDB	Category A
11.	EPABX System	Category A
12.	Cathodic protection- Transformer/ Rectifier (T/ R) units	Category A
13.	Outdoor 33kV accessories for substation (i.e. Fuse, ACSR Conductor, Clamps and connectors, hardwares,	Category B
14.	Cathodic Protection equipment other than T/ R units	Category B
15.	Neutral Grounding Resistor	Category B
16.	Sub-Distribution Boards, Lighting Panels	Category B
17.	Lighting System	Category B
18.	VHF Communication System	Category B
19.	UPS System	Category B
20.	HV, MV and LV Power and Control Cables	Category B
21.	MV/LV Cable Termination	Category B
22.	Laptop Computers	Category B
23.	Printers	Category B
24.	Earthing System	Category B
25.	Local Push Buttons	Category C
26.	Cable tray and accessories	Category B

1.1.5.11. ELECTRO MECHANICAL (INDICATIVE QA/QC PLAN)

Sr. No.	Material/ Equipment	Tests/ Frequency of test	Size of Sample	Authority to conduct test	Witness to test	Location of conducting test- manufacturer's place/ Site/ laboratory	Remarks
1	Raw water/ Clear water / Back wash pumps	Material test certificate	100%	Manufacturer	Record verification	Manufacturers works/ Laboratory	
		Dynamic balancing	100%	Manufacturer	Record verification	Manufacturers works	
		NDT/ Surface finish on shaft and impeller	100%	Manufacturer	AMC	Manufacturers works/ Laboratory	
		Hydro test of casing	100%	Manufacturer	Record verification	Manufacturers works	
		Performance test	100%	Manufacturer	AMC	Manufacturers works	BS 5316 Part 2
2	Valves- Sluice/ Butterfly/ Non return	Material test certificate	100%	Manufacturer	AMC	Manufacturers works/ Laboratory	
		Hydro test	100%	Manufacturer	AMC	Manufacturers works	BS 5150/ BS EN 593/ API 594
3	EOT Crane	Material test certificate	100%	Manufacturer	AMC	Manufacturers works/ Laboratory	
		Load test	100%	Manufacturer	AMC	Manufacturers works	IS 3177
4	Surge vessels / Pressure filters	Material test certificate	100%	Manufacturer	Record verification	Manufacturers works/ Laboratory	
		Welding qualification		Manufacturer	Record verification	Manufacturers works	
		Heat treatment	100%	Manufacturer	Record verification	Manufacturers works	
		Hydro test	100%	Manufacturer	AMC	Manufacturers works	IS 2825
5	Piping above 300mm	Material test certificate	100%	Manufacturer	Record verification	Manufacturers works/ Laboratory	

Sr. No.	Material/ Equipment	Tests/ Frequency of test	Size of Sample	Authority to conduct test	Witness to test	Location of conducting test- manufacturer's place/ Site/ laboratory	Remarks
		Hydro test	100%	Manufacturer	AMC	Manufacturers works	IS 3589
6	Expansion bellow/ Dismantling joint	Material test certificate	100%	Manufacturer	Record verification	Manufacturers works	
		Hydro test	100%	Manufacturer	AMC	Manufacturers works	
ELECTRICAL							
1	Transformers	Temp. rise test	100%	Manufacturer	AMC	Manufacturers works	
		One minute power frequency withstand voltage	100%	Manufacturer	AMC	Manufacturers works	
		Impulse voltage withstand	100%	Manufacturer	AMC	Manufacturers works	
		Measurement of resistance of windings	100%	Manufacturer	AMC	Manufacturers works	
		Measurement of no load current, losses	100%	Manufacturer	AMC	Manufacturers works	
		Measurement of load losses	100%	Manufacturer	AMC	Manufacturers works	
		Measurement of efficiency and regulation	100%	Manufacturer	AMC	Manufacturers works	
		Magnetic balance test	100%	Manufacturer	AMC	Manufacturers works	
		Separate source voltage withstand	100%	Manufacturer	AMC	Manufacturers works	
		Test on OLTC	100%	Manufacturer	AMC	Manufacturers works	
		Test on RTCC	100%	Manufacturer	AMC	Manufacturers works	

Sr. No.	Material/ Equipment	Tests/ Frequency of test	Size of Sample	Authority to conduct test	Witness to test	Location of conducting test- manufacturer's place/ Site/ laboratory	Remarks
2	Switchboards HV/ MV/ LV	One minute power frequency voltage on main and aux. circuits	100%	Manufacturer	AMC	Manufacturers works	
		HV pressure test for CB	100%	Manufacturer	AMC	Manufacturers works	
		Milli- volt drop test for CB	100%	Manufacturer	AMC	Manufacturers works	
		Operation of closing and trip coils	100%	Manufacturer	AMC	Manufacturers works	
		Functionality checks	100%	Manufacturer	AMC	Manufacturers works	
		Primary injection test for CTs/ VTs	100%	Manufacturer	AMC	Manufacturers works	
3	MV Motors and LV Motors > 90kW	HV test	100%	Manufacturer	AMC	Manufacturers works	
		No load/ Full load test for efficiency, power factor and slip	100%	Manufacturer	AMC	Manufacturers works	
		Momentary overload	100%	Manufacturer	AMC	Manufacturers works	
		Over speed test	100%	Manufacturer	AMC	Manufacturers works	
		Locked rotor readings at reduced voltage	100%	Manufacturer	AMC	Manufacturers works	
		Test for vibration severity of motor	100%	Manufacturer	AMC	Manufacturers works	
4	MV/ LV Capacitors	Load test at 110% rated	100%	Manufacturer	AMC	Manufacturers works	

Sr. No.	Material/ Equipment	Tests/ Frequency of test	Size of Sample	Authority to conduct test	Witness to test	Location of conducting test- manufacturer's place/ Site/ laboratory	Remarks
		voltage					
		Leak proof ness test	100%	Manufacturer	AMC	Manufacturers works	
		Capacitor losses	100%	Manufacturer	AMC	Manufacturers works	
5	LV variable frequency drives	Efficiencies at various loads at different frequency levels	100%	Manufacturer	AMC	Manufacturers works	
6	Battery, Battery Charger	Capacity test	100%	Manufacturer	AMC	Manufacturers works	
		Test for voltage charging and discharging	100%	Manufacturer	AMC	Manufacturers works	
		Ampere- hour and watt- hour efficiency test	100%	Manufacturer	AMC	Manufacturers works	
7	Starters for MV Motors	Characteristics during starting and acceleration	100%	Manufacturer	AMC	Manufacturers works	
8	Transformer / Rectifier Unit	Efficiencies at 25%, 50%, 75% and 100% loads for Transformer/ Rectifier units and 100% rated current for transformer after isolating rectifier unit.	100%	Manufacturer	AMC	Manufacturers works	
		Ratio and polarity test at 25%, 50%, 75% and 100% rated for	100%	Manufacturer	AMC	Manufacturers works	

Sr. No.	Material/ Equipment	Tests/ Frequency of test	Size of Sample	Authority to conduct test	Witness to test	Location of conducting test- manufacturer's place/ Site/ laboratory	Remarks
		all T/ R units.					
		Insulation resistance test at 2kV between primary and secondary, primary and earth and secondary and earth	100%	Manufacturer	AMC	Manufacturers works	
		Electronic current control for supply voltage variation and load resistance from 25% to 100%	100%	Manufacturer	AMC	Manufacturers works	
		Electronic current limiting feature.	100%	Manufacturer	AMC	Manufacturers works	

1.1.6.1. MANUFACTURER'S WORKS ACCEPTANCE TESTS

The Contractor shall carry out further specified tests of Equipment as indicated in corresponding sub sections. Visual Inspection for all equipments shall cover:

- Material Certificates for all the specified material.
- Welding Qualifications
- Dimension Checking
- Stage Inspections (in process inspection)
- Dynamic balancing for all rotating parts
- Hydrostatic / Leak testing for all pressure parts, Pneumatic Leak Test wherever applicable
- Operation check
- Liquid penetrate tests or magnetic particle tests for all machined surfaces of pressure parts.
- Ultrasonic test for forging materials viz.,
- Plates of thickness 20mm and above for pressed / formed parts such as heads, etc.
- Plates, flanges and bars of thickness / dia. 40mm and above used for fabrication of pressure and load bearing members and rotating parts.
- Radiographic testing for all but welded parts, as per applicable codes.

- Hardness tests for all Hardened surfaces.
- Type, routine and acceptance test, as applicable

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.

Works Testing and Inspection shall be carried out at the manufacturer's works in accordance with the Specification. The Contractor shall in addition to any obligations under the Conditions of Contract inform the Engineer's duly appointed designated representative of the date when the Plant and Equipment will be ready for inspection and witness testing.

1.1.6.2. LABORATORY

The Contractor is required to establish a field laboratory for ensuring the timely inspection of the material and works. The laboratory will be equipped with testing facilities sufficient to cope with the requirements of the tests to be conducted on site. It should have at least the following equipment which may be supplemented with additional equipment as may be found necessary by the Employer's Representative/Contractor.

The Test Equipment, meters, instruments etc., used for testing shall be calibrated at Recognized Test Laboratories at regular intervals and valid certificates shall be made available to the Employer's Representative. The calibration certificates should be produced in advance for the approval of the Employer's Representative and if necessary they shall be got recalibrated or substituted before commencement of the tests.

List of Minimum Laboratory Equipment

S.No.	General
1.	Oven -Electrically operated, thermostatically controlled, range upto 2000°C sensitivity 1°C
2.	Platform balance 300 kg capacity
3.	Balance 20 kg capacity-self indicating type
4.	Electronic Balance 5 kg capacity accuracy 0.5 gm
5.	Water bath-electrically operated and thermostatically controlled with adjustable shelves, sensitivity 1°C
6.	Thermometers: Mercury-in-glass thermometer range 0° to 250°C Mercury-in-steel thermometer with 30 cm stem, range upto 300°C
7.	Kerosene or gas stove or electric hot plate
8.	Glasswares, spatulas, wire gauzes, steel scales, measuring tape, casseroles, karahis, enamelled trays of assorted sizes, pestle-mortar, porcelain dishes, gunny bags, plastic bags, chemicals, digging tools like pickaxes, shovels etc.
9.	Set of IS sieves with lid and pan: 450 mm diameter: 63 mm, 53 mm, 37.5 mm, 26.5 mm, 13.2 mm, 9.5 .mm, 6.7 mm and 4.75 mm size
10.	200 mm diameter: 2.36' mm, 2.0 mm, 1.18 mm, 600 micron, 425 micron, 300 micron, 150 micron, and 75 micron
11.	Water testing kit
12.	Hydrometer
13.	Gauges to measure diameter of pipe
14.	Total station equipment

S.No.	General
15.	Measuring tape, vernier scale, die for concrete cubes, vibrating platform, tools and tackles
16.	Core drilling equipment
17.	First aid box
	For soils and aggregates
1.	Riffle Box
2.	Atterberg Limits (liquid and plastic limits) determination apparatus
3.	Compaction Test Equipment both 2.5 kg and 4.5 kg rammers (Light and Heavy compactive efforts)
4.	Dry Bulk Density Test apparatus (sand pouring cylinder, tray, can etc.) complete
5.	Speedy Moisture Meter complete with chemicals
6.	Post -hole Auger with extensions
7.	Core cutter apparatus 10 cm dia, 10/15 cm height, complete with dolly, rammer etc.
8.	Aggregate Impact Value Test apparatus/Los Angeles Abrasion Test apparatus
9.	Flakiness and Elongation Test Gauges
10.	Standard measures of 30, 15 and 3 liters capacity along with standard tamping rod
11.	California Bearing Ratio test apparatus
12.	Unconfined compression test apparatus
	For Cement and cement concrete
1.	Vicat apparatus for testing setting times
2.	Slump testing apparatus
3.	Compression and Flexural strength testing machine of 200 tonne capacity with additional dial for flexural testing
4.	Needle Vibrator and plate vibrators
5.	Air Meter
6.	Vibrating hammer for vibrating dry mix as for Dry Lean Cement concrete sub-base
	For M.S. Pipe
1.	Ultrasonic Test Equipment
2.	Radiographic Test Equipment
3.	Coating, Lining Thickness Checking Equipment
4.	Holiday Checking Equipment
5.	Ultra sonic gauges for thickness measurement of coating, lining and MS Plate – 4 Nos.
6.	Hydraulic Testing Equipments calibrated pressure gauge
	For Pumps
1.	Portable Temperature Measuring Equipment

S.No.	General
2.	Portable Sound Measuring Equipment
3.	Portable Vibration Measuring Equipment
4.	Illumination Measuring Equipment
5.	Portable Tachometer
	For Electrical Works
1.	-------- Volt Megger (hand driven)
2.	--------- KV Megger (Motorised)
3.	Earth Megger (Electrically Operated)
4.	Digital Multimeter
5.	Tongue Tester (with current and voltage measurement provisions)
6.	Insulating Oil tester
7.	Electronic Stop Watch
	For bitumen and bituminous mixes
1.	Penetrometer with standard needles
2.	Centrifuge type bitumen extractor, hand operated, complete with petrol/commercial benzene
3.	Marshall stability test apparatus, complete with all accessories
4.	Field density bottle along with cutting tray, chisel, hammer and standard sand
5.	3 m straight edge
6.	Camber board
7.	Core cutting machine with 10 cm dia diamond cutting edge
8.	Vacuum pump and 3 specific gravity bottles