

BIDDING DOCUMENT

National Competitive Bidding - NCB
(Two-Envelope Bidding Process with e-Procurement)



Engineering, Procurement and Construction (EPC)
Contract
For
Renovation and Modernization of Existing
Navigational Lock at Farakka,
West Bengal

VOLUME-2

TECHNICAL SPECIFICATIONS AND DRAWINGS

RFB: IN-IWAI-350002-CW-RFB

Issued on 8th May 2023

**Employer: Inland Waterways Authority of India,
Ministry of Shipping, Government of India
A-13, Sector -1, Noida**

Country: India

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1. GENERAL INFORMATION AND EMPLOYER'S REQUIREMENTS/ SCOPE OF WORK

1.1 General Information

1.1.1 Background

An efficient transport sector is vital for development of the economy of any country. In a large country like India, efficient transportation becomes pivotal to stimulate a competitive business environment. The Indian transport system comprises various types, viz. Railways, Roadways, Inland Waterways, Coastal Shipping and Airways.

Inland Water Transport (IWT) is a fuel efficient and cost-effective mode of transport having the potential to supplement the overburdened rail and congested roads. For this, however, it is necessary that IWT is developed with public funding at least to a threshold level, after which point it is expected that the private sector would see the transport method as a viable alternative and make further investment as required.

The Inland Waterways Authority of India (IWAI), an autonomous organization under the Ministry of Ports, Shipping & Waterways, Govt. of India was constituted in October 1986 for development and regulation of the inland waterways of the country. Waterways which have been declared as National Waterways (NWs) are developed, maintained and regulated by IWAI for shipping and navigation.

The Ganga – Bhagirathi – Hooghly River system from Haldia to Allahabad has been declared as National Waterway No. 1 in 1986 and since then various developmental activities on this waterway are under progress. A barrage has been constructed across river Ganga at Farakka to divert the water from Ganga to Bhagirathi through a feeder canal. The navigable

route through the main Ganga River up-stream to the river Bhagirathi downstream is facilitated by the Navigational lock at Farakka. The Feeder Canal of Farakka Barrage and the Navigational lock becomes the link between the main Ganga and Bhagirathi.

1.1.2 Navigational lock s at Farakka

- a. A barrage has been constructed across river Ganga at Farakka, to divert the water from Ganga to Bhagirathi through a feeder canal. The navigable route was facilitated by the Existing Navigational lock . The Feeder Canal of Farakka Barrage and the existing Navigational lock become the link between the main Ganga and Bhagirathi rivers.
- b. The existing Navigational lock was a part of Farakka Barrage Project (FBP) with the primary objective of improving the navigation facilities of river Hooghly and maintaining Kolkata Port. This Navigational lock was constructed and commissioned in the year 1987 at Farakka (in Murshidabad district in the state of West Bengal) to facilitate movement of inland vessels on National Waterway-1 (NW-1) through Feeder Canal. This existing Navigational lock along with all ancillary assets was taken over by the Inland Waterways Authority of India from FBP Authority in April 2018.
- c. In addition to the existing Navigational lock , the construction of a parallel New Navigational lock at Farakka is currently on-going and is expected to be functional soon.

The existing Navigational lock is an important part of NW-1 and the renovation of the same will help in improving the navigability of NW-1. Accordingly, the renovation & modernization of the existing Navigational lock is being undertaken by IWAI for further improve the navigability & capacity of NW-1.

1.1.3 Project Site Location

The Site is located at Farakka in Murshidabad district of West Bengal. An index map of the project area is shown in Figure 1.1 whereas Figure 1.2 and Figure 1.3 shows the various project components. Index plan of Farakka Navigational lock is shown in Drawing No. ENL001.

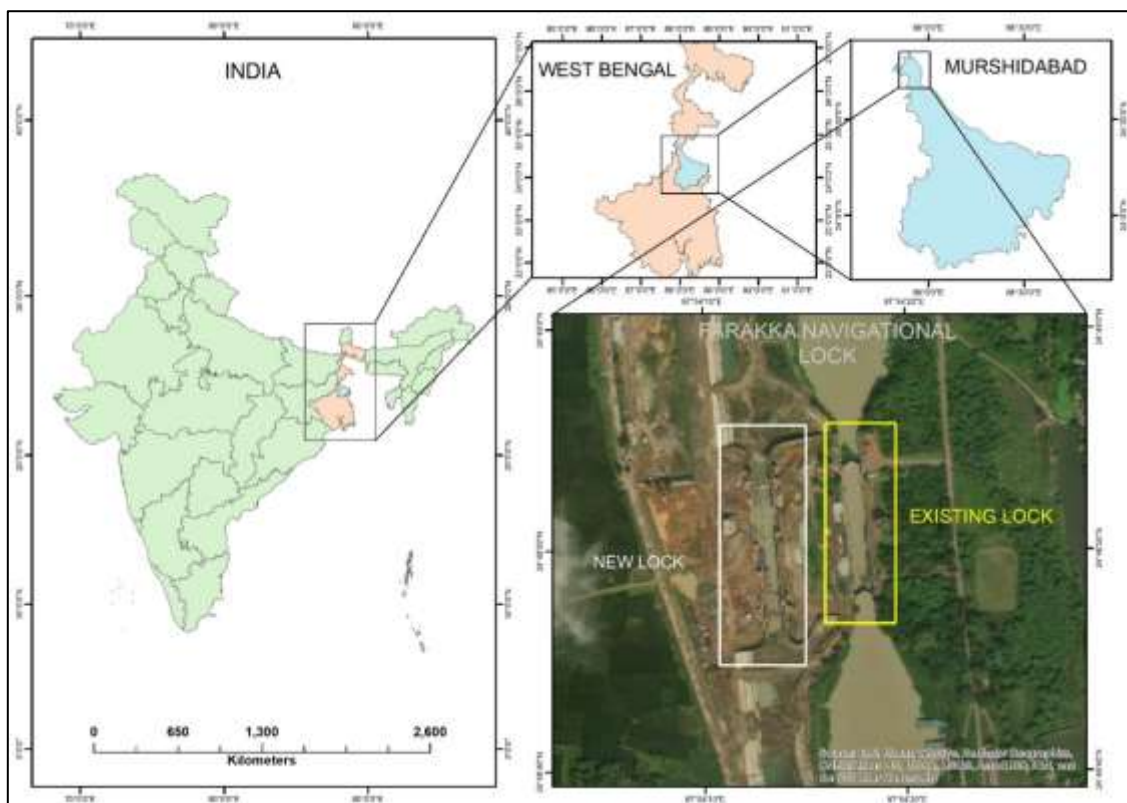


Figure 1.1 Index map of the project area with existing and new lock



Figure 1.2 Plan Map of Farakka Barrage and Navigational lock

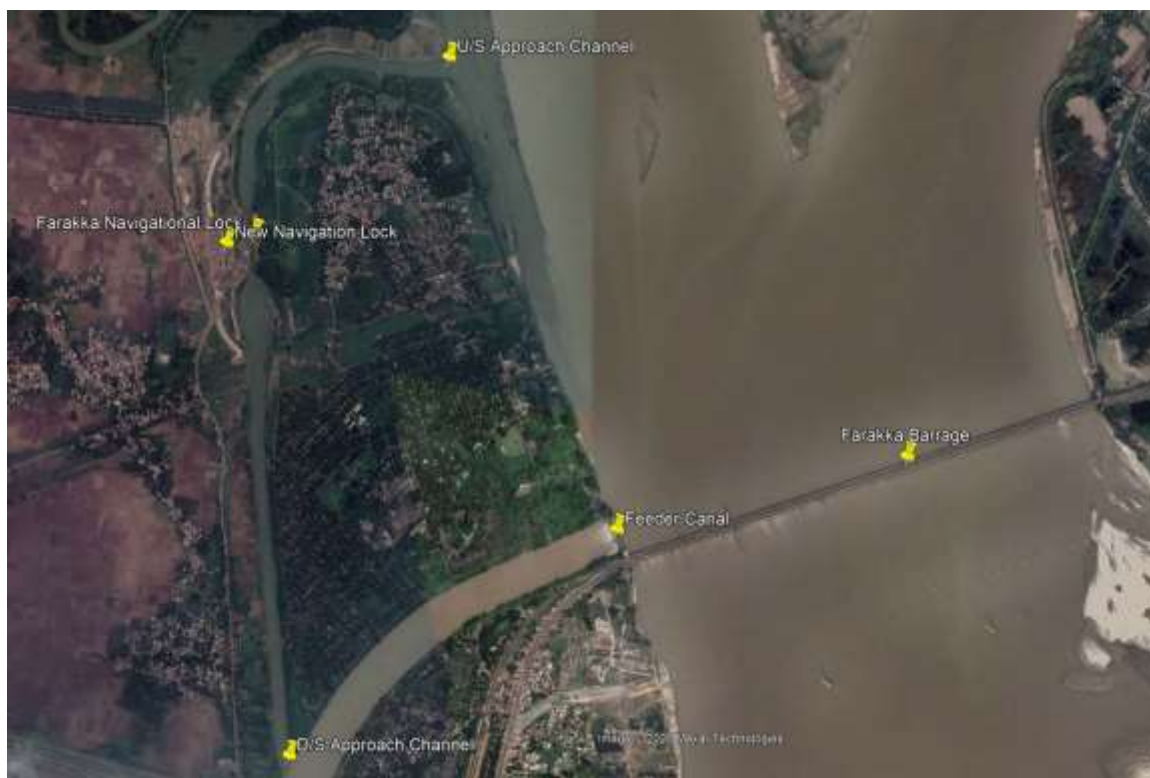


Figure 1.3 Close up view of Farakka Barrage, Feeder Canal and Locks

1.1.4 Existing Navigational lock

The existing Navigational lock is 179.8m long and 25.145m wide. It comprises of Mitre Gates, Radial Gates, Bollards, Caisson Gates/Stoplogs and Bulkhead Gates. Layout of the existing Navigational lock is given in Figure 1.4 and Drawing No. ENL003. The salient features of the existing lock are given in Table 1.1.

Table 1.1 Salient Features of Existing Navigational lock

S. No.	Parameter	Details
1	Number of Locks	One (1)
2	Length of lock	179.8m (b/w Mitre Gates) 250m (b/w Caisson Gates)
3	Width of lock	25.148m
4	Average depth of lock	12.89m at u/s to 10.89m at d/s
5	Major Structural Components	<ul style="list-style-type: none"> Base Slab, Retaining Walls & Guide Walls Filling / emptying Culverts including gate chambers Bollards – eight (8) numbers floating type (four (4) on each

		bank) and fourteen (14) numbers fixed type (seven (7) on each bank) <ul style="list-style-type: none"> 1 Central Control Room and 2 local control room
6	Major Hydro-mechanical Components	<ul style="list-style-type: none"> Mitre Gates – two (2) sets 1 on U/S and 1 on D/S end, having two (2) leaves per set, Caisson Gates/Stoplogs - 2 numbers (one (1) for u/s & one (1) for d/s) Radial Gates – four (4) numbers (two (2) for u/s & two (2) for d/s) Bulkhead Gates – eight (8) numbers (four (4) numbers for u/s and d/s each)

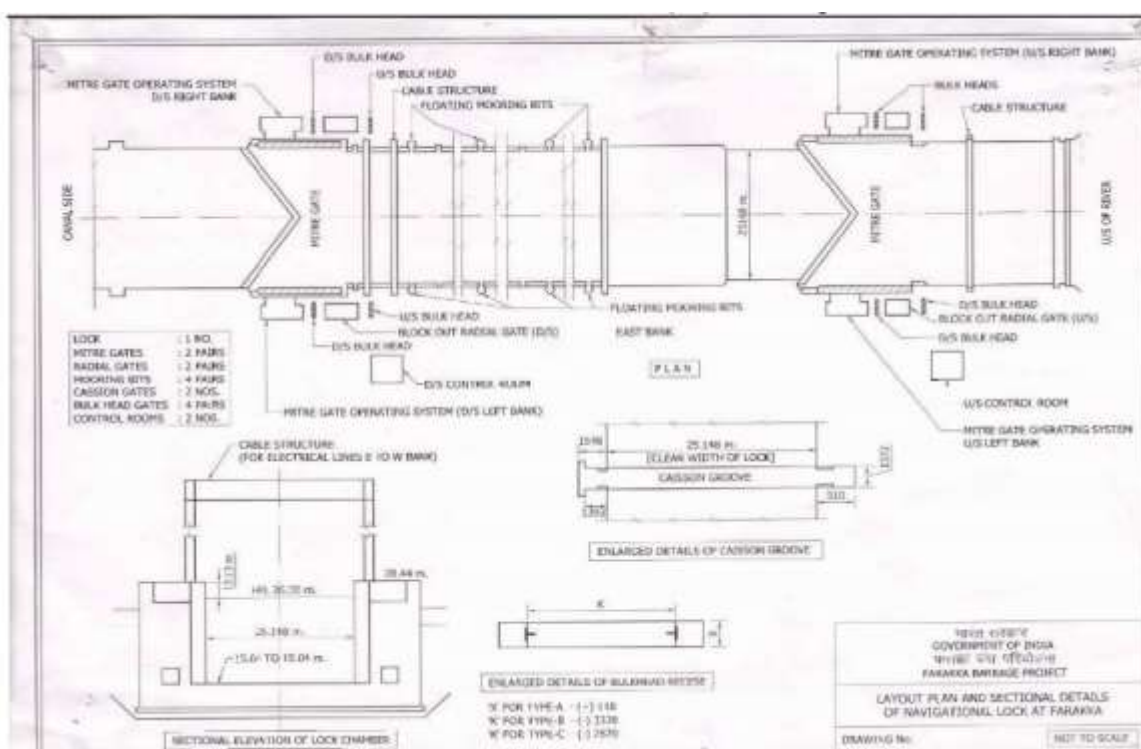


Figure 1.4 Layout of the existing Navigational lock

1.1.4.1 Operations system:

Caisson Gate: By filling up top buoyancy tanks from river water by gravity and draining the same from end tanks during floating operation through drain valve. Caisson gate shall be capable of being ballasted or de-ballasted in 30 minutes or less. Normal raising and sinking operation shall be carried out using suitable valve arrangement without the operation of pumps. However, for any emergency, provision

of pumping water from lower tanks to top tanks by means of electric driven submersible pumps shall be made.

Mitre Gate: To be operated through electro-hydraulic system to achieve opening and closing time preferably in 3 mins (not more than 5 mins).

Radial Gates: To be operated through electro-hydraulic system to achieve opening and closing time preferably in 1 min (not more than 2 mins).

Bulkhead Gates: To be operated by rope drum hoists.

1.1.5 Metrological Data

1.1.5.1 Rainfall

Gridded rainfall data has been collected from India Meteorological Department (IMD) for the project location between latitude and longitude of 24.75° N, 88° E and 24.75° N, 87.75° E. The data has been collected for a duration of 41 years from year 1980-2021. Average annual rainfall is around 1470 mm and the maximum rainfall occurs in the month of July which is of the order of 350 mm. The average monthly rainfall data from 1980-2021 is presented in Table 1.2 and plotted in Figure 1.5.

Table 1.2 Rainfall (mm) Data for the Project Site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1980	6.9	2.8	11.6	8.3	185.6	299.3	506.4	703.8	346.0	90.7	0.0	0.0	2161.2
1981	33.4	11.4	6.1	130.4	193.5	123.1	488.5	262.3	286.3	0.0	2.8	35.2	1572.7
1982	1.0	4.7	40.1	11.9	52.9	216.7	200.5	316.0	117.3	55.4	37.9	0.5	1054.7
1983	11.9	0.9	23.9	33.1	88.5	134.4	331.8	180.3	367.2	126.3	0.0	29.0	1326.9
1984	45.9	25.4	4.3	8.1	128.2	375.0	388.5	234.6	227.0	114.7	0.0	1.4	1552.8
1985	4.2	1.9	3.4	11.9	174.3	170.2	406.7	209.5	281.7	162.1	0.0	3.7	1429.4
1986	0.6	7.8	0.1	58.2	90.8	152.9	284.8	109.2	261.8	227.4	3.3	6.2	1202.9
1987	0.2	3.8	25.7	61.3	94.1	174.4	581.0	751.3	357.4	50.3	6.4	3.9	2109.4
1988	0.3	15.2	29.1	29.1	99.6	260.8	287.7	399.9	171.6	69.6	33.0	2.7	1398.3
1989	0.7	16.0	0.4	0.0	189.4	155.4	341.2	193.3	433.6	60.9	0.0	12.1	1402.8
1990	0.0	28.4	20.2	20.0	196.1	162.1	514.9	251.6	257.3	145.0	0.9	0.0	1596.2
1991	6.2	5.7	9.1	13.1	116.2	327.4	391.8	204.6	472.4	60.7	0.0	68.6	1675.6

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	0.0	14.3	1.5	4.7	84.1	161.9	458.5	237.2	200.2	75.1	9.0	0.6	1246.6
1993	21.0	1.8	21.7	67.7	71.1	340.6	236.2	385.2	396.9	67.0	37.4	0.0	1646.3
1994	21.9	20.6	0.0	13.2	27.4	240.6	171.9	200.3	150.3	131.9	0.0	0.0	977.9
1995	3.1	7.9	0.5	1.9	48.2	186.4	278.8	322.9	1020.3	9.1	58.8	8.1	1945.7
1996	10.3	10.4	0.4	15.1	29.6	248.0	303.0	513.7	277.9	70.0	0.0	0.0	1478.1
1997	23.3	9.4	8.3	77.9	109.5	242.3	387.5	510.3	270.1	29.8	14.2	32.8	1715.2
1998	7.6	11.1	61.9	45.7	141.5	143.7	568.1	359.1	324.4	226.2	20.5	0.0	1909.7
1999	0.0	0.0	0.4	5.7	108.3	308.1	489.5	566.6	541.6	172.9	0.6	0.0	2193.3
2000	4.1	36.2	26.6	111.4	181.5	327.5	264.9	176.1	635.2	25.9	0.0	0.0	1789.2
2001	0.3	0.0	1.5	16.9	185.7	272.8	221.8	230.6	259.7	209.9	0.0	0.0	1399.0
2002	10.9	0.6	2.9	88.1	104.1	195.5	259.3	358.2	329.9	54.8	9.3	0.0	1413.3
2003	1.0	52.7	30.8	14.5	136.8	309.7	194.3	176.1	210.7	258.5	0.0	2.0	1386.8
2004	19.0	0.0	2.0	44.7	62.7	346.7	332.7	215.2	130.7	485.9	0.0	0.0	1639.4
2005	15.6	3.8	52.1	17.2	96.6	87.1	571.4	329.9	163.3	154.8	0.0	0.0	1491.7
2006	0.0	0.0	4.3	67.6	99.1	204.3	239.8	247.3	488.2	67.8	11.3	0.5	1429.9
2007	0.0	42.7	44.2	0.4	85.8	275.2	549.3	235.7	272.2	51.5	0.9	0.0	1557.6
2008	43.3	1.9	5.0	21.0	40.1	392.8	416.3	292.5	216.9	34.6	0.0	0.0	1464.1
2009	0.8	5.3	0.9	0.2	227.4	73.4	298.9	463.4	157.5	276.7	2.4	0.0	1506.8
2010	0.0	1.8	0.1	30.9	168.8	187.4	151.1	113.8	239.4	106.3	9.6	9.5	1018.5
2011	0.0	0.5	0.1	9.0	43.0	79.0	473.0	308.2	323.8	18.6	0.3	0.0	1255.2
2012	6.6	0.1	1.4	70.1	26.6	128.1	299.3	160.7	164.3	88.4	39.2	0.0	984.6
2013	0.1	14.3	1.0	32.6	134.2	320.9	118.1	381.8	169.3	309.5	2.9	0.0	1484.5
2014	0.3	55.0	1.4	11.5	168.3	236.5	382.0	251.2	217.0	29.6	0.0	0.0	1352.6
2015	18.9	2.9	35.7	97.5	137.2	269.9	452.5	322.6	221.6	32.0	3.0	0.0	1593.5
2016	14.9	0.0	4.0	16.6	78.2	130.8	358.4	163.9	338.9	46.7	0.0	0.0	1152.2
2017	2.1	0.0	7.6	69.5	101.2	87.9	311.4	413.4	165.6	111.8	0.2	8.9	1279.4
2018	0.0	13.2	24.6	143.2	142.5	91.3	199.6	157.4	115.3	69.0	0.0	13.5	969.4
2019	0.0	33.0	2.1	65.4	113.1	65.9	333.7	148.5	269.4	174.4	0.0	1.3	1206.6
2020	9.2	13.2	55.7	74.3	170.9	329.4	263.0	197.1	272.7	89.2	0.1	0.0	1474.5
2021	0.0	0.0	1.9	6.9	356.1	252.0	233.3	272.9	112.5	83.6	0.0	6.3	1325.2
Average	8.2	11.3	13.7	38.7	121.1	216.3	346.2	298.3	291.3	112.5	7.2	5.9	1470.7

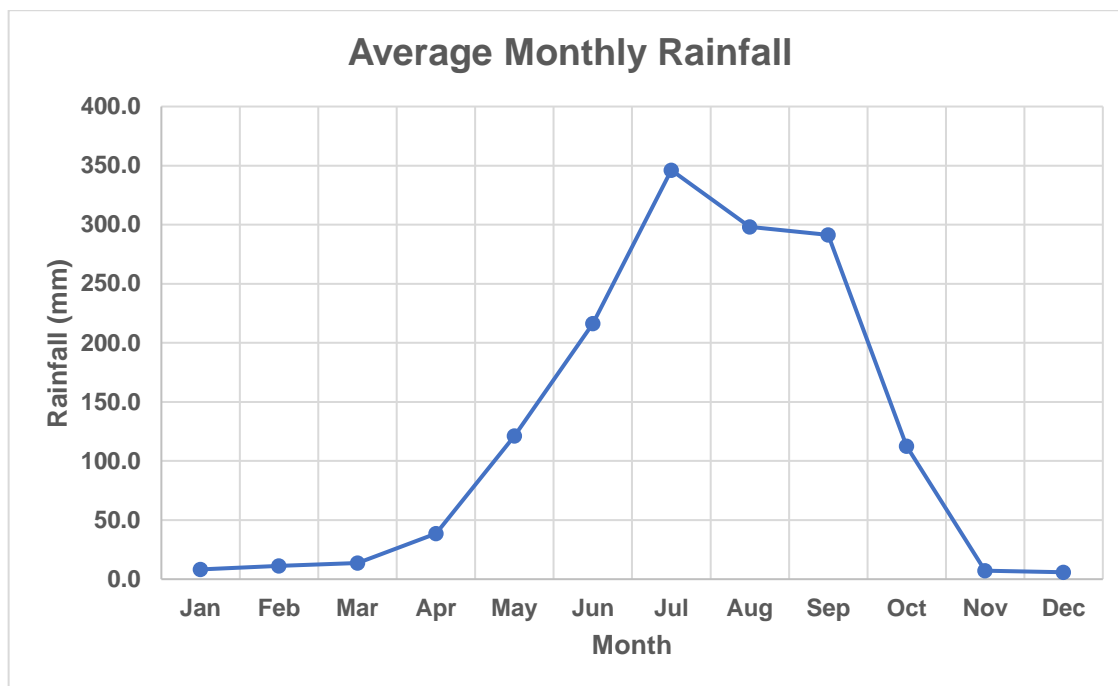


Figure 1.5 Average monthly rainfall distribution

1.1.5.2 Wind

Wind speed data at 2m above ground has been collected from NASA POWER LARC for the project location. The data has been collected for a duration of 40 years from year 1981-2021. Average annual wind speed at the project location is around 2m/s. The maximum wind speed occurs in the month of June i.e., 2.60 m/s. The average wind speed varies from 1.38 m/s to 2.60 m/s throughout the year. The average monthly wind speed from 1981-2021 is presented as tabulated in Table 1.3 & plotted in Figure 1.6.

Table 1.3 Wind speed (m/s) for the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	1.57	1.85	1.91	2.25	2.41	2.91	2.76	2.24	1.65	1.27	1.54	1.59	2.00
1982	1.60	1.95	1.90	2.03	1.98	2.66	2.51	2.92	1.95	1.30	1.42	1.61	1.98
1983	1.59	2.02	2.47	2.66	2.27	3.27	2.90	3.00	2.41	1.76	1.45	1.59	2.28
1984	1.77	2.18	2.11	2.05	2.55	3.11	2.52	2.56	1.77	1.48	1.52	1.52	2.09
1985	1.73	1.74	2.24	2.47	2.50	2.66	2.69	2.53	1.87	1.68	1.65	1.66	2.12
1986	1.92	2.25	2.28	2.14	1.91	3.27	2.74	2.25	2.28	1.28	1.08	1.36	2.06
1987	1.54	1.55	1.62	2.27	1.91	2.69	2.45	2.17	1.93	1.38	1.70	1.66	1.91
1988	1.80	1.71	2.10	1.93	2.58	3.30	2.49	2.53	1.84	1.84	1.85	1.64	2.14

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1989	1.87	2.62	2.38	2.43	2.95	3.23	2.24	2.63	2.32	1.45	1.45	1.57	2.26
1990	1.64	1.70	1.64	2.10	2.57	3.47	2.34	2.18	2.17	1.95	1.58	1.43	2.06
1991	1.62	2.00	1.84	2.00	2.47	2.70	2.94	2.70	1.88	1.44	1.32	1.51	2.04
1992	1.29	1.73	3.20	2.50	2.12	2.52	2.71	2.75	2.35	1.50	1.55	1.36	2.13
1993	1.81	1.54	2.52	2.23	2.57	3.55	3.33	2.71	2.38	1.20	1.42	1.57	2.24
1994	1.77	1.92	2.16	2.09	2.41	3.48	3.20	2.92	2.44	1.66	1.50	1.62	2.27
1995	2.05	2.00	2.75	2.07	2.53	3.40	2.77	2.56	2.61	1.32	1.71	1.62	2.28
1996	1.95	1.99	2.50	2.01	2.38	3.02	2.64	2.30	1.62	1.73	1.63	1.66	2.12
1997	1.79	2.00	2.20	1.90	2.09	3.17	2.49	2.40	1.79	1.16	1.40	1.65	2.00
1998	1.65	2.01	2.39	1.97	2.41	2.84	2.55	1.89	1.76	1.35	1.45	1.38	1.97
1999	1.55	1.87	2.25	1.83	2.16	2.50	2.30	2.41	2.25	1.56	0.98	1.19	1.91
2000	1.47	1.80	1.67	2.18	2.42	2.52	2.70	2.16	2.09	1.18	1.12	1.21	1.88
2001	1.54	1.39	1.90	1.90	2.59	3.06	2.98	2.06	1.51	1.30	1.10	1.17	1.88
2002	1.43	1.80	1.52	2.11	2.50	2.45	2.26	2.56	1.91	1.19	1.26	1.06	1.84
2003	1.48	1.62	1.76	1.95	2.05	3.00	2.56	2.43	2.01	1.49	1.12	1.42	1.91
2004	1.46	1.52	1.73	2.05	2.27	2.53	2.62	2.55	2.34	1.52	1.00	1.15	1.90
2005	1.36	2.12	1.89	1.56	2.15	2.82	2.56	2.02	1.58	1.70	1.02	1.29	1.84
2006	1.27	1.23	1.77	1.68	2.30	2.12	2.60	2.41	2.21	1.03	1.29	1.34	1.77
2007	1.44	1.68	1.77	2.05	1.88	2.70	2.91	1.91	2.08	1.25	1.56	1.35	1.88
2008	1.55	1.38	1.51	1.69	1.81	2.90	2.20	2.17	1.63	1.30	1.20	1.12	1.70
2009	1.29	1.89	1.62	1.81	2.34	2.31	2.60	2.07	1.87	1.53	1.32	1.15	1.81
2010	1.63	1.70	2.03	2.01	2.39	2.43	2.65	2.05	1.71	1.59	1.30	1.41	1.91
2011	1.58	1.77	2.06	1.66	2.04	2.99	2.36	2.37	2.45	1.06	1.11	1.25	1.89
2012	1.64	2.08	1.92	2.19	2.12	2.69	2.27	1.62	1.94	2.05	2.18	2.29	2.08
2013	2.69	3.18	2.45	2.19	2.17	1.88	2.39	1.92	1.62	1.61	1.48	1.34	2.07
2014	1.94	2.22	2.16	1.88	2.44	1.95	2.49	2.22	1.69	1.14	1.30	1.72	1.93
2015	2.03	1.65	2.66	2.02	2.51	3.16	2.38	2.11	1.52	1.08	0.95	1.22	1.95
2016	1.45	1.70	2.26	2.56	2.24	2.53	2.75	2.48	1.52	1.18	1.28	1.63	1.97
2017	1.75	1.73	1.89	2.27	2.30	2.77	2.66	2.02	1.66	1.62	1.31	1.40	1.95
2018	1.60	1.54	1.70	2.02	2.39	2.23	2.72	1.91	1.82	1.22	1.21	1.57	1.83
2019	1.65	1.88	2.10	1.85	2.50	2.73	2.78	2.28	1.92	1.35	1.48	1.71	2.02
2020	1.61	1.56	1.86	1.93	2.31	2.45	2.30	2.27	1.62	1.05	1.43	1.17	1.80
2021	1.27	1.35	1.88	1.73	2.23	2.59	2.41	1.99	1.82	1.61	1.23	1.39	1.80
Average	1.65	1.84	2.06	2.05	2.31	2.79	2.60	2.32	1.95	1.42	1.38	1.45	1.99

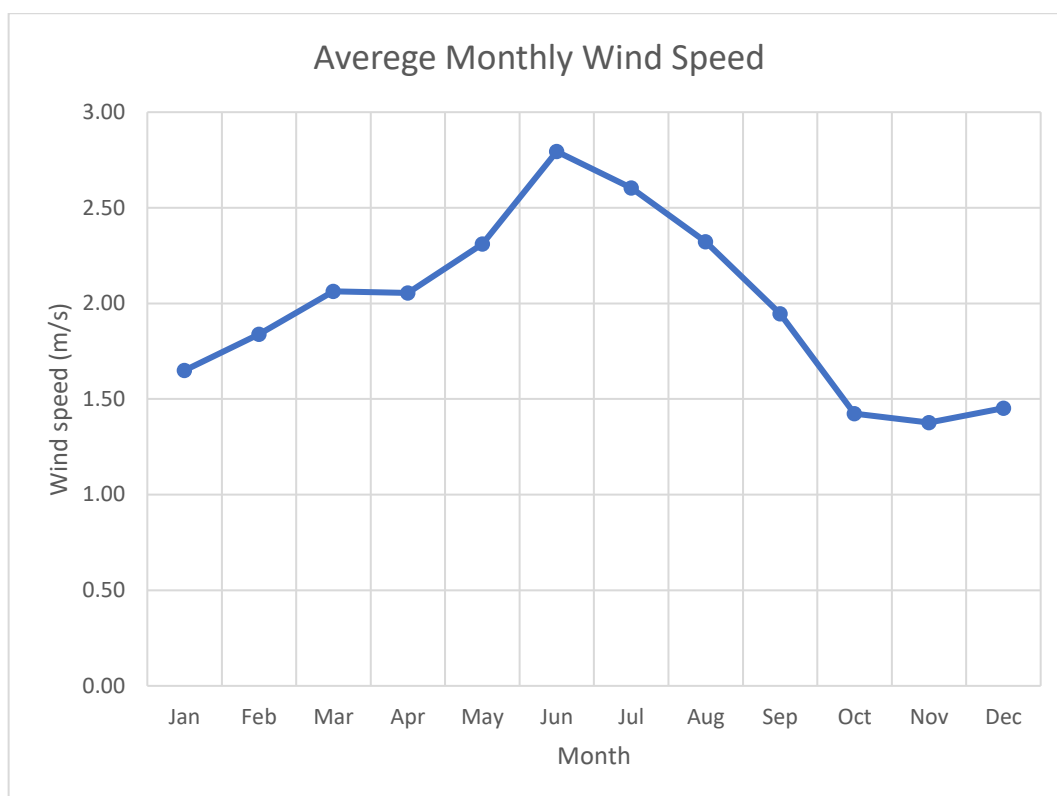


Figure 1.6 Average monthly wind speed distribution

1.1.5.3 Temperature

Temperature data has been collected from NASA POWER LARC for the project location. The data has been collected for a duration of 40 years from year 1981-2021. Average annual maximum and minimum temperature at the project location is around 44° C and 6° C respectively. The average maximum and minimum temperature vary from 27.8° C to 43.1° C and 6.6° C to 25.9° C respectively. The maximum and minimum average monthly temperature from 1981-2021 is presented in Table 1.4 and Table 1.5 respectively and plotted in Figure 1.7.

Table 1.4 Maximum Temperature(°C) at the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	28.8	35.9	37.1	39.7	41.2	41.6	34.8	33.6	33.8	31.6	30.7	29.1	41.6
1982	30.4	31.7	37.3	40.2	43.0	40.6	40.6	34.6	35.1	36.1	33.1	29.0	43.0
1983	31.0	34.2	40.2	42.9	43.9	46.8	41.7	38.0	36.0	36.0	32.6	29.4	46.8
1984	28.2	32.4	41.5	44.5	43.8	42.1	35.3	35.6	32.4	33.4	31.8	30.3	44.5

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	31.0	33.7	41.2	44.9	44.0	43.1	37.9	37.6	37.0	36.1	32.2	28.9	44.9
1986	30.5	34.3	43.7	43.7	41.1	43.6	37.8	36.8	36.4	30.8	29.3	27.9	43.7
1987	29.0	35.3	39.9	42.2	43.0	43.1	38.1	34.6	33.7	35.0	34.4	30.1	43.1
1988	29.8	34.7	40.0	43.9	46.3	42.3	37.9	37.6	37.8	37.0	34.5	31.0	46.3
1989	29.0	35.7	40.1	44.2	45.6	41.6	39.1	38.9	39.2	36.4	33.8	31.0	45.6
1990	34.2	32.8	39.5	44.0	42.3	41.9	36.0	36.7	37.3	32.8	35.2	30.1	44.0
1991	31.1	36.9	40.1	43.0	45.8	41.7	39.1	38.7	35.8	32.9	32.5	29.1	45.8
1992	31.1	32.5	42.0	44.9	44.4	42.8	42.7	40.4	39.8	37.2	36.0	29.3	44.9
1993	29.8	36.3	38.5	42.0	44.2	41.6	38.7	37.5	37.8	36.7	33.3	30.8	44.2
1994	31.2	34.4	41.2	42.9	45.4	43.8	38.0	38.9	37.6	37.3	34.5	30.3	45.4
1995	29.1	35.0	41.6	44.8	45.6	43.4	36.7	36.8	36.7	36.0	34.6	28.8	45.6
1996	28.5	34.3	41.5	44.2	45.8	43.3	38.5	36.0	37.6	36.7	35.8	30.3	45.8
1997	28.7	33.6	38.4	40.2	44.2	43.7	34.6	34.6	33.0	31.3	31.1	28.6	44.2
1998	28.0	32.7	36.5	41.2	43.6	45.6	34.6	32.6	33.4	32.8	29.0	25.0	45.6
1999	27.0	34.4	39.7	46.1	43.9	40.9	33.8	32.9	31.9	30.9	30.2	25.4	46.1
2000	28.3	30.1	37.7	43.1	40.1	36.2	35.3	33.2	32.8	32.3	30.1	26.8	43.1
2001	28.6	34.2	39.2	45.0	40.3	37.2	34.5	33.9	32.7	31.7	30.0	24.9	45.0
2002	28.1	33.4	38.4	40.5	44.1	38.4	35.8	33.8	32.8	32.3	28.5	26.3	44.1
2003	27.5	31.6	36.7	41.7	42.5	41.4	35.2	34.4	33.3	31.2	29.2	26.6	42.5
2004	27.3	34.7	41.2	43.8	43.7	38.7	33.2	32.7	32.4	30.8	27.5	25.2	43.8
2005	25.2	34.4	39.2	41.2	43.2	44.7	36.9	34.2	33.5	31.1	27.3	24.4	44.7
2006	25.3	36.5	39.7	42.4	41.1	38.5	34.0	34.2	33.7	32.9	29.5	27.8	42.4
2007	28.8	31.5	39.8	42.0	42.9	42.8	34.6	34.8	32.8	32.6	28.6	24.8	42.9
2008	27.0	30.2	39.3	42.4	41.7	37.4	33.8	35.0	33.2	32.3	29.7	27.7	42.4
2009	29.3	34.7	37.9	42.3	42.6	42.5	36.8	34.4	33.0	32.4	29.3	25.5	42.6
2010	25.7	31.9	41.9	44.3	43.5	41.4	34.7	35.2	33.2	32.3	31.0	27.7	44.3
2011	27.6	33.4	40.3	39.6	39.3	39.7	34.3	34.7	32.7	31.7	27.8	27.0	40.3
2012	26.2	34.6	39.7	42.2	44.9	44.7	36.6	33.8	33.7	32.0	28.8	26.6	44.9
2013	28.2	34.4	39.5	43.4	43.7	36.6	34.1	33.8	33.3	31.2	28.6	25.7	43.7
2014	27.0	30.6	41.2	43.7	45.1	40.9	35.1	33.7	34.2	32.6	30.4	28.0	45.1
2015	29.0	34.7	39.0	39.4	43.4	43.4	35.4	33.8	33.9	33.4	30.6	30.5	43.4
2016	28.7	36.4	39.7	45.0	43.3	42.6	36.1	34.6	32.4	32.8	30.1	27.5	45.0
2017	30.6	35.3	40.5	41.4	39.9	41.3	33.7	33.3	33.7	32.6	29.3	26.6	41.4
2018	24.6	32.7	37.7	39.8	39.1	39.6	34.7	34.2	33.0	33.2	32.8	28.2	39.8
2019	28.6	34.0	39.7	43.2	43.5	40.8	35.8	35.1	33.1	31.2	28.7	25.3	43.5
2020	25.2	29.6	37.0	39.3	40.8	36.1	33.5	34.8	33.3	32.7	29.8	25.6	40.8
2021	26.7	34.9	40.1	42.5	40.2	36.8	34.1	34.2	33.1	32.4	27.2	26.5	42.5
Average	28.5	33.8	39.6	42.6	43.1	41.3	36.2	35.2	34.4	33.3	30.9	27.8	43.9

Table 1.5 Minimum Temperature(°C) at the project site

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1981	8.3	9.5	13.9	16.6	23.7	24.8	25.1	25.4	23.5	16.2	11.5	7.7	7.7
1982	7.4	8.9	11.9	19.1	21.9	25.8	25.6	25.2	20.9	19.0	9.8	8.9	7.4
1983	7.3	6.5	14.1	19.4	24.4	27.7	26.3	25.5	24.6	15.8	13.7	7.0	6.5
1984	7.3	7.9	12.1	20.4	22.3	25.6	24.9	25.3	20.1	16.8	11.5	6.5	6.5
1985	8.9	9.3	14.9	20.9	25.0	27.6	25.0	25.3	24.0	17.2	10.5	8.4	8.4
1986	7.0	10.4	14.9	20.6	19.4	25.1	24.4	24.7	22.8	15.7	12.4	7.0	7.0

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1987	6.0	11.7	14.9	20.7	21.3	26.1	25.7	24.8	23.2	16.6	9.8	9.1	6.0
1988	7.7	9.5	14.2	17.9	25.0	24.7	26.2	25.2	23.6	19.8	13.5	10.1	7.7
1989	5.4	9.9	11.8	16.3	22.4	26.0	23.5	24.7	24.5	17.1	13.5	7.6	5.4
1990	7.3	10.0	13.0	16.2	25.1	26.1	25.4	25.0	24.3	15.5	11.4	8.6	7.3
1991	7.3	11.5	15.4	19.8	26.2	24.1	26.5	25.9	22.9	17.0	11.1	7.0	7.0
1992	5.9	9.4	13.0	19.8	22.5	25.5	26.0	25.1	22.3	16.5	13.2	9.8	5.9
1993	5.9	9.5	14.3	18.4	25.4	26.2	26.0	24.9	24.5	16.7	11.8	9.5	5.9
1994	7.7	10.8	13.3	21.3	24.0	26.4	26.1	25.9	20.4	17.7	13.7	7.1	7.1
1995	6.6	9.9	13.7	18.7	25.7	26.4	25.8	25.3	23.9	16.9	10.0	8.7	6.6
1996	7.2	7.7	15.6	16.4	22.7	26.6	25.4	24.7	24.3	17.8	10.9	8.2	7.2
1997	7.4	8.0	14.3	18.5	20.6	25.5	25.2	25.1	20.7	16.6	14.6	7.4	7.4
1998	6.0	8.9	11.8	19.0	24.3	27.1	25.8	25.5	23.8	15.7	11.1	7.3	6.0
1999	6.4	8.2	12.8	18.9	24.8	26.0	25.5	23.9	23.6	18.7	10.1	8.4	6.4
2000	5.1	8.1	11.6	18.1	23.7	25.3	25.2	24.8	21.9	15.8	13.3	8.9	5.1
2001	5.6	8.6	14.3	19.6	24.3	25.3	25.7	25.3	23.9	19.0	11.3	7.6	5.6
2002	6.9	7.2	14.1	18.3	23.2	25.7	25.6	24.8	23.0	15.3	13.3	9.0	6.9
2003	4.9	11.1	10.6	19.3	22.0	26.3	25.1	25.8	24.2	18.5	10.9	8.0	4.9
2004	6.7	8.0	12.3	21.5	21.3	26.2	25.1	25.5	22.8	16.2	13.7	5.9	5.9
2005	7.7	7.9	16.3	17.9	23.2	26.6	25.0	25.2	24.0	18.9	12.9	7.1	7.1
2006	6.3	11.6	15.0	19.9	24.1	25.5	25.2	24.6	23.7	17.1	10.3	8.5	6.3
2007	6.8	11.2	12.9	20.8	24.1	26.2	24.5	24.7	23.6	17.3	12.9	6.6	6.6
2008	7.3	6.3	14.8	19.0	25.3	24.7	25.5	25.0	23.4	16.6	11.4	10.4	6.3
2009	8.1	10.2	13.2	19.9	23.8	26.2	26.1	25.0	23.5	15.7	10.0	6.7	6.7
2010	6.4	7.9	15.2	21.3	24.7	26.0	25.1	25.0	21.9	17.1	13.1	6.9	6.4
2011	6.0	10.7	11.5	18.8	22.8	26.2	25.0	24.6	23.2	15.7	12.8	7.0	6.0
2012	6.2	7.2	13.7	21.6	24.5	27.0	25.9	25.4	21.9	14.0	9.1	4.7	4.7
2013	2.5	9.1	13.7	19.6	23.9	25.7	26.1	25.1	23.9	17.2	11.8	7.6	2.5
2014	6.1	8.8	14.1	19.8	24.7	26.2	25.8	25.4	23.3	17.1	11.3	6.6	6.1
2015	6.8	8.0	13.6	20.4	24.5	25.1	25.1	24.9	22.7	18.7	16.7	8.0	6.8
2016	6.7	10.1	18.5	21.0	25.1	26.4	24.8	24.6	24.7	19.1	11.7	8.8	6.7
2017	5.0	11.0	13.1	19.0	23.3	26.5	25.4	24.9	25.1	18.2	10.2	8.3	5.0
2018	5.2	11.2	15.0	21.1	22.6	25.6	26.2	25.2	22.2	17.7	13.9	6.7	5.2
2019	7.4	9.0	11.2	20.3	22.6	26.4	25.5	25.5	23.1	17.9	14.0	4.5	4.5
2020	6.1	7.2	14.3	18.7	22.4	25.6	25.6	25.4	24.5	18.3	10.8	6.2	6.1
2021	6.3	6.9	15.7	19.0	23.4	25.0	25.1	24.9	24.2	16.0	11.9	5.3	5.3
Average	6.6	9.1	13.8	19.3	23.6	25.9	25.4	25.1	23.2	17.1	12.0	7.6	6.2

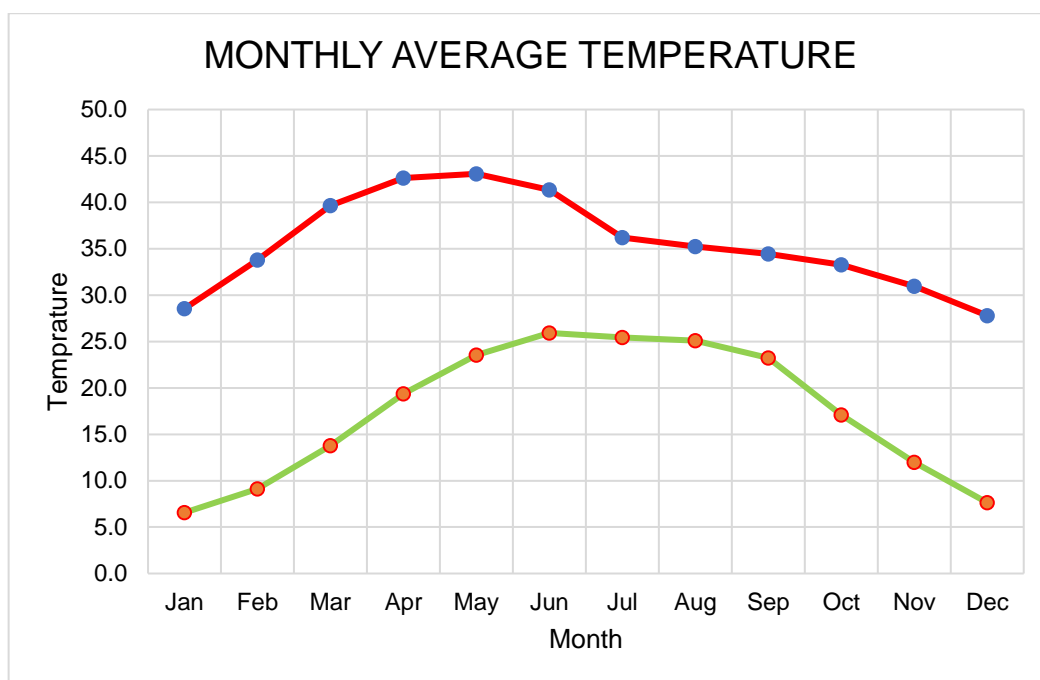


Figure 1.7 Monthly Average Temperature Variation at Project Site

1.1.6 Topographic Information

Topographic survey has been conducted for the site. The ground levels at the site, broadly, vary from RL +13.00 to RL +28.00 m. The survey plan along with contours is shown in the Figure 1.8. The detailed topographic survey is presented in the Drawing No. ENL002.



Figure 1.8 Topographical plan of the Navigational lock

1.1.7 Hydrological Information

The water levels U/S and D/S of the existing Navigational lock as mentioned in the Operation Maintenance Manual for the existing Lock are given in Table 1.6.

Table 1.6 Water Level at Navigational lock

High Water Level U/S	RL +26.30 m
Low Water Level U/S	RL +18.288 m
High Water Level D/S	RL +24.38 m
Low Water Level D/S	RL +18.288 m

1.1.8 Geotechnical Data

As per the condition survey, the renovation and modernization work of existing Navigational lock shall not require any major foundation to be constructed. However, new parking bay for the caisson gates storage is

proposed in the upstream and downstream of the existing Navigational lock . The geotechnical investigation report attached in the DPR of new Navigational lock has been used in the design of new parking bay. Borehole's location plan as per the geotechnical investigation report of new Navigational lock is shown in Figure 1.9. Generalized soil profile in the vicinity of project site is shown in Figure 1.10 and the geotechnical investigation report is attached in Annexure 1.

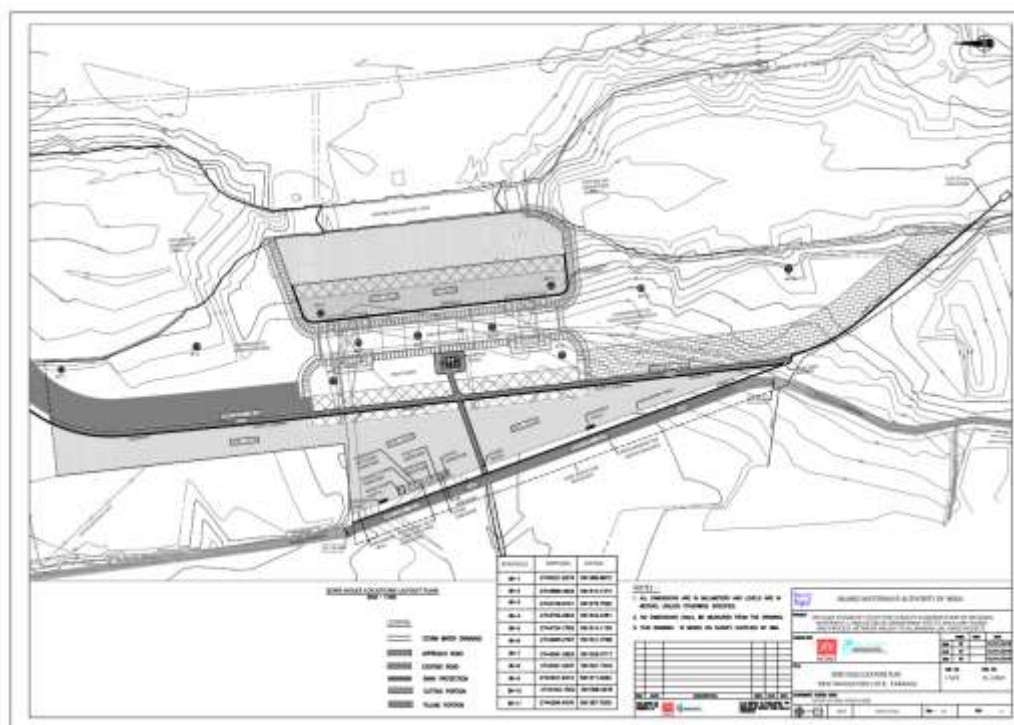


Figure 1.9 Boreholes location for the new Navigational lock

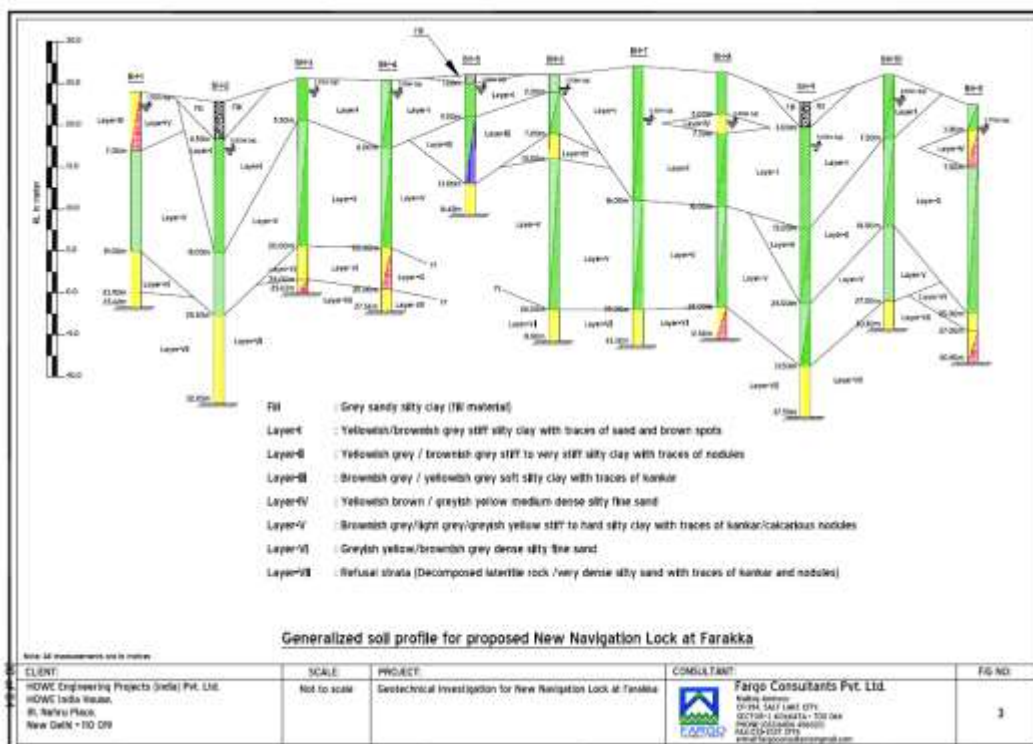


Figure 1.10 Generalize soil profile as per the DPR of the new Navigational lock

1.2 Employer's Requirements

1.2.1 General

The Employer's Requirements are that the Contractor shall carryout the Engineering, Design, Procurement of materials and Construction / installation of all the items listed below, along with associated works as outlined in this tender document. For this purpose, the Tenderer shall conduct all necessary field tests and surveys to satisfy / verify himself regarding the correctness of the data furnished vis-à-vis actual condition. No claim whatsoever will be entertained for any variation between the actual site condition met with during the execution of the work and those indicated herein. While working for this Contract, the contractor shall be fully responsible to ensure that there will not be any damages in the New Navigational lock which are already in advance stage of operationalization.

The broad items of works covered are listed below:

- Renovation/Modernization of Lock Structure including all associated facilities
- Bank protection works
- Renovation/Modernization of Control Room building with associated electrical, mechanical and other facilities for remote operation of gates
- Electrical works
- Communication system
- Roads
- Vehicle parking area
- Security office cum check post
- Toilet block
- Water supply
- Storm water drainage
- Sewerage system
- Waste collection system
- Fire-fighting system
- Store room for storing spare parts

1.2.2 Renovation/Modernization Lock Structures including all associated facilities

I. The length and width of the new lock are as following:

Length = 179.0 m

Width = 25.148 m

II. The lock shall be connected to river Ganga in U/S and Feeder canal in D/S by approach channel as shown in **Drawing ENL001**.

III. The general arrangement of existing Lock with approach channels showing typical plan are presented in the **Drawing ENL003**.

IV. The existing navigational lock shall have all the required accessories/ fixtures including but not limited to the following:

- a. Mitre gates (2.0 nos. one each in U/S and D/S)
- b. Radial gates (4.0 nos. Two each in U/S and D/S inlets)
- c. Bulkhead gates (8.0 nos. Two each in U/S & D/S inlets and two each in U/S and D/S outlets)
- d. Fenders including all its ancillaries
- e. Bollards
- f. Mooring rings
- g. Safety rung

V. The Contractor shall adhere to and honor the Conditions of the Contract in all respects.

VI. The Contractor while executing the Works shall observe/follow good industry practice, which however shall meet the Employer's Requirements.

1.2.3 Bank Protection Works

Bank protection works shall be carried out on the left bank of the approach channel to protect the river bank from erosion and flooding. Stability of the bank slopes shall be carried out in accordance with the Indian standards and guidelines.

1.2.4 Retaining Wall Structure

A counterfort retaining wall has been proposed on the sides of the caisson gate parking bay. The retaining wall has been dimensioned so as to take the earth pressure and earthquake forces etc. The contractor can envisage alternate options, as one alternates the specifications for Diaphragm wall is given in the document. The top of wall has been kept at El. 28.44m. The bottom elevation of wall varies from El. 12.8m to El. 14.8m along the length to provide a slope of 1 vertical to 370 horizontal. The stability analysis of the

structure shall be carried out considering the section of the Retaining wall at deepest point.

1.2.5 Buildings

The following buildings shall be renovate/modernize as part of this Contract:

S. No.	Building	Type
1.	Control Room building	Three storey building
2.	Residential Quarters	Type III and IV
3.	Toilet Block	Single storey building with capacity of 2 Water Closet (flush toilet) for women and men and 4 urinals for men
4.	Security Office cum check post	Single storey building

Rain water harvesting system shall be provided for all the buildings in the Lock area.

1.2.5.1 Control Room Building

The Contractor shall renovate/modernize the existing Control room building located at central place of the existing Navigational lock for remote control operation of gates of lock. It should provide full view of the lock along with approach channels for monitoring movement of vessel through the lock. The space of the existing Control Room building shall be utilised to accommodate the following equipment/rooms:

- Diesel Generator set, Metering panels, electrical panels and Transformer at Ground floor.
- Operating cum programming station, server station, PLC panels, CCTV Terminals, Third party control system for field instruments, conference room and various utilities rooms at first and second floor.
- Two store rooms for spare parts (one for General Electric items and other for specialized components).

- Conference Room, two room for administration at ground floor and two number of Guest Rooms.

1.2.5.2 Residential Building

The Contractor shall plan, design and construct Residential quarters for the chief lock officer and lock officer of the Navigational lock s. 2 units of Type IV and 4 units of Type III quarters have been proposed. The plinth area shall be fixed as per the New Plinth Area Norms 2012 of CPWD. In the proposed quarters following amenities shall be available:

1. Kitchen
2. Kitchen sink
3. Ceramic glazed tiles
4. Built in cupboard with open shelves below cooking platform
5. Cooking platform standing
6. Wardrobes
7. Curtain rods with bracket
8. Storage tank
9. Ceiling Fans
10. Exhaust Fans

All other required amenities shall be provided as per the Revised Specifications & Scale of Amenities for General Pool Residential Accommodation (Type I to VI). Location of the proposed quarters are shown in Drawing No. ENL 013

1.2.5.3 Toilet Block

The Contractor shall plan, design and construct toilet block at the suitable location.

1.2.5.4 Security Office

The Contractor shall plan, design and construct security office at the suitable location to handle entry and exit clearances of the Navigational lock

1.2.6 Roads

The Contractor shall plan, design and construct internal roads for Navigational Lock and same shall be provided as per the layout shown in tender document drawings. Any culverts required at the crossing of the drains and drainage system shall be provided. Details of Roads as planned have been provided herein below:

Roads	Carriageway Width	Length
Internal	5 m	600 m

General layout of Roads and are shown in **Drawing ENL013**.

The contractor shall also design and construct the road as a replacement of existing road before the existing road is demolished to make way for renovation/modernization of the Lock.

1.2.7 Vehicle Parking Area

The Contractor shall plan, design and construct suitable roofed paved area for vehicle parking nearby the control room building.

1.2.8 Water Supply

The Contractor shall do design, installation and commissioning of the complete water supply distribution system including the supply of potable water to the buildings.

1.2.9 Storm Water Drainage

A drainage system for carrying the storm water run-off from the Lock area is to be designed and provided. Tentative layout for drainage is shown in **Drawing ENL013**. The drain will provide the drainage of entire area within the boundary wall of lock area.

1.2.10 Sewerage System

The Contractor shall plan, design and construct complete sewerage system including laying of pipelines for collection of sewage from buildings to Sewerage Treatment Plant (STP) to constructed by the contractor. The treated water from STP shall be stored in a separate tank and will be used for horticulture. Plumbing arrangement along with pumping system should be planned and constructed by the contractor.

1.2.11 Waste Collection System

The Contractor shall plan, design and construct complete waste collection system including dustbin and paved area at suitable location.

1.2.12 Electrical Works

1.2.12.1 Authority's (IWAI's) Requirements

The Authority's Requirements are that the Contractor shall carryout the Engineering, Design, Manufacturing/Procurement, Supply, Storage at site, Construction/installation, Testing, Commissioning & Handing over of all the items/systems listed, along with associated works as outlined in this tender. Brief list of Authority's requirements are as follows:

- Renovate/modernization of the existing central control room for the electrical distributionsystem at the location identified in the tender.

- Internal (Central Control Room Building) and External illumination including lighting fixtures, necessary poles and high masts, MCB boxes, accessories and hardware including civil works.
- The Contractor shall provide complete Electrical works for all equipment / buildings as required.
- Electrical and Control cabling from proposed Central Control Room to individual equipment / buildings.
- All Earthing and Lightning protection works.
- Associated Civil Works

The Contractor while executing the Works shall follow good industry practice, which however shall meet the Authority's Requirements. The Contractor shall adhere to and honour the Conditions of the Contract in all respects. The specifications provided in the tender together with enclosed drawings outlines the functional requirements and the operating characteristics which the equipment must fulfil. Alternative technical features other than those specified may be acceptable subject to the approval of the Authority. In any case, the performance of the system / equipment delivered shall be guaranteed in every detail by the Contractor. Overall dimensions (boundary dimensions) and functional requirements as specified shall be strictly adhered to. The scope of work outlined below and quantities indicated are for overall understanding of the Works, and does not absolve the Contractor from successful commissioning and operation of the Works with best available latest technology. Any item/equipment not listed but required for completion of the Works shall be considered as included in the scope of the Contractor.

The Contractor shall be deemed to have examined the site and familiarized himself with all existing site conditions. He shall accept the Site in the existing condition at the time of award of the Contract.

1.2.12.2 Detailed Electrical Scope of Work

Power at 11kV shall be made available up to a DP (Double Pole) Structure adjacent or within the Project boundary by West Bengal State Electricity Distribution Company Limited (WBSEDCL). Beyond this DP structure, power shall be fed to the Metering cubicle of WBSEDCL through buried 11kV cable by WBSEDCL. DP Structure shall also be provided by WBSEDCL. 11kV cable from metering cubicle of WBSEDCL to 11kV switchgear Incomer shall be in the scope of the EPC contractor. Power at 11kV received at the incomer of HT Switchgear shall be further stepped down to 415V through one number of distribution transformer capable to handling 100% load. Further Power distribution shall be as per the attached **Drawing ENL011.**

SLD attached with this tender is indicative, final Load List and corresponding final SLD shall be prepared by the Contractor during detailed engineering.

The particulars of power supply are as follows:

Receiving Voltage	11kV \pm 10%
Supply Voltage	415V \pm 10%
Phase	11kV – 3 PH 3 Wires 415V - 3 PH 4 Wires
Frequency	50 Hz \pm 3%
Combined Voltage & Frequency Variation	10%

Fault level	26.3kA for 3 second at 11kV 50kA for 1 second at 415V
System Earthing (415V)	Solidly Earthed
Control Circuits:	
Circuit Breaker Protection & Tripping Control System	110 V DC, 2 Wire grounded
Control System:	
Server, PLC, FI (Intelligent) I/O, VDU, Keyboard, Printer	240 V \pm 10%, AC, 50 HZ \pm 3%, 1 Ph, 2 Wire; All equipment shall have internal close loop regulation & spike arrestors
UPS System, Field instruments	240 V \pm 10%, AC, 50 HZ \pm 3%, 1 Ph, 2 Wire

The detailed scope of electrical works is given below:

S. No.	DESCRIPTION	QTY.
1.	11kV Indoor Incoming Cum Outgoing HT Switchgear, Draw out type as per the attached SLD	1 No.
2.	11kV/433V, 400KVA, indoor Dry type Utility Transformers, having off circuit tapping of +/-10%, in steps of 2.5%, winding temperature detectors with scanner for temperature alarm and trip, door safety limit switch and accessories	1 No.
3.	415V Silent DG set, 400kVA with AMF Panel and exhaust pipes as per pollution norms, including foundation	1 No.
4.	415V Capacitor Panel of rating 170kVAR as per the attached SLD at substation with 415V main Circuit Breaker, sets of Fuse and Contactors for each capacitor bank, automatic Power Factor Correction Relay, Capacitor banks with series reactors, discharge resistance, residual voltage transformer & neutral displacement protection relay.	1 set
5.	415 V panels LT switchgear as per the attached SLD.	
	a) 415V PCC	1 No.
	b) 415V MLDB	1 No.
	c) 415V ACDB	1 No.
	d) 415V CDB	1 No.
6.	Distribution Boards 415 Volts, 3 Ph, 4 wires with suitable busbars for Lighting, and Auxiliary supplies in Control Room & Local Control Panel Room	Lot
7.	Substation Battery, Lead Acid (Valve regulated) Sealed Maintenance Free type, 110V DC with minimum 1 Hour back up, 110V DC battery charger with dual battery charging and DC Distribution boards	1 Set

8.	General Purpose Industrial compact batten suitable for 2x20W LED Tube Light fitted with Aluminium heat sink for Control Room Ground Floor, for achieving 200 lux	20 Nos.
9.	General Purpose Industrial compact batten suitable for 1x20W LED Tube Light fitted with Aluminium heat sink for Local Control Panel Room for achieving 200 lux	8 Nos.
10.	34Watt LED Panel with ultra-modern recess mounting luminaire suitable for armstrong/grid/POP ceiling complete with separate electronic driver & high brightness SMD LEDs for Control Room First Floor for achieving 300 lux	60 Nos.
11.	Well Glass 40W LED for Stair case	3 No.
12.	Aviation Light at the top most point of Control Room towards river side	1 Nos.
13.	Industrial power sockets 240 V 15A in Control Room & Local Control Panel Room and as required for convenience at suitable locations.	Lot
14.	Welding socket 415 V TPN and earth 63A, in Control Room & Local Control Panel Room and as required for convenience at suitable locations.	Lot
15.	Exhaust Fans of suitable size in Control Room & Local Control Panel Room for ventilation so as to remove heat generated by the Panels/Equipment.	Lot
16.	Internal illumination through LED fixtures and electrification including wiring & installation of fixtures, switches, sockets, fans, conduits, brackets, junction boxes, etc., Control Room & Local Control Panel Room including peripheral	Lot
S. No.	DESCRIPTION	QTY.
	lighting of buildings and structures.	
17.	High Mast (30m).	4 Nos.
18.	LED Streetlight system wattage 30W IP66 Multiple LED With Lens optics and Pressure die-cast aluminium housing for effective thermal management. Total system Lumen of 30W LED should be Lumen Efficacy >95 Lm/W, Power factor>0.95, CRI>70. Complete with Mounting Brackets & accessories as required with connections. It consist of GI pipe bracket of 3.5 m length , 1 m Tilted at 45 degree & 2.5 m straight with 3 nos. of suitable size Clamp having MS plate 300 mm x 300 mm x 6 mm thick welded with bottom of pole and suitable hole with rectangle shape wiring of pole with 3 x 1.5 sq mm copper conductor FR wires, Bracket should be Painted from bottom and rest of pole with 2 coat of aluminium paint of superior quality of approved brand etc. as required for boundary wall as per the "High Mast & Cable Layout".	57 Nos.

19.	Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5-Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup in Control Room & Local Control Panel Room etc., to ensure minimum 10 Lux in all the buildings, all exit / entry points etc.	Lot
20.	Split air conditioning units 2.5 Ton with 5 meters of insulated copper tubing in Control Room	5 Nos.
21.	Split air conditioning units 1.5 Ton with 5 meters of insulated copper tubing in Local Control Panel Rooms (where RIO panels are located)	4 Nos.
22.	Cables	Lot
	a) 11kV (E), Heavy Duty, Armoured Cable, FRLS, XLPE, stranded Aluminium Conductor and Accessories	
	b) 1.1 KV, Heavy Duty, Armoured, Power Cables, FRLS, stranded Aluminium /Copper Conductor and Accessories.	
	c) 1.1 KV, Lighting Wires, PVC Insulated, FRLS, Stranded Copper Conductor and Accessories.	
23.	FRP Cable Tray with all accessories, mounting hardware, support structures, Cable risers, cable racks etc.	Lot
24.	a) Cable terminations including cable termination kits, cable lugs, glands etc. for 11kV (E) grade cables	Lot
	b) Straight through Cable Joints. for 11kV (E) grade cables	Lot
	c) Cable terminations including cable lugs, glands etc. for 1.1kV grade cables for power, lighting and auxiliaries	Lot
	d) Straight through Cable Joints for 1.1kV grade cables for power, lighting and auxiliaries	Lot
25.	Earthing Protection System with Materials:	
	a) Earthing of HT, LT Equipment, Transformers, Generators, Panels, Distribution Boards, Motors, Junction Boxes and all equipment, lighting and power distribution network within the scope	Lot
	b) Main Earthing grid in the Control Room and overall project area	Lot
26.	Lightning Protection for all buildings and structures within the scope as per	Lot
S. No.	DESCRIPTION	QTY.
	IS/IEC-62305:2010 (Superseding IS-2309: 1989) comprising lightning finials, GI Strips for Horizontal and vertical conductors for Lightning protection, Earth pits with Test links for Lightning protection	
27.	Excavation and backfilling of soil, sand cushion, protection bricks for buried cables wherever buried cables are taken	Lot

28.	Communication system including Telephone system-EPABX (3 PNT Line 12Hybrid Extension)	Lot
29.	Control Room Safety Equipment	Lot
	a) CO2 type Fire extinguisher of 1 gallon capacity, each mounted on wheeled portable trolley	
	b) Sand buckets (4 nos.) filled with sand alongwith required stand	
	c) Caution Board (11 KV & 415 V) and shock treatment chart	
	d) 900mm wide 12mm thick rubber mat (Electrical grade) in front of panels	
	e) First Aid box	
	f) 11kV Safety gloves	
	g) Discharge earthing rod for 11kV rating	
30.	Special maintenance tools & tackles like	Lot
	a) Earthing trucks of each type in Control Room Building	
	b) CB Racking handles of each type in Control Room Building	
	c) Spring Charging handle of each type in Control Room Building	
	d) Any other item as per recommendation of manufacturer of equipment	
31.	Any other item not included above but required for completion	

Note: The above quantities are indicative only.

1.2.12.3 Civil

S. No.	ITEM DESCRIPTION	Qty.
1.	Complete renovation and modernization of existing Control Room building including interior power and lighting	Lot
2.	Renovation of the existing Cable trenches etc.	Lot
3.	Supports and foundations of DP structure, high masts, transformers etc.	Lot
4.	Cut outs on walls for taking cables, drilling & fixing of fasteners for fixing of fixtures/cables/conduits etc.	Lot

1.2.12.4 Miscellaneous/General Works/Services

i)	Mobilization of all resources including Construction Machinery / Tools & Tackles / Welding Sets / Cranes / DG Set etc. for expeditious construction / fabrication / erection/ installation of the required System to ensure timely implementation of the Works.
ii)	Contractor shall arrange & post sufficient number of skilled and experienced personnel at Site to ensure trouble free Installation, Erection,

	Construction, Operation and Handing
	over to the Employer.
iii)	The Contractor's Scope of Work shall include development of land / construction of his site fabrication yard at area allocated to him by the Employer.
iv)	Fabrication and Erection of all temporary structures, arrangement for temporary power and water supply etc. adequate site lighting arrangement, transport logistics at site etc.
v)	Supply of all consumables / materials / lubricants, hydraulic fluids, oil, etc. including fueloil for DG set.
vi)	Clean up at site of all debris and temporary structures on a daily basis and final clean up at the time of handing over of the plant.
vii)	All electrical safety requirements during site fabrication, erection, testing and commissioning, including adequate earthing of erection machinery and equipment.
viii)	Proper and safe storage / security of all equipment and materials at site in the areas designated by the Employer in line with the Customs Authority / Regulations, where applicable.
ix)	Supply of Lubricants, Oil, etc. for Initial fill, flushing, cleaning, refill, topping up & maintenance of Material handling system till the Works is put into satisfactory and continuous commercial use and has been "Taken Over" by the Employer.
x)	Attending meetings at the office of the Employer/ Authority's Representative or site or at any other station that may be fixed by the Employer for planning, co-ordination, clarifications, review, discussions etc.
xi)	Co-ordination with other contractors, if any, and supplying necessary engineering data/ information to the Employer to ensure satisfactory installation of equipment / execution of works.
xii)	Supply of necessary calibrated instruments for carrying out performance tests of Equipment.
xiii)	Complete lot of base plates, foundation bolts, inserts, embedment, clamps, nuts, washers etc. as required for the system.
xiv)	All necessary painting and corrosion protection. The painting and corrosion protection for the equipment and structures is included in Contractor's scope. The painting and corrosion protection shall be as per the specification furnished elsewhere. The painting scheme and the finish colour for all the equipment shall be as specified by the Employer after award of contract. Necessary finish paints including touch-up paints, if not applied at shop, should be supplied by the Contractor, in sealed containers for site application.

1.2.13 Control and Automation Works

1.	Server at Control Room with Control and required Management software and interfaces, complete with all necessary accessories and High-Speed Printer as per Basic Control Architecture. Software for operating Terminals shall have interfacing capability with all equipment and SAP.	1 No.
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2.	Programmable Logic Controller (PLC) (with hot stand-by processor and various communication modules) at Control room, Processing Control & Associated Communication Modules. Data processing software and required interfaces, hot standby, complete with all accessories. The communication module should support the communication between RIO (Intelligent), Other operating Terminal PLCs/Controllers and all third parties interfaces.	1+1 (Hot Standby system)
3.	Managed Ethernet Switch (Redundant)	1+1 (Dual Redundant)
4.	Mimic, Large Screen Video Display LED, Size 32" at Control room.	1 No.
5.	Operating Station Terminal and Operating cum Programming Station with necessary software	1 Nos.
7.	Remote Input Output units (Intelligent) (RIO) with mini processor, suitable for field mounting with IP 65 degree of enclosure protection inside transfer towers or at outdoors (IP-55 or IP-54 degree of protection inside the rooms) complete with in-built UPS (1 hour back-up- status shall be indicated in CCR-VDU), signal converter and transmitter and all accessories having the following parameters.	4 Nos.
	i) Digital Input Module, 32-unit module	Lot
	ii) Digital Input Module, 16 modules	
	iii) Digital Output Module, 32-unit module	
	iv) Digital Output Module, 16-unit module	
	v) Resistance Temperature Detector (RTD)	
	vi) Analogue Input Module, 16-unit module	
	vii) Analogue Input Module, 32-unit module	
	viii) Analogue Output Module, 16-unit module	
	ix) Analogue Output Module, 32-unit module	
9.	21" LED colored Monitors, PC Keyboards and software as per functional requirements.	2 Nos.
10.	CCTV System including the following:	
	a. Network Video Recorder (NVR) at Control Room with required software and complete with all accessories.	1
	b. PC Computer terminal having 21" LED Monitors, PC Keyboards and mouse with NVR software as per CCTV functional requirements. It shall support the communication between all operating terminal PC and IP-based cameras located at various areas.	1
	c. Interfacing of CCTV System for Monitoring System along with all the necessary software's and hardware's.	1-Unit
	d. PTZ Infrared cameras (IP-based) 36 X Optical Zoom.	3 Nos.
	e. Media Converters (Ethernet to Optical Converter)	Lot

	f. Auxiliary Hardware, like connectors, converters, light-interface units, networks adapters/Switches etc. for the complete system under scope of this contract.	Lot
	g. Power Cables (to feed power to the Contractor's supplied items)	Lot
11.	Plant Control Data Bus Cable, fibre optic (8 core-single mode-armoured), must be capable of high-speed data transmission inside/outside the plant in a recognized universal configuration along with all accessories.	Lot
12.	Copper Data Cable (RS-485-ModBus RTU), Shielded, individual & overall screened 4 core twisted pair.(CAT5e)	Lot
13.	Auxiliary Hardware, like connectors, line amplifier (if necessary, for long conveyor system to get the status of all safety switches to nearest RIO's and respective MCC's, line diverters, networks, alternators, multipliers,	Lot
	etc. for the complete system under scope of this contract.	
14.	Interconnecting hardwired multicore cables, shielded 2.5 mm ² copper (or larger to suit the requirement), FRLS insulated, between vendor items (LCP/JB/LV switchgear) to the nearest FI. (Hand-Off-Auto control stations/Local Panel for bought out items (by others)	Lot
15.	Local-Off-Auto Station - IP-65 (Lockable at 'OFF' Position)	Lot
16.	Control Junction Boxes (Terminal Blocks)(IP-65)	Lot
17.	CDB's (Control Power Distribution Board) shall be furnished, manufactured and installed in Control Room & Local Control Panel Rooms for feeding power supply to Contractor supplied items.	Lot
18.	Required accessories, connectors, auxiliary contactors, timers, counters, opto-couplers, Ethernet switches, Light interface units, transducers etc.	Lot
19.	UPS at Control room for Control System, on line complete with all accessories and batteries as per Specification (1 hour back-up). Status shall be indicated in CCR-VDU.	2 Nos.
20.	Chairs matching with decor, revolving with rollers and storage cabinet	Lot
21.	Any other item not included above but required for completion	

1.2.14 Fire-fighting System

The Contractor shall do design, installation and commissioning of the complete fire- fighting system within the scope area including all the buildings as per specifications for fire-fighting system covered under Section 7.

1.2.15 Existing Navigational Lock Traffic Signal System

The movement of traffic through the existing Navigational lock shall be managed from a dedicated signal system which should be installed at the upstream, downstream and inside of the lock chamber for safe and reliable movement of vessels through the lock. The contractor shall do the design, installation, testing & commissioning of the movement of vessels through the Existing Navigational Lock as per specifications for Signal System covered under Section 4.25.

1.2.16 Synchronized Operation of Existing and New Navigational Lock through Integrated Signal System

The movement of traffic through both the navigational locks (Existing & New) shall be managed from an integrated signal system. The integrated signal system should be installed at the upstream and downstream of the lock for synchronized operation through both the locks (Existing & New) resulting in safe and reliable and smooth movement of vessels. The integrated signal system should be interoperable from both the existing and new navigational lock control room. The Contractor shall do the design, installation, testing and commissioning of the integrated signal system for traffic management for synchronized operations of the movement of traffic through the Existing and New Navigational lock as per specifications for Signal System covered under Section 4.25. After awarding the contract, the required details of New Navigational lock for synchronization of both the locks (Existing & New) shall be shared with the contractor for further designing & implementation purpose.

2. DESIGN CRITERIA

2.1 Civil

2.1.1 Codes and Standards

The codes and standards stated here below or elsewhere in these documents shall be the latest editions prevailing till October 2022. All materials, testing, design and execution shall be in conformity with these codes and standards unless otherwise stated in these specifications. It is well understood that when a brand name is given for a material, the Contractor has the right to propose any equivalent material of any other brand for approval of the Employer.

Indian Standards shall generally be followed. In case, any work or item is not covered by the Indian Standards, following standards shall be adopted in order of preference.

- ✓ British Standards
- ✓ American Standards
- ✓ General Standards

Wherever details for part of works are not defined adequately in Indian Standards, relevant acceptable International Standards shall be adopted. Codes and standards covering the major part of the works are included in the Tender Document and some of them are listed below:

IS 1893	Criteria for Earthquake Resistant Design of Structures
IS 875	Code of Practice for Design Loads for Buildings & Structures – (Parts 1–5)
IS 456	Code of Practice for Plain and Reinforced Concrete
IS 2911	Code of Practice for Design & Construction of Pile Foundations
IRC 37	Guideline for the Design of Flexible Pavements

IS 13920	Ductile Detailing of Reinforced Concrete Structures subjected to Seismic Forces – Code of Practice
IS 4326	Earthquake Resistant Design & Construction of Buildings – Code of Practice
IS 14262	Planning and Design of Revetment Guidelines
IRC 58	Guidelines for the Design of Plain Jointed Rigid Pavements for Highways
IRC 73	Geometric Design Standards for Rural Highways
BS 449	The use of Structural Steel in Building (Permissible Stress)
BS 648	Schedule of Weights and Building Materials
BS 5493	Protective Coating of Iron and Steel Structures against Corrosion
BS 5950	Structural Use of Steel work in Building (Limit State)
BS 6031	Earthworks
BS 6367	Code of Practice for Drainage of Roads and Paved Areas
BS 6399	Loading for Buildings
BS 8002	Earth Retaining Structures
BS 8004	Foundations
BS 8110	Structural Use of Concrete
BS 5930	Site Investigation
BS 8000	Foundations
MJ Tomlinson	Pile Design and Construction Practice

2.1.2 Design Life

The permanent works shall be designed and constructed to give the following design lives:

- Locks - 50 years (As per PIANC 2011 workshop)
- Bank protection works - 50 years
- Fenders, Bollards and ladders - 8 years
- Buildings - 50 years

Above design lives are defined as a period within which the asset will continue to be serviceable for design loads without collapse.

2.1.3 Navigational Lock and caisson gate parking bay

2.1.3.1 Loads

A) Dead Load

The dead loads shall be assessed based upon the volume of the material using the following densities:

- Plain Concrete : 2.40 T/m³
- R.C.C. : 2.50 T/m³
- Steel : 7.85 T/m³
- Compacted Earth Fill : 2.10 T/m³ (Saturated)
- Water : 1.00 T/m³

The unit weight of all other materials shall satisfy the requirements of IS:875.

B) Live Load

The live load surcharge equivalent to 1.2m earth fill shall be considered on the top of earthfill as per IRC 6 – 2014

2.1.4 Fendering System

Considering the level variation of the order of 8m between high water level and low water level in the lock and also the variation in the sizes of vessels to be handled, the fendering system is designed such that sufficient contact area between the hull of the vessel and the fender face is ensured at all water levels.

It is required to provide a suitable fender system to keep the vessel's hull pressure below the limit of 20 T/m². Based on these criteria, the fender of AN 800, grade E3.0 of Trelleborg/ Bridgestone/ Hi-Tech elastomers make or equivalent has been proposed.

2.1.5 Mooring Load

Mooring force of 30 T, as per Table-4, IS: 4651- Part III, shall be applied at any of the bollard location.

2.1.6 Earthquake Load

Earthquake load shall be considered in design as applicable for the site as per IS 1893- 2002.

The design horizontal seismic coefficient a_h is calculated based on the following parameters:

- $a_h = Z I (S_a/g) / (2R)$, where
- Z = Zone factor = 0.16 (Zone 3 as per IS:1893-2002)
- I = Importance factor = 1.5
- R = Response reduction factor = 5 (with ductile detailing)
- S_a/g = Average response acceleration coefficient, which depends on Time Period of the Structure the Time Period, T of the structure will be evaluated by STAADAnalysis considering Dead Load and 50% Live Load.

2.1.7 Discharge

Discharge of 1416 cumec (50,000 cusec) shall be considered in the feeder canal.

2.1.8 Scour Depth

Scour depth shall be considered suitably in compliance with IS 14262.

2.1.9 Load Combinations

The above loads with appropriate load combinations, as per IS 4651 (Part 4): 2014 shall be applied on the different components of the Lock.

2.1.10 Minimum Cover

Clear cover to any reinforcement shall be provided as per relevant Indian standards but shall not be less than as given below.

- a) Pile : 75 mm
- b) Pile cap : 75 mm
- c) Top, bottom & side of footing (if any) : 75 mm
- d) Beams : 50 mm
- e) slab : 50 mm
- f) Walls : 50 mm

2.1.11 Serviceability Criteria

Crack Width

The crack width is calculated for service load combinations in accordance with IS:4651(part 4)-2014.

2.1.12 Material Specification

The specifications are as given in this volume.

Structural Concrete	M-40
Leveling Concrete	M-15 (Not less than 150 mm thick)
Reinforcement	Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500

Cement	<p>Ordinary Portland Cement of minimum grade 53 as per IS:8112</p> <p>In addition, cement in accordance with IS:456 and IS:4651 PartIV shall be considered.</p> <p>If Chloride & Sulphate content as per the soil investigation report are found on the higher side than following measures shall be adopted:</p> <p>Chlorides:</p> <ul style="list-style-type: none"> • Prestressed Concrete or grouting Mortar:- 500mg/l • Concrete with reinforcement or embedded metal parts:- 1000 mg/l • Concrete without reinforcement or embedded metalparts:-4500 mg/l <p>Sulphur:</p> <p>The sulphur content of the water must not be more than 2000 mg/l else following measures shall be adopted:</p> <ul style="list-style-type: none"> • Use of Sulphate resistance cement • Low water/cement ratio • Curing suited to the structure
Structural Steel	As per IS:2062 (Grade-A) with minimum thickness of 10 mm
Protective coating to structural steel	Minimum DFT of 240 micron after sand blasting to SA 2.5 grade.

2.1.13 Bank protection Works

Suitable bank protection works shall be designed as per relevant Indian standards or CWC guidelines and other necessary codal provision, to protect river bank along the Lock.

2.1.14 Retaining Wall

The structures shall be designed as per IS 456. In addition to the pressure due to earth or material, the structures shall be designed for surcharge of 1.2m earth fill vehicular loads. For the design of structures, the ground water table shall be considered at ground level.

- Factor of Safety for Overturning : 1.5 (Seismic case)
- : 2.0 (Normal Case)
- : 1.2 (Seismic Case)

- Factor of Safety for Sliding : 1.5
- Check for Base Pressure : Maximum pressure shall not exceed allowable bearing capacity of soil

2.1.15 Diaphragm Wall

2.1.15.1 General

The specifications given below shall be read in conjunction with that given for Bored Piles whenever applicable.

2.1.15.2 Standard

The construction of diaphragm wall shall be carried out in accordance with provision of IS:9556 "Code of Practice for Design and Construction of Diaphragm Walls", except where otherwise specified, described or directed by the Employer's Engineer.

2.1.15.3 Method of Construction

The Contractor must furnish to the Employer's Engineer, along with the tender, a detailed method of construction he intends to adopt for diaphragm walling work together with the program of construction.

2.1.15.4 Guide Walls

Two guide walls of adequate strength shall be constructed in reinforced concrete along the exact alignment of the diaphragm walls. Trenching operation shall commence only after the alignment and adequacy of the guide walls have been approved by the Employer's Engineer. The clearance between the finished diaphragm wall and the guide wall may be a minimum of 100 mm for straight panels. For curved panels, the clearance shall be suitably increased. The top of the guide wall shall be at a suitable

level and the depth of wall under the ground shall be according to the design calculations and drawings as approved by the Employer's Engineer.

2.1.15.5 Reinforcement

Reinforcement shall be mild steel bars conforming to IS:432, high yield strength deformed bars conforming to IS:1786, TMT 500 bars manufactured by SAIL or CRS 500 manufactured by TISCO or equivalent.

Any reinforcement used shall be made up into stiff cages sufficiently well wired or welded to withstand handling without any distortion or damage. The bars shall be so placed as not to impede the placing of the concrete. They should be placed correctly in position and be supported away from the sides of the shaft by means of spacer blocks to assume proper alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the wall without any distortion or displacement. Care shall be taken to preserve the correct cover and alignment of the reinforcement throughout the whole operation of placing the concrete.

Normal lap between reinforcement cages shall be provided in consultation with Employer's Engineer in-charge. The main reinforcing steel shall project for a length sufficient to develop bond above the cut-off level. The clear concrete cover to main reinforcement shall be 75 mm and suitable spacer blocks shall be provided at intervals not exceeding 2 M and wired to main reinforcement.

2.1.15.6 Formation of Panels

The trench shall be flushed properly before placing of concrete to clean the bottom and to remove all thicker suspension from the lower levels. The density of the slurry at a level of about 0.2 metre from the bottom shall then be checked. If the density is more than 1.25 g/ml further flushing should be carried out. Pouring of concrete shall be done only after getting clearance from the Employer's Engineer. Concrete of specified grade with a minimum slump 150 mm shall be placed by a tremie in such a way that the wet concrete displaces the bentonite slurry and a mixing of the two does not occur.

To prevent egress of concrete from the primary panels of the anchor diaphragm wall, suitable stop-end pipes shall be used at the ends of the panels to act as a shuttering.

2.1.15.7 Drilling Fluid

The chemical additives, if any, shall be approved by the Employer's Engineer. The results of the control tests on the bentonite slurry shall conform to the characteristics stipulated in Clause 6.1 of IS:9556.

2.1.15.8 Boring

The construction of the wall shall be either by successive panel method or alternate panel method as instructed by the Employer's Engineer. Trenching or boring operations shall be carried out by any of the recognized processes. The method of trenching shall be such that the finished sections of the diaphragm walls at any locations shall not be less than the specified thickness. During the trenching or boring the sides of the trench shall be supported by the bentonite slurry. Adequate head of the bentonite slurry

shall be maintained throughout the trenching operations. Fresh bentonite shall be added as the work proceeds in order to compensate for any loss through the sides and bottom of the trench as well as for the volume of soil removed.

A stop end tube with a smooth surface or a structural section shall be inserted in the trench at the end of the panel to support concrete and to form a suitable joint with the next panel. The type and method of joints between adjacent panels shall be as approved by the Employer's Engineer.

The trenching operation may meet with subterranean laterite stones/boulders, etc. of earlier construction and the Contractor shall take appropriate measures for cutting through them.

2.1.15.9 Tolerance

The face of the guide wall towards the trench shall be vertical. Variation from a straightline or a specified profile shall not exceed 25 mm in 3 M. The face shall not have any undulations and abrupt changes.

For diaphragm walls, the face of the wall and ends of the panel to be exposed shall be vertical within a tolerance of 1 in 80. There shall be no bulges or cavities. The trimmed final wall level shall be between 150 to 500 mm above the specified wall level.

2.1.15.10 Inspection of Completed Diaphragm Wall

The whole of the completed diaphragm wall works shall be inspected and necessary tests shall be carried out to check for defects such as honeycombing, bulging etc. Any defects that are found shall be rectified by the Contractor.

2.1.15.11 *Fill Material beyond Diaphragm Wall*

The fill material shall be granular (murrum or like) with fines smaller than 75 microns not exceeding 15%.

The maximum laboratory dry density (IS 2720, Part 8) shall not be less than 1.6 T/cu.m.

2.1.15.12 *Water Bars (Water Stops)*

PVC water bars shall be used in reinforced concrete construction of diaphragm wall to safeguard them from hydrostatic pressure and water leakage and any relative movement between two parts of the structure due to thermal loading shrinkage or differential movement of foundations. These shall be pre-formed and shall provide a permanent water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. This shall be able to withstand a water head of at least 15 metres.

Performance requirements of PVC water bars shall meet the requirements of IS:12200. These shall be of approved make and of ribbed/serrated/plane type with a bulb at the centre. The thickness shall not be less than 5 mm and width less than 150 mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

2.1.15.13 *Anchors*

Material for Anchors such as bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant IS Codes.

2.1.16 Internal Roads and Vehicle Parking Area

Internal Roads and Vehicle Parking Area shall be designed with the provision of relevant IRC codes with the following minimum requirement:

Geometric Parameters:

- Maximum longitudinal grade : 3.0%
- Cross slope : Both direction 1.5% for All Roads
- Maximum super elevation : 5%
- Sight Distance : Intermediate sight distance
- Turning Radius at junction : Min. 25 m
- Design Speed : 80 km/hr

Pavement Design:

Traffic : 10 MSA

Specifications:

- ✓ Embankment : Min. density shall be 1.6 T/cum
- ✓ Sub grade : Min. CBR 8% and density 1.75 T/cum
- ✓ Granular Sub Base : Minimum 150 mm
- ✓ CBM Base : Minimum 200 mm
- ✓ Sand Bed : Minimum 30mm
- ✓ Surfacing : Paver Block

The culverts, if any, required for the cross drainage works shall be designed as per the IRC codes.

2.2 ELECTRICAL

2.2.1 General

The contractor shall work as per the drawings and designs described in the Tender document and the best current engineering practice. Particular

attention should be paid to internal and external access to the electrical equipment in order to facilitate inspection, cleaning and maintenance. The contractor shall comply with latest code of practice published by the Bureau of Indian Standards as applicable. Care shall be taken so that materials and equipment supplied by contractor are the standard catalogued products of manufacturers regularly engaged in the manufacturer of such products and shall be of the latest standard designs that conform to the specific requirements.

- a) The essence of design shall be safety, simplicity and reliability in order to give long continuous service with high economy and low maintenance cost.
- b) All equipment shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.
- c) The design shall comply with relevant codes and regulations listed.
- d) All apparatus, equipment and works shall be so designed that they provide satisfactory service without any harmful effects for prolonged and continuous periods in the worst climatic conditions, stated hereinbefore.
- e) The reference design ambient temperature for all electrical equipment shall be taken as 45°C and appropriate de-rating factors shall be considered for equipment as applicable.
- f) Suitable de-rating shall be applied based on published data against the most severe conditions encountered in the site, by reducing the permissible temperature rise above the ambient level.

2.2.2 Errors, Omissions and discrepancies

In case of errors, omissions and discrepancies between technical specification, schedules and drawings the following order shall prevail:

- MOM with contractor in reverse chronological order.

- Technical specifications
- Tender drawings
- Schedule of Quantities
- Bureau of Indian Standards
- International Standards
- In all case of doubt or omissions or discrepancies noticed in any item of work any drawing, the decision of the Employer's Engineer shall be final and binding on the contractor.

2.2.3 Other Technical Requirements

The contractor shall arrange all the instruments, materials and labour involved in setting out the works to the satisfaction of the Employer's Engineer.

2.2.4 Standards and Regulations

The design and manufacture of the electrical equipment shall conform as a minimum to applicable codes, regulations and standards published by the following bodies:

BIS : Bureau of Indian Standards

IER : Indian Electricity Rules

BSI : British Standard Institution

ISO : International Organization for Standardization

IEC : International Electro-Technical Commission

IEEE : Institute of Electrical & Electronics Engineers

NFPA : National Fire Protection Association

NEC : National Electrical Code

Following is the list of some of the directly applicable Standards particular to the equipment. Any other relevant Indian Standard, not covered shall also be applicable.

IS: 375	Marking and arrangement of Switchgear Bus
IS: 13118	Specification for high voltage alternating current circuit breaker
IS: 12729	Switchgear and Control gear for voltages exceeding 1000V - General Requirements
IS: 2705	Current transformers
IS: 3156	Voltage Transformers
IS: 335	New Insulating oils
IS: 2026	Power transformers
IS: 3639	Fittings and accessories for Power transformers
IS: 4257	Dimensions of clamping arrangement for porcelain transformer bushings
IS: 11171	Specification for Dry-Type Power transformer
IS: 10028	Code of Practice for selection, installation and maintenance of transformer
IS: 3427	A.C. Metal enclosed switchgear and controlgear for rated voltages above 1kV and upto and including 52kV
IS: 8623	Specification for low voltage switchgear and control gear assemblies of switchgear & controlgear for voltages not exceeding 1000V AC.
IS: 13703	Low Voltage fuses
IS: 13947	Low Voltage switchgear and controlgear
IS: 1651	Stationary cells and batteries, Lead Acid Type (with tubular positive plates) – Specification
IS: 266	Specification for Sulphuric acid
IS: 3895	Mono crystalline Semi-conductor rectifier cells and stacks
IS: 4540	Mono –crystalline Semi-conductor rectifier assemblies and equipment
IEEE:484	Recommended Design for Installation design and installation of large lead storage batteries for generating stations and substations.
IEEE:485	Sizing large lead storage batteries for generating stations and substations.
IS: 1554	PVC insulated (heavy duty) electric cables for working voltages up to and including 1100 volts.

IS: 7098 -I	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to and including 1100 volts.
IS: 7098 -II	Cross linked polyethylene insulated PVC sheathed cables for working voltages from 3.3 kV up to and including 33 kV.
IS: 10810	Methods of tests for cables.
IS: 418	Tungsten filament general service electric lamps
IS: 1777	Industrial luminaire with metal reflectors.
IS: 1947	Flood Lights
IS: 10322	Luminaires for street lighting.
IS: 1944	Code of practice for design of Street lighting
IS: 2206	Flame proof electric lighting fittings
IS: 2215	Starters for fluorescent lamps.
IS: 2418	Tubular fluorescent lamps for general lighting services
IS: 4013	Dust-light electric lighting fittings
IS: 8224	Specification for Electric Lighting fittings for Division 2 areas
IS: 9583	Emergency lighting units
IS: 9900	High-pressure mercury vapour lamps
IS: 9974	High Pressure sodium vapour lamps
IS: 2713	Specification for Tubular Steel Poles for Overhead Power Lines
IS: 1255	Code of practice for installation and maintenance of power cables up to and including 33 kV rating.
IS: 732	Electrical wiring installation (system voltage not exceeding 1100 V).
IS: 2309	Code of practice for the protection of building and allied structures against lightning.
IS: 3043	Code of practice for earthing.
IS:15885 (Part2/Sec13)	2012 Safety of Lamp Control Gear, Part 2 Particular Requirements Section 13 d.c. or a.c., Supplied Electronic Controlgear for LED Modules
IS:16101: 2012	General Lighting - LEDs and LED modules – Terms and Definitions
IS:16102 (Part 1) : 2012	Self- Ballasted LED Lamps for General Lighting Services Part 1 Safety Requirements
IS:16102 (Part 2) : 2012	Self- Ballasted LED Lamps for General Lighting Services Part 2 Performance Requirements
IS:16103 (Part 1) : 2012	Led Modules for General Lighting Part 1 Safety Requirements

IS:16103 (Part 2) : 2012	Led Modules for General Lighting Part 2 Performance Requirements
IS:16104: 2012	D.C. or A.C. Supplied Electronic Control Gear for LED Modules - Performance Requirements
IS:16105: 2012	Method of Measurement of Lumen Maintenance of Solid-State Light(LED) Sources
IS:16106: 2012	Method of Electrical and Photometric Measurements of Solid-State Lighting (LED) Products
IS:16107 (Part 1) : 2012	Luminaires Performance Part 1 General Requirements
IS:16107-1: 2012	Luminaires Performance Part 2 Particular Requirements Section 1 LED Luminaire
IS:16108: 2012	Photobiological Safety of Lamps and Lamp Systems
IS:60470-2000	High-Voltage Alternating Current Contactors

In addition to Codes and standards, the installation works shall also conform to the requirements of following:

- a) Indian Electricity Act
- b) Fire insurance regulations
- c) Regulations laid down by Chief Electrical Inspector of West Bengal
- d) Regulations laid down by the Factory Inspector
- e) Regulations for the electrical equipment of Tariff Advisory committee
- f) Any other regulations laid down by the authority
- g) Regulation of Pollution Control Board of West Bengal

2.2.4.1 Standardization

Care shall be taken so that the materials and equipment are standard catalogued products of manufacturers regularly engaged in manufacture of such products and shall be of the latest standard designs conforming to specification requirements. Design shall also be based on similar types of electrical equipment supplied from one manufacturer, utilizing interchangeable parts wherever practicable. Materials and equipment

incorporated shall be of a type for which spare parts and replacements are readily available in India.

2.2.5 Earthing and Lightning Protection System

The complete earthing system shall conform to the provision of Indian Electricity Rules, and applicable code of practice for earthing IS: 3043, however for chemical earthing IEEE:80-2000 shall also be followed. Working layout drawings shall be prepared by the successful Contractor. Value of earth resistivity shall be considered as per the areas indicated in IS:3043 or the actual value as obtained from the site from previous records available with the employer, if any.

All Non-conducting structures shall be provided with Lightning protection consisting of Air termination network at the top and down conductors as per IS/IEC 62305:2010 (Superseding IS-2309: 1989). All Structures made of conducting material shall be protected by adequate earthing arrangements and air terminations at the top as per IS/IEC 62305:2010. Conductors shall be Galvanized Iron (GI) of suitable size as per IS/IEC 62305:2010. Buried lightning grid conductors of 75mm x 8mm size shall be provided for interconnection of the Lightning earth pits around individual building. The same shall also be connected with the main plant earth grid at places through isolating link installed in Earth pits.

2.2.5.1 Earthing Below Ground

- a) The main earthing grid shall be buried below ground unless required otherwise. For crossing any trench or under-ground pipe minimum earth coverage of 500 mm shall be provided over the earthing conductor.
- b) Where the earthing conductor passes through reinforcement or steel

plate it shall be bonded to the same.

- c) All building steels and columns shall be bonded directly to the earthing grid.
- d) The riser/pigtails from earthing grid shall project 600 mm above grade/concrete level unless shown otherwise.
- e) All earthing conductor connections shall be made by electric arc welding or by nuts and bolts using plain washers and spring washers.
- f) All arc welding shall be carried out with low hydrogen content electrode.
- g) All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. No artificial cooling should be adopted to cool welded joints.
- h) The welding required for earthing shall serve the following three purposes (i) sufficient mechanical strength between the jointing materials (ii) sufficient electrical area for the flow of system short circuit current and (iii) sufficient electrical area available after commissioning during the life time of the plant.
- i) Before welding, the earth conductors shall be clamped tightly to ensure good surface contact at welding points.
- j) Before applying bitumen compound two coats of red oxide primer shall be applied to risers and exposed portion of earth grid, if any. Construction joints shall be given treatment with Barium Chromate before applying red oxide paint and bitumen.
- k) Earthing shall be mechanically robust and all joints shall be capable of retaining low resistance even after passages of many fault current.
- l) All the connections are to be made carefully and properly. Improper/poor connections are to be remade at the cost of Contractor.
- m) Welded areas of risers/pigtail shall be thickly coated with bitumen compound to prevent corrosion.
- n) Earthing pits/conductors shall be laid in field to avoid fouling with concrete foundations and in consultation with the Employer at site.

- o) Trenches shall be filled up with 'Free of Stones' earth after laying earth conductor. After filling up of trenches the earth shall be rammed carefully.
- p) The successful Contractor shall submit detailed working drawings of earthing grid for approval by Employer prior to construction of the grounding system.
- q) The rate quoted shall be inclusive of cost of all materials, labour required for excavation, backfilling, welding, cutting, bending, placing of GI strips etc. complete as per specification.
- r) All tests as per relevant standards shall be conducted to certify the effectiveness and other requirements of the earthing grid.
- s) Depth of laying of earth conductor for earth grid, ring and inter-connections shall generally be min. 500 mm from ground level and 300 mm below all foundations.
- t) Erection of earth pits shall include making of masonry enclosure and supply of chemical and other materials.

2.2.5.2 Earthing Above Ground

- a) The successful Contractor shall lay the above ground earthing conductors inside the buildings and on various structures for connection to various equipment/ drives etc. These earthing conductors may be installed within the cable trays in the form of runway conductors. The connection to equipment shall be tapped from these runway conductors at suitable locations. One runway conductor shall be provided for each side of cable trench/tray.
- b) The neutral points of all earthed system of different voltages, all equipment frame works, other non-current carrying metallic structures and equipment such as motor frame enclosures of MCCs, panel boards, cable armour, cable trays, sheaths etc. shall be earthed by a minimum of two separate and distinct connections.
- c) Armour of all power and control cables shall be earthed at both ends through gland earth ring provided with the cable glands.
- d) All cable trays and supporting structure are to be earthed. All cable tray

sections shall be bonded with each other for continuity.

- e) All earth leads and riser connections shall be as short as possible.
- f) Metal pipes and conduits through which cables run shall be effectively bonded and earthed.
- g) Neutral connection shall not be used for equipment earthing.
- h) All connections to earth conductors shall be welded/bolted type. Earthing connections to all equipment shall be bolted type.
- i) Earthing conductor along their run on steel columns, beams etc. shall be tack welded at intervals of 1000 mm.
- j) All joints in earthing conductor shall be welded type. All joints shall be welded with an overlap of 65 mm. Joints shall be thoroughly cleaned before welding. Welding is to be done around joint completely. All joints shall be given two coats of anti-corrosive paint (Red Oxide) to a thickness of 3-5 mils, followed by a coat of bitumen paint. Joints shall be thoroughly cleaned before applying paints.
- k) All nuts, bolts washers etc. shall be cadmium plated or zinc passivated. Generally, earthing studs and terminals shall be provided on all equipment. In such cases, where it is not provided, the Contractor shall have to drill and tap the equipment for deriving earth terminals.
- l) Connections of earthing conductors to the main earthing loops or to equipment shall generally be made by means of cable lugs in case of round conductors, solid or stranded and directly in case of strips. Devices like spring washers and lock washers must be used to ensure that the connections are vibration proof.
- m) Laying of earthing conductor shall include fabrication and fixing of clamps, cleats and supply fixing device i.e. nuts, bolts, washers as also civil work such as preparation of floor surface and finishing them to the finished floor level after installation of earthing strips.

2.2.5.3 Earth Pits for Earthing and Lightning Protection Systems

Earth pits shall be based on High Conductivity Technology. In this technology of chemical earthing, a compound of high electrical conductivity shall be filled up in the space around the ground electrode, so that the earth resistance value would decrease appreciably. The high Conductive Compound shall be able to perform in any weather and soil Conditions and shall have following properties;

- I.It shall have high electrical conductivity, which should remain constant and unaffected by changes in temperature & moisture.
- II.It shall permanently remain embedded and should neither dissolve in and swept away by water.
- III.It shall have an ability to absorb large amount of water and retain the same over along period of time.
- IV.It shall decrease earth pit resistance with passage of time.
- V.Solubility: Shall be partly miscible; so that it does not dissolve fully like common salt and thus increasing the Earth Pit Life.
- VI.The pH value shall be near neutral so that it does not pollute soil or water and also does not corrode earth electrode.
- VII.It shall be maintenance free Compound so that there shall be no need of extra water pouring at regular interval as in conventional earthing material, because it should retain the moisture.
- VIII.Chemical Compound shall be thermally conductive, in order to maintain a constant Earth resistance in temperature range of -50 to +60 degree Celsius.
- IX.The Compound shall have relatively High conductivity so that it can create very low resistance even in rocky areas.
- X.It shall have low earth resistance, carries high peak current repeatedly.
- XI.It shall have a Long and reliable life.

XII.It shall be easily installed in any soil conditions.

Minimum Electrode size shall be as per the latest amendments of IS:3043. Earth electrodes/ plates for body earth, DG & transformer neutral, Instrumentation earthing and Lightning earth pits shall be selected as per the latest amendments / requirements of IS:3043.

All earth electrodes comprising an earth system shall be connected together with a continuous ring of earth tape. After installation, test shall be made to ascertain that the earthing resistance hereinafter specified is obtained. If the required resistance value cannot be obtained, a sufficient number of additional pipes shall be installed, until the resultant resistance not exceeding the specified value can be obtained.

In all cases the pipes shall be driven such that their zones of earthing do not overlap. Each earth electrode shall be connected to its associated earth tape through a linked connection. The link shall be installed as close to the earth electrode as possible. Each earth electrode shall be enclosed together with the link in a reinforced concrete hand-hole with cast iron cover, which shall be set flush with the ground.

2.2.5.4 Earth System

The Contractor shall furnish and install a 75 x 8 mm GI strip as the main grid. The resistance between any point on each earthing system and the earth electrode shall not exceed 0.1 ohm. The overall resistance between the earthing installation and the general mass of earth shall be less than 1 ohm.

The main earthing bars shall be so placed that earthing terminals of major equipment and where required cable sheaths to be earthed, can be readily connected to them. Branch connections from the main earth bars shall be provided to all switchboards, power transformers, capacitors, Control Consoles, distribution boards, etc. The bonds shall be made to the cable glands on which the lead sheath shall be plumed and the armour clamped. All steelwork supporting electrical equipment shall be bounded to the main earthing bars.

The Sizes of GI earth bus and earth wires shall be as follows:

Main earthing grid	75 x 8 mm GI strips
Riser upto ground level	75x8 mm GI Strip
HT & LT switchboards, MCC panels, cable trays, LT motors above 30kW	40 x 6 mm GI strip
High Masts Earthing	40 x 6 mm GI strip
LT Motors > 3.7kW & upto 30kW	25 x 6 mm GI strips
Control desk/Panel, LDB, Weld socket	25 x 6 mm GI strips
Structures	25 x 6 mm GI strips
Lighting panels, Distribution Boards etc.	25 x 6 mm GI strips
LT motors below 3.7kW	8 SWG GI Wire
Junction boxes, Field instruments, Gland earthing Lighting fixtures, 15A switch sockets	8 SWG GI Wire
Air Conditioner	8 SWG GI Wire

Joints, termination, fixing of the earth bars and their protection from corrosion shall be in accordance with the recommendation given in the aforementioned code of practice subject to the additional requirements specified herein. GI tapes shall be secured at intervals not exceeding 1m by means of single-screw fixing purpose made gunmetal saddle of a pattern approved by the Employer. The tapes shall run in square and symmetrical

lines. Links shall be provided in the system adjacent to all junctions to enable tests to be carried out from time to time. All links shall have high tensile steel bolts and the nuts shall be tightened by means of a torsion spanner. All joints in exposed sections shall be protected against moisture and corrosion by the application of two coats of anticorrosive paint and shall be taped with self-adhesive PVC tape.

2.2.5.5 Earthing of Equipment

- I. All lighting panels, junction boxes, receptacles, fixtures, conduit etc. shall be grounded in compliance with the provision of I.E. rule.
- II. Ground connections of Control room shall be made from nearest available 75 x 8 mm ground grid. All connections to ground grid shall be done by arc welding.
- III. Lighting panels shall be directly connected to ground system grid by two nos. 25 x 6 mm GI strip at two different locations.
- IV. A continuous ground conductor of 8 SWG G.I. wire shall be run all along each conduit run and bended at every 600mm by not less than two turns of the same size of wires. This conductor shall be connected to panel ground bus. All junction boxes, receptacles, lighting fixtures, etc. shall be connected to this 8 SWG ground bus.
- V. Earthing of High Mast light towers shall be done by connecting 2 nos. of 40x6 GI strip at two different places.

2.2.5.6 Lightning Protection System

Lightning protection system shall be provided for all the buildings and structures covered under the Scope as per the provisions contained in the

latest issues of Indian Electricity Rules and IS/IEC 62305:2010 (Superseding IS-2309: 1989). Lightning protection system shall comprise of air terminations, down conductors, test links, earth terminations & earth electrodes.

Material for lightning protection conductor shall be as follows:

- 75 x 8 mm Galvanized steel strip for interconnection between the various earth pits and riser.
- 50 x 6 mm Galvanized steel strip for Down Conductors
- 25 x 6 mm Galvanized steel strip for horizontal conductor on roof along the periphery on parapet wall.
- 20 mm dia 1000 mm long Galvanized steel rod for Vertical air termination
- 40 mm dia 3 m long Galvanized Steel pipe of 6mm thickness with earth pit for Earth termination

Air termination network shall consist of vertical or horizontal conductors or combination of both. Down conductors should follow the most direct path possible between the air terminal network and the earth termination network. The down conductors should be arranged as evenly as practicable around the outside walls of the structure. Each down conductor shall be provided with a test link for testing. An earth electrode with treated earth pit shall be connected to each down conductor.

2.2.6 Lighting System

2.2.6.1 General

This specification covers design requirements, supply and installation of lighting system for the project including all buildings and structures.

All equipment and materials shall be suitable for the system voltage. All materials and works shall comply with IS code of practices, Indian Electricity Rules and regulations. The lighting system of particular area whether indoor or outdoor shall be designed in such a way that uniform illumination is achieved. As far as possible, dark spots shall be avoided. This requires careful placing of luminaires, selection of proper mounting heights and provision of supplementary lighting, wherever required. The type of lighting adopted shall provide adequate level of glare-free illumination, without creating undesirable shadows. Design of lighting layout shall be based on the minimum lighting intensities at the working plane and the type of luminaire specified as under:

Location	Average lux level	Type of Luminaire
Outdoor Area	30	2x400W HPSV twin lamp & 1x1000W Flood Light, weather proof, Heavy duty High Mast (30 m) in die cast Aluminum alloy housing
Boundary Wall	20	Single Arm Street light poles with GI pipe of 3.5m height (1 m Tilted at 45 degree & 2.5 m straight) above boundary wall with 30W LED luminaires @ 15m distance
Control Room Building (Ground Floor), DG & Transformer Room, & Local Control Panel Rooms	200	General Purpose Industrial compact batten suitable for 2x20 W LED Tube Light fitted with Aluminium heat sink

Control Room Building (First & Second Floor)	300	34Watt LED Panel with ultra-modern recess mounting luminaire suitable for armstrong/grid/POP ceiling complete with separate electronic driver & high brightness Surface Mounted Device(SMD) LEDs
Control Room Building (Ground, First & Second Floor) & Local Control Panel rooms & at all entry / exit points etc.	10 (Minimum)	Battery operated emergency lighting unit consist of aesthetically designed rechargeable 5 Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type & 5V DC Li-ion charger with 1 hour battery backup.

2.2.6.2 Luminaires

- a) All luminaires shall be industrial/decorative type as specified. Where the specific type of luminaire is not indicated, the Contractor shall select suitable type of LED luminaires to meet the requirement. Special luminaires may be provided when required by the seeing task or architectural treatment. The number of different type of luminaires and their wattages shall be minimum consistent with the lighting requirements.
- b) While using discharge lamps, stroboscopic effect shall be minimized by various methods, which should be considered while planning lighting installation. All fluorescent fittings shall be of rapid start type and shall be so arranged that the power factor will be 90% or higher.
- c) All luminaries alongwith its terminal boxes shall have IP56 degree of enclosure protection for internal areas and IP65 degree of enclosure protection for external areas and battery room.

2.2.6.3 Emergency Lighting

For safety and protection of personnel and for shutdown of the equipment, battery operated lighting units shall be installed as a part of fixed wiring system. Battery operated lighting unit shall consist of aesthetically designed rechargeable 5-Watt LED lantern with dimming and SOS feature. Battery shall be rechargeable Li-ion type with fully automatic 5V DC Li-ion charger, transfer switch to automatically transfer from main supply to the battery

and vice versa. The charger shall be capable of recharging fully in 12 hours. The unit shall operate on 1 Ph 240 V 50 Hz. Emergency lighting shall be designed to ensure minimum 10 lux in all the areas to ensure safe evacuation of persons in case of failure of both mains and DG supply.

2.2.6.4 Lighting Installation

All installation shall be of rigid steel conduit executed to IS: 1653. Minimum diameter of conduit used shall not be less than 19 mm. Conduits shall be concealed wherever practicable. The number and size of wire in any conduit shall not exceed that stated in IS regulations. Not more than three (3) lighting circuits or two (2) socket circuits shall be bunched in the same conduit. The wiring from the lighting panel to the outdoor lighting fixtures shall be done by PVC armoured, 650/1100V grade cable. For control room lighting stranded Cu conductor shall be used. The minimum size of conductor shall be 2.5 sq. mm. copper.

2.2.7 Switchgear

Design of the Switchgear shall be in accordance with the requirements of these specifications and the best current engineering practice, together with the following general requirements:

- a. Switchgear shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.
- b. All panels, boards, etc. shall be suitably labeled with labels of design approved by the Employer's Engineer.
- c. Equipment shall be installed indoor/outdoor in a hot, dry climate. All equipment, accessories and wiring shall be provided with tropical finish to prevent fungus growth.
- d. Maximum temperature rise in any part of the equipment at specified

rating shall not exceed the permissible limits as stipulated in relevant standards. The de-rating, of the equipment shall be made taking 45°C as an ambient temperature.

- e. The rated peak short circuit current or the rated short time current carried by the equipment shall not cause:
 - Mechanical damage to any part of the switchgear.
 - separation of contacts
 - insulation damage of "Current Carrying Part"
- f. Transformer primary circuit breakers and the secondary circuit breakers should be arranged for inter-tripping as follows:
 - Tripping of transformer primary circuit breaker, either manually or automatically on fault shall intertrip the transformer secondary circuit breaker.
 - Tripping of the transformer secondary circuit breaker on fault shall intertrip the transformer primary circuit breaker.
 - Manual tripping of the transformer secondary circuit breaker will not intertrip the transformer primary circuit breaker.
- g. All controls shall be suitable for 240V AC / 110V DC.
- h. At least 20% spare with at least one number of each type of feeder shall be provided as spare on either side of the BUS for LT Panels. The spare feeders selected shall be with highest rating in the event of reoccurrence in same type.

2.2.8 Cables

2.2.8.1 Cable Selection Criteria

- A. HT (11KV) Cables Fault level withstand KA:**
 - 1 sec. for Main incoming cables
 - 0.5 sec. for outgoing feeder cables
- B. LV Cables Fault level withstand kA:**
 - 1 sec. for Main incoming cables from Transformer

- For outgoing feeder cables, withstand time based on fault clearance time of ACB/MCCB

C. Permissible Voltage drop in Cables:

- Transformer to Switchgear Busbars: - 1%
- Switchgear, PCC to Motor: - 3%
- Switchgear, PCC, ACDB, MLDB to Lighting DB (LDB): - 2%
- LDB to farthest lighting fixture in the circuit: - 2.5%
- Starting Voltage drop of Motor: 15%
- Running Voltage drop of Motor: 3%

D. Other factors to be considered: -

- Short circuit capacity to be considered while selecting HT cables
- Factor for Ambient temp. 45°C
- Grouping Factor for Cables laid touching in single/ multitier racks.
- Grouping Factor for Cables laid Buried
- 10% reserve capacity in cable over the load current requirement.

The cable shall be laid on cable trays / in cable trenches in Control room.

In some cases, cables may also be laid buried.

2.2.8.2 Cable Laying and Terminations

The cables shall be laid using the following methods.

- Laying direct in ground
- Laying in pipes
- Laying in Concrete trench
- Laying in cable tray running along cable corridor

While laying the new cables or rerouting the existing cables, successful Contractor shall take all safety measures and manual excavation operations are preferred.

I.Laying Direct in the Ground

Laying and installation of directly buried cables in ground shall conform to the requirements of IS:1255. This shall consist of excavating suitably dimensioned trench in ground, and directly laying cable on a bedding of riddled soil free from potentially corrosive elements, or sand at the bottom of the trench encasing cable with half round cut pipes, covering cable with additional riddled soil or sand, and filling up the trench. Depth of laying and formation of cables shall be as per IS:1255. A minimum separation of 300 mm shall be maintained between power and communication cables.

II.Drawing into Pipes

This system shall consist of required number and size of double wall corrugated pipes conforming to applicable requirements of IS or BS with simplex joints. Conduits shall be completely enclosed in concrete. Clearance between conduits comprising a duct shall be 50 mm on the sides, bottom and top. Conduit joints in concrete encasement may be placed side by side horizontally but be staggered at least 15 cm vertically. Duct lines shall be laid to a minimum gradient of 1:300. Conduit shall be thoroughly cleaned before using or laying. Particular care shall be taken to keep the conduits clean of concrete, dirt and any substance during the course of construction.

The cable route shall be generally be indicated by painting the concrete slabs. Where ever applicable cable route markers circular in shape galvanized and route direction indicated by an arrow shall be provided. This system of cable laying shall be adopted while cable is to be laid a

cross roads, railway lines, water ways, and in such situations where subsequent excavation of a trench is both expensive and inconvenient.

III. Laying in Concrete Trench

- This system of cable laying shall be adopted inside Control Room.
- Ladder type & Perforated type FRP cable trays shall be used for cables in the RCC trench.

Successful Contractor shall prepare actual drawings as per the requirement and obtain approval from the Employer before executing the same.

2.2.8.3 Cable Trays and Fittings

The size of cable tray shall be to suit the cable requirement of the particular section. However, successful Contractor shall provide the number of cables and tray size required.

A. Design Requirements and Construction

Cable trays and accessories shall be Fibre Reinforced Plastics (FRP) as per NEMA FG 1 1984- 1993 with minimum thickness of 3mm upto 200mm width and 4mm above that. Horizontal rung spacing shall be 250mm.

Cable trays shall be in piece length of 2.5 meters. Tray ends shall be connected to either other straight tray or horizontal elbow, vertical elbows, Tee, cross, reducer etc. by using coupler plates. The bending radius on minor side of bends shall be 600 mm. Bends of lesser/bigger radius shall be made if warranted. Cable trays shall be supplied complete with side coupler plate and necessary nuts and bolts. Required number of reducers, bends, crosses, tees shall also form part of the supply.

To facilitate assembly, all accessories at ends shall have 100 mm straight portion. The width and length of trays and accessories shall be within a

tolerance of ± 3 mm. The Contractor shall have to secure racks and supports by suitable methods on available building/structural steel and the required accessories shall form part of the supply. In some areas, the Contractor may have to secure the supports on wall, ceiling or floor by suitable anchoring.

Fifty (50) percent spare space shall be provided in the cable trays, racks and risers.

All welded joints shall be smooth enough to provide a good appearance and shall not cause any injury to working personnel or any damage to the cable laid directly on it. All welding work shall be carried out by electric arc welding method only. Necessary welding sets, all consumables etc. to be arranged for the Contractor.

Successful Contractor shall prepare the actual drawings as per the requirement and obtain approval from the Employer before executing the same.

B. Cable Clamps

Trefoil clamps for single core cables shall be pressure die cast aluminium (hot galvanized) or fibre glass or nylon "claw" type and shall include necessary fixing accessories like GI nuts, bolts, washers etc. Trefoil clamps shall have adequate mechanical withstand capability in case of a fault and shall be tested and proven type. For clamping the multicore cables self-locking, de-interlocking type nylon clamps shall be used.

C. Cable Glands and Lugs

Double compression type tinned, of coating thickness 20 microns, brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof sealing. Rubber components used in cable glands shall be neoprene or synthetic rubber and of tested quality.

Cable lugs shall be tinned copper of approved design/make, solderless crimping type conforming to IS. Cable lugs for control cables and special cables shall be suitable for copper cable. Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided on the equipment. Crimping tool used shall be of approved design and make.

2.3 HYDROMECHANICAL

2.3.1 Codes and Standards

The codes and standards stated here below or elsewhere in these documents shall be the latest editions prevailing till October 2015. All materials, testing, design and execution shall be in conformity with these codes and standards unless otherwise stated in these specifications. It is well understood that when a brand name is given for a material, the Contractor has the right to propose any equivalent material of any other brand for approval of the Employer.

Indian Standards shall generally be followed. In case, any work or item is not covered by the Indian Standards, following standards shall be adopted in order of preference.

1. British Standards
2. American Standards

3. General Standards

Wherever details for part of works are not defined adequately in Indian Standards, relevant acceptable International Standards shall be adopted. Codes and standards covering the major part of the works are included in the Tender Document and some of them are listed below:

Rules and regulations of any IACS member classification societies in respect to structural design, pumps, valves, piping, electricals and control system.

BS6349-Part 3	Designing of dry docks, locks, slipways and shipbuilding berths, shiplifts and dock and lock gates.
BS5400-Part 3	Code of practice for design of steel bridges.
IS:4623	Recommendation for standard design of radial gates.
IS:4622	Recommendations for structural design of fixed wheel gates.
IS:5620	Recommendation for structural design criteria for low head slidegate.
IS:9349	Recommendation for structural design of medium and high headslide gate.
IS:7718	Recommendations for inspection, testing & maintenance of fixedwheels and slide gate
IS:10096 (Part I to III)	Recommendations for inspection, testing & maintenance of radialgates & their hoists
IS:6938	Code of practise for design of rope drums and chain hoists forhydraulic gates.
IS:10210	Criteria for design of hydraulic hoists for gates.
IS:3029	Structural steel for construction of hulls of ships.
IS:2062	Hot rolled medium and high tensile structural steel.
IS:2985	Steel castings for ships structure.
DIN 19704 (Part 1, 2 and 3)	Hydraulic steel structures.
Engineers Manual 1110-2- 2105	Design of Hydraulic Steel Structure
IS:1570 Part V	Corrosion resistant steel

IS:800	Code of practice for general construction of steel.
IS:2595	Code of practice for radiographic testing.
IS:7307	Approval tests for welding procedures (Part 1) of steel.
IS:7310	Approval tests for welders working to approved welding procedures of steel.
IS:7318	Approval tests for welders when welding procedures approval is not required.
IS:11855	Guidelines for design and use of different types of rubber seals for hydraulic gate.
IS:14177	Guidelines for painting system for hydraulic gates.
IS:15466	Rubber seals for hydraulic gates – specifications.
ISO:12944	Corrosion Protection of Steel Structures by Protective Paint System
IS:1239	Steel tubes, Tubulars and other wrought steel fittings
PIANC Guidelines	Design and Operation of gates, impact of seismic loads and ship impact on lock gates.
AISC	Load and Resistance Factor Design Specification for structural steel buildings.

2.3.2 Lock Gate Size and Numbers

Type of Gate	U/S		D/S		Nos.
	Height	Width of Lock Opening	Height	Width of Lock Opening	
Mitre Gate	13.94 m	25.15 m	13.94 m	25.15 m	2
Caisson Gate	13.94 m	25.15 m	13.94 m	25.15 m	2
Radial Gate	2.210 m	2.210 m	2.21 m	2.210 m	4
Bulk Head Gate on U/S of upstream radial gate. Type A	2.210 m	3.658 m	-	-	2
Bulk Head Gate on D/S of upstream radial gate. Type B	2.210 m	3.268 m	-	-	2
Bulk Head Gate for D/S radial gate. . Type C	-	-	2.210 m	2.210 m	4

2.3.3 Design Life

The gates shall be designed as per the following design life considering proper maintenance.

Gate Structure – 30 years

Electro Hydraulic and Mechanical components – 15 years Pumps

Valves and Piping – 10 years

2.3.4 Range of Differential Water Levels

All the gates should be designed for the differential water head considering maximum water level i.e., 26.3 m on one side and other side considering empty.

2.3.5 Load considered for Structural Design

Gates shall be designed for the following loading conditions:

- All static and dynamic hydraulic loads due to differential water levels mentioned above.
- All loads due to dead weight and frictional forces.
- Accidental impact from 3000 DWT fully loaded barge on Caisson and Mitre gate.
- Seismic / wind load as per IS:800-2007.
- All temperature loads as per IS:800-2007.
- Loadings from small forklift trucks of 1 T capacity on the top deck of caisson gate.
- Induced pressure during de-ballasting operation of the caisson gate on the waterballast tank plate work and piping system.

The stresses for the design of mitre, radial and bulkhead gates shall be as per IS: 4622, IS: 5620 and IS: 9349.

2.3.6 Structure and Scantling

The envelope plating and all structural members (primary & secondary) of caisson and mitre gates shall be designed as per Rules of any IACS

member Classification Society. However, thickness of envelope plating and all primary structural members shall be 25% over Rule requirement. Scantling of all secondary members to be 15% over Rule requirement.

2.3.7 Design Method

The sizing of structural plating and stiffening of the gate shall be based on the above-mentioned loading criteria and hydrostatic pressure. The slenderness, buckling resistance and yielding of each plate panel, stiffener and beam members shall be assessed for finalising the structural design. The rules and regulations of any IACS member of classification society will have to be followed in addition to BS-6349: Part 3 and design calculations with detailed drawings need to be approved by the classification society for caisson gates. Maximum combined stresses shall be checked to be less than the allowable stresses given in BS-5400 Part 3 or any equivalent Indian Standards. A minimum load factor of 1.2 shall be used as per BS-5400 in conjunction with water levels mentioned above.

Contractor shall formulate a design methodology based on relevant BS & IS codes for mitre radial and bulkhead gates and obtain the approval of the classification society for sizing the structural components.

2.3.8 Operation System

Caisson Gate: By filling up top buoyancy tanks from river water by gravity and draining the same from end tanks during floating operation through drain valve. Caisson gate shall be capable of being ballasted or de-ballasted in 30 minutes or less. Normal raising and sinking operation shall be carried out using suitable valve arrangement without the operation of pumps. However, for any emergency, provision of pumping water from

lower tanks to top tanks by means of electric driven submersible pumps shall be made.

Mitre Gate: To be operated through electrohydraulic system to achieve opening and closing time preferably in 3 mins (not more than 5 mins)

Radial Gates: To be operated through electro-hydraulic system to achieve opening and closing time preferably in 1 min (not more than 2 mins).

Bulkhead Gates: To be operated by rope drum hoists.

2.3.9 Floatation and Stability – Caisson Gate

Downstream lock approach channel has water depth of 5.28m. There is no tide effect in the approach channel. Gate shall be designed to be floated in and out of the lock entrance. The gate shall float with sufficient stability at light ship draft such that it can be safely maneuverer in and out of the entrance. The gate shall also remain stable during sinking and raising operations.

The following floatation and stability criteria shall be considered:

A minimum metacentric height of 0.6 m during sinking and raising operation

I. A positive preponderance shall be achieved when the gate is on the sill during all states of lock water levels.

II. Minimum freeboard during floating condition – 0.6 m

III. Minimum under keel clearance at lightship draft – 0.5 m

IV. The gate shall be capable of being ballasted for de-ballasted in 30 minutes or less.

The Contractor shall design and locate the tanks to accommodation sufficient ballast weight for the sinking of the gate during all states of lock

water levels with a positive preponderance. The sequence of the valve operations and the conditions of various tanks/compartments (full or empty) before starting the raising or lowering operation of caisson depends on the detailed design to be carried out by the contractor.

2.3.10 Corrosion Protection and Corrosion Allowance

The gates shall be coated with anti-corrosive and anti-fouling paint system to achieve minimum guarantee life to first maintenance of 15 years as per ISO: 12944.

To supplement the coating protection, it is proposed to provide aluminium alloy sacrificial cathodic protection which shall have a planned life of 15 years.

A corrosion allowance of 1mm per wetted face shall be taken in normal thickness of all steel plate and sections of the gates.

2.3.11 Material:

Lock gate envelope plating and primary

Structural members	Ship building quality steel (IS:3039)
Secondary structural members	Hot Rolled Medium & High Tensile Structural Steel (IS:2062)
Seals	Rubber (IS:11855 & IS:15466)
Polished Building Stones Specifications	Granite (IS:14223 – Part I)
Seal Seats and fasteners	Stainless steel (IS:1570 Part V)
Bushings	Bronze (IS:305, IS:318)
Guide Roller	Cast steel (IS:1030/IS:2014)

Guide Roller pin	Corrosion resistant steel (IS:1570 Part V)
Wheels	Cast steel / forged steel (IS:1030, IS:2004)
Wheel pin	Corrosion resistant steel (IS:1570 Part V)
Ballast	Cast Iron (IS:210) or concrete
Components of Hydraulic System	IS:10210 & DIN 19704
Valves	2% Ni-Cast Iron
Piping	G.I. (IS: 1239)

All the materials shall be approved IACS member of classification society, engaged for design and drawing approval.

2.3.12 Fatigue and Fracture Criteria

All possible modes of failure should be considered while designing lock gates. Possible failure modes are:

- I. General yielding or excessive plastic deformation.
- II. Buckling or general instability.
- III. Subcritical crack growth leading to loss of cross section or unstable crack growth.
- IV. Unstable crack extension leading to failure of a member.

Failure modes 1 and 2 are addressed by Load and Resistance Factor Design (LRFD) and Allowable Stress Design (ASD) principles whereas failure modes 3 (fatigue) and 4 (brittle fracture) can be addressed using fatigue and fracture mechanics principles. Welded

construction with its emphasis on monolithic structural members has led to the increased desirability of including fracture criterion in addition to

strength and buckling criteria when designing a structure. Stress range detailing and the number and frequency of load cycles control fatigue, while geometry, toughness, and stress levels control fracture. In these aspects, Appendix B of Engineer Manual (EM) 1110-2-2105 (Design Criteria for Mitre Gates) and IS:800 shall be followed for fatigue consideration of gates.

2.3.12.1 Fatigue requirements

Fatigue can be controlled by stress range and the number of frequencies of load cycles. While the number and frequency of load cycles are usually controlled by the structure's purpose, for control of stress range, AISC (Current Edition) Appendix 'K' (which covers concentrated forces, ponding and fatigue pertaining to design for cyclic loadings) shall be considered.

2.3.12.2 Fracture Control Requirements

The fracture of critical members is defined as "members and their associated connections subjected to tensile stresses and whose failure would cause the structure to be inoperable. In this connection for minimum Charpy V-Notch impact test values, EM-1110- 2-2105 and relevant IS Codes shall be considered.

2.3.13 Water-tightness of Gates

The allowable average water leakage tolerance of gates under any head and without the use of any additional sealing material per metre length of seal shall be 0.10 l/s.

2.3.14 Design Certification

The design of caisson gates will be as per the rules of any IACS member classification societies. The classification society for design approval will verify all design calculations, and approve construction drawings.

For Mitre, Radial and Bulkhead Gates, the Contractor will formulate a design methodology based on the relevant BS & IS codes pertaining to structural design and obtain approval of classification society accordingly on design calculations and construction drawings.

The charges of classification society will be borne by the Contractor.

3. GENERAL REQUIREMENTS

3.1 SITE ACCEPTANCE AND MOBILIZATION/DEMOBILIZATION

3.1.1 Acceptance of Site

In accordance with these specifications, the Contractor shall have examined the site and familiarized himself with all existing conditions. He shall accept the site in its existing condition at the time of award of contract.

3.1.2 Mobilization

Upon award of the Contract and within a reasonable time but not exceeding 2 months the Contractor shall mobilize all such labour, equipment and materials that are necessary to complete the project in due time.

3.1.3 Demobilization

Upon due performance of the Contract and before the Taking Over Certificate is issued to the Contractor, he (the Contractor) shall demobilize all such labour, equipment and materials that are necessary to clear the site within one (1) month to the Employer's satisfaction.

3.1.4 Access

The Contractor shall provide and maintain adequate access to the project site and all areas related to the works at his expense. If existing roads are to be used for access to the site, the Contractor shall maintain such roads for the duration of their use.

3.1.5 Permits and Licenses

Except as expressly stated in the Employer's Responsibilities, the Contractor shall obtain all permits and licenses necessary for the execution and completion of the Works. The Contractor shall pay all associated fees including royalty. He shall also give the Employer a copy of all relevant

correspondence and other documents relating to the Contractor's permits and licenses.

3.2 TEMPORARY WORKS

The Contractor shall design, install and maintain all temporary facilities required for the construction of facilities under this contract Package, throughout the execution of the work and remove the same on completion of the works. He shall provide all such buoys, fencing, watching, lighting, water supply, disposal of waste water, connections to public utilities etc. as he needs or as required by authorities and shall install and use his temporary facilities in accordance with all statutory regulations and the requirement of the relevant authorities.

The Contractor shall submit his plan for temporary works to the Employer, for approval, within 30 days of award of contract.

The Contractor shall establish a site office, laboratory, stores, workshop, toilet block separate for ladies and gents for construction workers and staff etc. at the work site. The tentative location of the temporary buildings is shown in Drawing No. ENL013. The temporary structures shall have dimensions sufficient to serve their purpose throughout the duration of project. All the buildings/facilities shall be kept clean and serviceable at all times.

Temporary construction shall be adequate for intended uses and for all loads imposed without excessive settlement, deflection or deformation. All parts and members shall be properly strengthened to prevent displacement or failure.

Before or upon completion of work, unless otherwise required or directed, preparatory structures, installations and utility services shall be disconnected and removed from the site.

3.2.1 Utilities/Temporary Buildings

Temporary utilities used for construction shall have to be adequate for the intended uses and not to be overloaded or otherwise used or arranged in any manner endangering persons, premises or works. Connections shall be properly made, lines and wiring securely anchored in place and protected against accidents.

3.2.1.1 Water

The Contractor shall provide his own arrangements for sourcing and for distribution adequate supply water for the Project including:

- Drinking water: Providing and maintaining canisters, coolers or connected drinking fountains of sufficient number to reasonably serve the Project.
- Construction water: Providing and maintaining temporary water service and distribution of adequate capacity for construction

He will obtain necessary permissions to draw water as required from the concerned department at his own cost.

3.2.1.2 Electricity

The Contractor shall make his own arrangement for power supply. If found necessary, the Contractor shall provide and maintain generators including a stand-by generator of adequate capacity to meet his additional Project requirements.

The Contractor shall make his own arrangements as outlined hereunder:

- Distribution of adequate capacity for power, lighting and other construction needs.
- As necessary to properly and safely perform work at enclosed spaces or under hazardous conditions. Likewise, providing lights for night work/ protection as necessary.

Temporary electrical systems shall comply with the local codes and regulations.

3.2.2 Waste and Rubbish

The Contractor shall provide regular daily clean-up and removal of trash, waste, scraps, construction debris, etc. from site and temporary work yard and shall arrange for disposal of waste and rubbish to disposal areas approved by the Employer.

3.2.3 First Aid and Fire Protection

3.2.3.1 Emergencies

The Contractor shall maintain the lists of nearest available police, hospital or medical services at the Contractor's Site Office and the same are to be displayed at a number of locations & work places.

3.2.3.2 Fire Protection

The Contractor shall establish and submit the following measures to the Employer.

- Establish appropriate emergency escape routes and procedures;
- Maintain fire extinguishers and other facilities necessary for reasonable fire-fighting action at the site and temporary work yard;
- Provide and maintain a first aid kit containing bandages, medicines and sterilized materials for first aid treatment of minor injuries at the Contractor's Site Office.

3.2.4 Construction Safeguards

3.2.4.1 Excavations

Trenches intersecting roads shall have to be provided with crossings suitable to carry the type of traffic involved. Vehicular curbs and pedestrian railings shall be provided as necessary. Open pits and in openings in floors and other accessible surfaces shall be protected by barricades or railings.

3.2.4.2 Access

Access to structures such as scaffolds, ladders, ramps, hoists etc. shall be provided, maintained and operated as necessary.

3.2.4.3 Storage Areas

Storage and shop areas shall be provided, arranged and maintained at approved locations as necessary to properly store, handle and fabricate the various materials and equipment required.

3.2.5 Protection of the Public

The Contractor shall provide barricades and enclosures as necessary for public protection.

3.2.6 Contractor's Laboratory & Equipment

The Contractor shall provide site laboratory in order to carry out the specified tests. This laboratory shall be completely staffed and properly equipped to the satisfaction of the Employer to carry out the tests as specified.

The Contractor's site laboratory shall be available for the use of or inspection by the Employer as required by him. The Employer may require

his representative to be present at any test and at any time during the working hours of the laboratory.

The Contractor shall furnish and maintain the laboratory, apparatus and supplies necessary to permit execution of the tests required by the Specifications. The Contractor shall submit to the Employer for his approval, within 28 days after award of work, a complete list of the equipment, apparatus and supplies he proposes to furnish the laboratory. The list shall include the manufacturer's name and descriptive literature.

List of instruments, tools & tackles required for Material testing laboratory /QA facility at project site to be submitted by the bidder for Employer approval.

3.3 ENVIRONMENTAL PROTECTION

The Contractor shall comply with all the conditions stipulated by the relevant statutory and regulatory organisation of Govt. of West Bengal / Govt. of India.

3.3.1 Fires

Fires and burning of rubbish on the Site are not permitted except when authorized by Employer.

Where fires or burning is permitted, the Contractor shall prevent the structures which are to be preserved from staining and smoke damage. The Contractor shall restore, clean and make good stained or damaged work to new condition.

3.3.2 Disposal of Waste and Cleanliness

The Contractor shall not bury rubbish and solid waste materials on the Site and he shall not dispose of waste or volatile materials, such as mineral spirits, oil or paint thinner into the waterways, storm water drainage or sanitary sewers.

The Contractor shall keep all pavements and areas leading to and from the site, clean and free of mud, dirt, and debris at all times for movement of vehicles and pedestrians.

3.3.3 Drainage

The Contractor shall provide temporary drainage and pumping facilities as necessary to keep the adjoining areas of work site free from water logging and flooding.

3.3.4 Pollution Control

The Contractor shall cover or wet down dry materials and rubbish to prevent blowing dust and debris, and provide dust control for temporary roads and yards.

The Contractor shall take all measures necessary to ensure that no pollution of the waterways or any land areas occurs as a result of his activities. He shall undertake at his own expense all measures necessary to clean up or otherwise rectify any pollution arising from his activities under this Contract to the satisfaction of the Employer.

3.3.5 Environment

The Contractor shall deploy most suitable construction equipment to minimise the suspension of fine sediments at the work site.

3.4 SUBMISSION OF DOCUMENTS DURING PROJECT EXECUTION

3.4.1 Programme of Works

The Contractor shall prepare and submit (both hard copy and soft copy) to the Employer within 30 days of receipt of Letter of Award the following:

- Detailed CPM Schedule showing the various activities of the Work using MS Project
- List of designs/drawings/documents along with their schedule of submission.
- List of Vendors/Suppliers of Bought-out items

The above shall be updated every month and submitted to the Employer.

3.4.2 Work Schedules, Survey Data & Drawings

The Contractor shall prepare and submit construction schedules, survey data, and field drawings to illustrate the appropriate portion of work. The work items shall be described and related to responsibility, fabrication, layout, and setting or erection details as specified in appropriate Sections.

The Contractor shall keep allowance in program of works for any stoppages during monsoon period, and he has to take all necessary measures to protect his equipment and the partly completed structures. The Contractor is expected to build such stoppages of work during monsoon in his overall schedule for completion. The Employer will not entertain any claims from the Contractor on this account.

Drawings shall be submitted in two sets of paper prints, maximum size 610 mm x 810 mm and on CD (in AutoCAD format).

3.4.3 Maintenance Plan

3.4.3.1 General

The Contractor shall prepare maintenance plan covering all aspects of the works for the review of the Employer. This plan shall be prepared to ensure that the design life periods stated are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life.

3.4.3.2 Maintenance Document

The Contractor shall provide six copies of the maintenance plan and manuals to the Employer upon the request of the Employer or following receipt of attention to the Employer's comments.

3.4.4 Weekly and Monthly Progress Reports

The Contractor shall maintain a daily log describing the important events pertaining to the Works, (the working hours, the number of labourers employed, effective operation time of equipment, overtime hours), progress made in the Works. This daily log shall be submitted to the Employer by 1:00 PM of the following day. Compilation of these logs and their summary shall be submitted to the Employer as Weekly Progress Report in three (3) copies by middle of the next week.

The monthly progress reports shall include progress photographs taken at a fixed point and angle. The photographs shall be sufficient in numbers and locations to record the exact progress of works. The colour photographs shall be in size 200 mm x 250 mm and the CD containing the digital version of the same shall be provided.

The Contractor shall furnish the Employer with five (5) copies of the monthly progress reports within seven (7) days after the end of every month.

3.4.5 Design & Drawing Submissions

3.4.5.1 Design Submissions – General

The scope of drawings listed in this Volume is issued for information and guidance to the extent mentioned in the Tender document. Contractor shall make all arrangement and design drawings and submit the same for approval to the Employer's Engineer. Detailed Engineering shall be done by the Contractor. The contractor shall not be entitled to any extension of time for completing construction/commissioning or any other relief on account of delay caused due to providing any clarifications or in resubmitting any designs and drawings.

The contractor shall not change any design and drawings reviewed by Employer's Engineer, without submitting such revised designs and drawings for the review of Employer.

The Contractor shall submit for the approval of Employer, progressively from the date of receipt of the Letter of Award, Five (5) copies of the following:

- Layout of Lock compound
- General arrangement of all structures
- Cross sections and other details showing important particulars such as overall dimensions, clearances, etc.
- Specification/catalogues of all standard bought-out items.
- All drawings other than shop fabrication/manufacturing drawings. These will include, but not be limited to assembly, sub-assembly, key components, etc. However, one week prior to fabrication, fabrication and part drawings shall be made available to the Employer.
- Power Requirement (installed and peak demand loads)

- Wiring drawings and equipment inter-connection diagrams of local control panels & Single Line Diagram of facility power distribution.
- All design calculations pertaining to all structures.

A further digital copy (in AutoCAD format) of the submission shall be given on compact disc. This digital copy shall include the full submission with scanned copies of any documents prepared by hand.

The list of submission will however be discussed with the Contractor after the award.

3.4.5.2 Submission of Calculations

All calculations submitted for the Employer's approval shall comply with the following:

- a) Each calculation page shall be uniquely numbered.
- b) Each section of calculations shall have a cover sheet, listing the subject of the calculations, document number and date of submission, name and qualifications of the Designer(s), the name and qualifications of the Design Verification engineer(s), and the relevant Standards, books and drawings which are the basis of the calculations.
- c) Each section of calculations shall have a Table of Contents, including page numbers.
- d) Calculations shall be accompanied by all necessary sketches or extracts from drawings.
- e) Calculations shall include introductions explaining the purpose of the calculations and the methods and design philosophies adopted. This shall clearly state the Standards on which the calculations are based.
- f) Equations and values from International Standards and Codes of Practice are to be clearly referenced which are used in the design and shall be attached to the submission.
- g) Where values used in the calculations are brought forward from

previous calculation pages, the page reference shall be included.

h) At the end of each section there shall be a summary, listing the conclusions of the calculations, and referring to construction drawings.

i) If calculations are revised due to design changes or corrections or comments of the Employer, the calculations sheets shall be clearly marked with a revision letter.

j) All calculations shall be signed / initialed by the designer and design verification engineer.

k) The design calculations shall be written in English. In case any software is utilized to perform the calculations a sample set of manual calculations with references of various formulae used shall also be submitted for proper verification.

3.4.5.3 Submission of Drawings

All drawings submitted for the EMPLOYER'S approval shall comply with the following:

1. All drawings shall be in metric millimeter dimensions, and be finally prepared in ink with legible lettering on either A0 1189mm x 841mm using AutoCAD format compatible with AutoCAD 2014 or lower version. The submitted prints shall be clearly legible throughout and there shall be no ambiguity.
2. All drawings shall be submitted in digital format on compact disc, as well as three paper prints.
3. Drafting Standards employed in the preparation of all drawings shall be sufficient to produce legible 297mm x 420mm (A3) reduced drawings.
4. Drawings from various sub-contracting services, specialist suppliers etc. shall also be presented in a similar manner (identical title blocks/format etc.) to provide a matched set of drawings.
5. All drawings shall clearly show the status and revision of the drawings. Revised drawings shall clearly indicate the nature and details of the revision work and also revision cloud & revision mark shall be marked wherever

revised.

6. All drawings shall clearly identify the drafts-person responsible together with the identity of the drawings checker.

Each drawing shall show the scale(s) of the components illustrated by the drawing related to the original drawing size, A0, A1, A3 etc.

3.4.5.4 Inspection of Drawings at Site

The Employer shall have the right at all reasonable times to inspect all drawings at the premises of the Contractor or call for any drawing to be given to Employer's office.

3.4.5.5 Manuals and Technical Data

A. Manuals

The Contractor shall supply Five (5) hard copies along with One (1) soft copy (in editable format) of Erection & Installation Manuals, Operation Manuals, Spare Parts Manuals and Inspection and Maintenance Manuals prior to the starting of erection. Recommendations of the manufacturer in respect of preventive maintenance, trouble shooting, and breakdown maintenance and Overhaul shall be brought out in the inspection and maintenance manuals. Soft copies of all drawings shall be supplied.

Operating instruction manuals shall be provided at the time of shipment with adequate information pertaining to the following:

- Programming procedures;
- System specifications;
- Electrical power requirements;
- Expansion of internal fault diagnostics;
- Troubleshooting procedures;

- Powering up procedures;
- Shut down procedures

B. Technical Data

i) On completion of the works and before handing over possession to Employer, the Contractor shall supply Five (5) hard copies together with One (1) soft copy of the following:

- Shop drawings of all wearing parts and also major assemblies and minor assemblies which require unit replacement;
- All “As Built” Drawings of equipment, civil / structural, electrical items etc.

ii) Complete technical data and dimensional drawings of all bought out product/ items in the system, shall be furnished - Six (6) hard copies together with One (1) soft copy of the following:

- List of recommended spare parts.
- Parts catalogues in the case of all equipment /assemblies illustrated with part numbers in drawings both for electrical and mechanical items.

3.4.5.6 Tools and Maintenance Equipment

A list of complete set of tools/tackles and instruments required to be provided for satisfactory maintenance of the Works shall be furnished.

3.4.5.7 Maintenance Plan

The Contractor shall prepare maintenance plan covering all aspects of the works for the review of the Employer as per the requirement of this tender document. This plan shall be prepared to ensure that the design life period stated in the Tender are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life. Contractor shall also furnish list of estimated manpower required to perform monthly plan.

3.4.5.8 As Built Drawings, Design and Final Construction Report

Before submitting a request for Taking over Certificate, the Contractor shall ensure that it has furnished to the Employer all required documents including but not limited to two (2) sets of as-built drawings, final design in the supporting of as-built drawings and a final construction report as draft. And within thirty (30) calendar days after receipt of comments from the Employer, the Contractor shall submit five (5) sets of the Final Construction Report and five (5) sets of Final As-built drawings & Design documents. As-built drawings of the works consists of two (2) sets of original size copies (white print) and six (6) sets of bound copies reduced to A3 size. All documents and drawings shall be also delivered on CDs (drawings in Auto-CAD format, documents in other required formats and soft copy of the file used in software on which design was carried out).

Before submitting a request for Taking over Certificate, the Contractor shall ensure that it has furnished to the Employer all required documents including but not limited to five copies of manuals for installation, commissioning, operation and maintenance and the drawings/ documents etc., covering all aspects of the Works for the review of the Employer. This plan shall be prepared to ensure that the design life periods stated are met in full and where no design life periods are stated, the maintenance plan shall be prepared to maximize the serviceable life. In the event the Contractor makes any changes effecting such submission the Contractor shall submit afresh such document duly revising to that extent.

3.5 QUALITY CONTROL AND ASSURANCE

3.5.1 General

The Contractor will be required to adopt a system of self-certification in accordance with his general quality plan and the appropriate detailed quality procedures. The quality system shall comply with Standards of ISO 9001.

The Contractor shall monitor his performance of executing his works against two levels of certification:

- The completion of individual work items
- The completion of activities listed in the Programme.

In addition to the certification of the completion of work items and activities, the Contractor shall be required to issue the Quality Assurance (QA) certificates concerning the Quality Plan, Quality Procedures and Construction Documents.

The Employer may monitor the Contractor's work against the Contractor's Quality Plan and Quality procedures. The Employer may do this by spot checks, and/or by continuous monitoring of the work. The Employer may also do this by carrying out compliance audits periodically against the Contractors Quality Procedures. The frequency and intensity of such checks will depend on the proven reliability of the Contractor as work progresses. Each non-compliance with the Quality Plan shall be notified promptly to the Employer by the Contractor, together with proposals for remedy of the non-compliance. The absence of monitoring of or commenting on quality aspects as above by the Employer shall not absolve the Contractor from any of its contractual obligations and/or shall not entitle the Contractor for any claim.

3.5.2 Improper Certification of Unsatisfactory Work

If the Contractor or its personnel repeatedly confirms/declares a work as being satisfactory when such work is not satisfactory, the Employer may reject such work any time during the currency of the Contract and instruct the Contractor to re-execute such work in full or a part thereof without any implication to the Employer. In case of improper certification and/or Contractor's failure to rectify, the Employer may proceed as per the Contract including terminating the Contract.

3.5.3 Quality Plan and Quality Procedures

The Contractor will be required to submit his complete General Quality Plan to the Employer within four weeks of the Commencement Date. A designer's quality plan will be accepted as an interim measure to permit design work to be started in advance of the preparation of the General Quality Plan.

Detailed Quality Procedures for each element or item of work must be submitted to the Employer for review at least four weeks before that work is due to commence. Detailed Quality Procedures are required for all items manufactured prior to delivery to site.

3.5.4 Submission and Certification of Construction Documents

The Contractor shall submit a Design Certificate (in duplicate) and Design Check Certificate whenever he is submitting Construction Documents to the Employer for review. Construction Documents submitted without the relevant Design Certificate will not be reviewed.

The Contractor is to ensure that all Construction Documents submissions are in a format that enables the Employer to review the Construction Documents as required by the Contract without delaying completion of the Works.

3.5.5 Certificates for Work Item Completion

Readily identifiable Work Items must be certified as checked and found satisfactory by

- A. Contractor's surveyor responsible for checking and
- B. Contractor's supervisor responsible for checking temporary works, material cleanliness, dimensions (not checked in (a) above), workmanship and all other matters to enable him to certify that the item of work complies in every respect to the contract.

The Work Item Completion Certificate shall be checked and approved by the Contractor's Quality Manager.

Each Work Item Completion Certificate must be identified by a unique and appropriate reference number.

If the Employer is not satisfied that the works have been carried out satisfactorily as certified, the Employer shall raise a non-conformance report to which the Contractor shall respond stating his proposals for rectifying the non-conforming item and what action will be taken to prevent recurrence. The Employer may reject such work any time during the currency of the Contract and instruct the Contractor to re-execute such work in full or a part thereof without any implication to the Employer. In case of recurrence/failure of the Contractor to rectify, the Employer may adjust the Contract price by deducting the value of such work.

Any consequences in respect of any revisions arising out of Work Item Completion Certificates being returned with comments shall not be treated as a compensation event.

3.5.6 Certificates for Activity Completion

When a section of work has been completed satisfactorily, the Contractor shall certify that the activity has been completed in accordance with the Contract.

The Activity Completion Certificate shall be checked by the Contractor's Quality Manager and confirmed by the Contractor. The Designer's Representative shall also certify that the activity has been completed in conformance with the relevant Construction Documents and the EMPLOYER'S Requirements.

The Activity Completion Certificate shall list the reference numbers and dates of Work Item Completion certificates that have been relied upon by the signatories to the Activity Completion Certificate.

Each Activity Completion Certificate shall have attached to it, copies of any materials test certificates which were received after signing the relevant Work Item Completion Certificates and which have not been submitted to the Employer under separate cover during the period between the signing of the Work Item Completion Certificate and the preparation of the Activity Completion Certificate.

3.6 FIELD SURVEYS AND INVESTIGATIONS

3.6.1 General

The Contractor shall carry out the engineering design and prepare drawings for the various components under this specification, based on the data on field surveys and investigations, including that of Temporary Works.

The Contractor may carry out all necessary investigations to supplement and complete his design data, in case he feels necessary:

- Topographic and bathymetric survey to supplement the surveys carried out by the Employer.
- Soil investigation work to supplement the investigations carried out by the Employer to verify that his design assumptions are in accordance with the ground conditions.

The Contractor shall, at his own expense, carry out all the necessary surveys, measurements and setting out of the works and shall for this purpose engage well qualified, experienced and competent surveyors.

3.6.2 Setting Out

The Contractor shall establish working bench marks related to the Reference Bench Mark in the area soon after taking possession of the site. The Employer shall provide the Contractor with one Permanent Bench Mark and its datum. A schedule of reference dimensions shall be prepared and supplied by the Contractor to the Employer. These marks shall be maintained until the works reach finished formation level and are accepted by the Employer.

The Contractor shall be solely responsible for safe-guarding all survey monuments, bench marks etc. All dimensions and levels shown on the

drawings or mentioned in documents forming part of or issue under the Contract shall be verified by the Contractor on the site and he shall immediately inform the Employer of any apparent errors or discrepancies in such dimensions and levels.

3.6.3 Topographic Surveys

The Contractor may conduct a precision triangulation survey to establish primary and secondary survey stations and tie these with respect to Spheroid WGS 84 UTM grid for setting out the Works.

Survey stations and other control devices required by the Contractor for his execution of the work shall be established by the Contractor at his own expense, and shall be removed upon completion of the works.

3.6.4 Geotechnical Investigations

The Contractor may carry out additional geotechnical investigations in the works area at his own cost. Plate load test shall be conducted after excavation at founding level to assess the bearing capacity of strata at that level.

3.6.5 Model Studies

The Mathematical/Physical model studies for the whole structure to access the filling/emptying time of the lock chamber, sedimentation in the hydraulic system, check for air entrapment in the hydraulic system, waves, currents and turbulence generation in the lock chamber. The speed of the flow inside the culverts, head losses and cavitation, particularly in bends and inter-independent interaction of various elements such as, speed of the opening of the valves with the locking duration, mooring forces, shall be

made during detailed designs and modification to structures, if required, shall be done by the contractor. Post Construction Survey

The completion of the works will be examined by the Contractor in the presence of the Employer. During these examinations, the Contractor shall perform the survey, which shall be used to prepare a final drawing showing all dimensions, elevations and cross sections of the “As Built” conditions of the structures. The Contractor shall be required to remove excess materials or place additional materials, as directed by the Employer, in order to comply with the Contract Documents. Contractor shall submit the final location of all structures with reference to the Master Grid, which shall show the actual position of each structure and deviation from the theoretical position.

3.6.6 Green Belt Development

Contractor shall develop green belt all along the boundary within the site. The length and width of the green belt shall be 1000 m x 10 m. About 900 trees along with herbs and shrubs will be planted in 10000 m² area reserved for green belt.

3.7 CONDITION SURVEY

3.7.1 General

The Contractor shall carryout the engineering design and prepare drawings for the various existing components under this specification, based on the data on condition surveys and investigations, including that of Temporary Works.

The Contractor shall, at his own expense, carry out all the necessary surveys, measurements and setting out of the works and shall for this purpose engage well qualified, experienced and competent surveyors.

The contractor shall verify all the drawings dimension with the ground condition. If any discrepancy found in the drawing, then contractor shall have to rectify.

3.7.2 Structural health assessment

Structural Health Assessment (SHA) aims to assess the behaviour of structures, evaluate the performance of materials during the life cycle and give a diagnosis of the "state" of the constituent materials, of the different parts, and the structure as a whole

The Contractor shall conduct the structural health assessment of the existing structure using the latest technology and shall follow the guideline of The Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program of the U.S. Army Corps of Engineers

The condition survey and assessment shall include but not limited to the following components:

- ✓ Visual Inspection
- ✓ Non-Destructive Testing

3.7.2.1 Visual inspection

Remotely Operated Vehicle, commonly known as ROV, have seen increased adoption and usage for remote visual inspections of underwater structures that are difficult to reach by traditional means. This proposed methodology for underwater inspection has various advantages over

manual operations including the ability to inspect in dark and flooded areas, otherwise constricted and risky zones with unlimited endurance, enhanced stability, and reliable data acquisition with repeatability. The results can aid the authorities rapidly make key decisions concerning repair, maintenance, and safety of the structure

Contractor shall carryout visual inspection using the Remotely Operated Vehicle or the latest technology which fulfil standard specification for underwater survey.

3.7.2.2 Non-destructive Test

Non-destructive testing (NDT) methods are techniques used to obtain information about the properties or internal condition of an object without damaging the object. Non-destructive testing is a descriptive term used for the examination of materials and components in such way that allows materials to be examined without changing or destroying their usefulness.

To assess the structural health of the concrete NDT shall be use by the contractor. Method of NDT shall be in accordance with the Indian Standard Code of Method of Non-destructive testing of concrete, IS 13311 all part and other relevant codes.

3.7.3 Performance Indicators

the contractor shall have to estimate the performance indicator and condition index (CI). by using the information gathered from condition survey and various type of inspection.

The Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program of the U.S. Army Corps of Engineers has developed a condition

index which is a numerical scale, ranging from a low of 0 to a high of 100. The numbers indicate the relative need to perform REMR work because of deteriorating characteristics of the structure. For management purposes, the CI scale is also calibrated to group structures into three basic categories or zones. Table below shows the Condition index scale and zone.

Zone	Condition Index	Condition Description	Recommended Action
1	85 to 100	Excellent: No noticeable defects. Some aging or wear may be visible	Immediate action is not required
	70 to 84	Good: Only minor deterioration or defects are evident	
2	55 to 69	Fair: Some deterioration or defects are evident, but function is not significantly affected	Economic analysis of repair alternatives is recommended to determine appropriate action
	40 to 54	Marginal: Moderate deterioration. Function is still adequate	
3	25 to 39	Poor: Serious deterioration in at least some portions of the structure. Function is inadequate	Detailed evaluation is required to determine the need for repair, rehabilitation or reconstruction. Safety evaluation recommended
	10 to 24	Very Poor: Extensive deterioration. Barely functional	

	0 to 9	Failed: No longer functions. General failure or complete failure of a major structural component	
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3.8 EMPLOYER'S RESPONSIBILITIES

3.8.1 Datum Points and Levels

The Employer will give the details of a reference Bench Mark in the vicinity of the Project Site and the Contractor shall establish working benchmarks linked to this and reduce to Mean Sea Level (MSL). The Contractor prior to the start of works shall confirm the location and details of datum points and levels. The Contractor shall convert all the levels accordingly with respect to MSL.

3.8.2 Contractor Working Area

The Employer shall provide land area limited to 2 acres within the Project Site for the Contractor's working area. No space for the labour camp shall be provided.

4. SPECIFICATIONS – CIVIL

4.1 MATERIALS

4.1.1 General

The Contractor shall be responsible for furnishing all materials required for execution of the Works. The Contractor shall submit the source and method of execution for the Employer's review before any execution. All materials used in the construction of permanent works required under this Contract shall be of 1st class quality as specified herein and comply with the latest IS Codes or equivalent. The material shall be tested before bringing it to the site.

This specification establishes and defines the requirements of various materials to be used in Civil and Structural works.

Whenever any reference to IS Codes is made, the same shall be taken as the latest revision (with all amendments issued thereto) as on the date of submission of the Tender.

Apart from the IS Codes mentioned in particular in various clauses of this specification, all other relevant codes related to specific job under consideration regarding quality, tests, testing and/or inspection procedures shall be applicable. Reference to some of the codes in various clauses of this specification does not limit or restrict the scope of applicability of other referred or relevant codes.

In case of any variation/contradiction between the provision of IS Codes and this specification, the provision given in this specification shall be followed, unless the Employer agrees/consents to follow IS codes or other proposal of the Contractor as provided in the Contract.

All materials shall be of standard quality and shall be procured from renowned sources/manufacturers approved by the Employer. It shall be the responsibility of the Contractor, to get all materials/manufacturers approved by the Employer prior to procurement and placement of order.

Wherever brand is not mentioned, Contractor can choose a brand complying with the tender specifications however mentioning the brand considered in the Bid submission for the approval of the Employer if required.

Whenever called for by the Employer, all tests of the materials as specified by the relevant IS Codes shall be carried out by the Contractor in an approved laboratory and test reports duly authenticated by the laboratory, shall be submitted to the Employer for his approval. If so desired by the Employer, tests shall be conducted in the presence of the Employer or his authorized nominee.

Quality and acceptability of materials not covered under this specification shall be governed by the relevant IS Codes. In case IS code is not available for the particular material, other codes e.g., B.S. or DIN or API/ASTM etc. shall be considered. The decision of Employer in this regard shall be final and binding on the Contractor.

Whenever asked for, the Contractor shall submit representative samples of materials to the Employer for his inspection and approval. Approval of any samples does not necessarily exempt the Contractor from submitting necessary test reports for the approved material, as per the specification/relevant IS Codes.

The Contractor shall submit manufacturer's test reports on quality and suitability of any material procured from them and their recommendation on storage, application, workmanship etc. for the intended use. Submission of manufacturer's test reports does not restrict the Employer from asking fresh test results from an approved laboratory of the actual material supplied from an approved manufacturer/source at any stage of execution of work.

All costs relating to or arising out of the tests and submission of test reports and or samples to the Employer for his approval till the date of issuance of Performance Certificate shall be borne by the Contractor.

Materials for approval shall be separately stored and marked, as directed by the Employer and shall not be used in the Works till these are approved. All rejected materials shall be immediately removed from the site by the Contractor at his own cost.

4.1.2 Water

Water used in construction for all civil & structural works shall be clean and free from injurious amount of oil, acids, alkalies, organic matters or other harmful substances, which may be deleterious to concrete, masonry or steel. The pH value of water sample shall be not less than 6. Potable water shall be considered satisfactory.

Tests on water samples shall be carried out in accordance with IS:3025 and they shall fulfil all the guidelines and requirements given in IS:456.

The Employer may require the Contractor to prove, that the concrete prepared with water, proposed to be used, shall not have average 28 days

compressive strength lower than 90% of the strength of concrete prepared with distilled water.

The Employer may require the Contractor to get the water tested from an approved laboratory before starting the construction work and in case the water contains any oil/organic matter or an excess of acid, alkalies or any injurious amount of salts etc., beyond the permissible maximum limits given in IS:456, the Employer may refuse to permit its use. In case there is any change in source of water, water samples shall be tested again to meet the specified requirements.

Water shall be stored in tin barrels, steel tanks or water tight reservoirs made with bricks/stone or reinforced concrete. Brick/stone masonry reservoirs shall have RCC base slab and shall be plastered inside, with 1 part of cement and 4 parts of sand and finished with neat cement punning. These reservoirs shall be of sufficient capacity to meet the water requirements, at any stage of construction.

4.1.3 Aggregate

4.1.3.1 General

Coarse and fine aggregates for civil and structural Works shall conform in all respects to IS:383 (Specification for coarse and fine aggregates from natural sources for concrete). Aggregates shall be obtained from an approved source known to produce the same satisfactorily. Aggregates shall consist of naturally occurring (crushed or uncrushed) stones, gravel and sand or a combination thereof. These shall be chemically inert, hard, strong, dense durable, clean and free from veins, adherent coatings,

injurious amount of alkalies, vegetable matter and other deleterious substances such as iron pyrites, coal, lignite, mica, shale, sea shells etc.

Source and type of aggregates shall be got approved from the Employer prior to procurement. Change in source and type of aggregates, at later stage, shall not be generally permitted; but under specific circumstances, the Employer subject to the Contract may accept the proposal to change. Contractor shall produce necessary test certificates from approved laboratories regarding the quality and suitability of the proposed aggregates and submit fresh mix design for approval of the Employer. Aggregates, which may chemically act with alkalies of cement or might cause corrosion of the reinforcement, shall not be used. If so desired by the Employer, the Contractor shall carry out alkali reactivity tests and submit the results to him for approval.

The maximum quantities of deleterious materials in the aggregates as determined in accordance with IS:2386 – Part II (Methods of Test for aggregates for concrete), shall not exceed the limits defined in IS:383. No special test is required to prove the absence of such deleterious matters if the aggregates are from a known source with satisfactory prior data on the properties of concrete made with them. In case of newly developed quarry sites, the Contractor shall submit necessary test results as per IS:383 and IS:2386 to the Employer prior to his acceptance and approval. The method of Sampling shall be in accordance with the requirements given in IS:2430.

Coarse and fine aggregates shall be batched separately. All-in-aggregates shall be used only where specifically permitted by the Employer.

Separate sieve analysis and grading curves shall be prepared by the Contractor for any/all batches of coarse and fine aggregates, and submitted to the Employer, whenever asked for, to ensure conformity with those submitted along with the mix design.

Whenever required by the Employer, the aggregates (coarse/fine) shall be washed and/or sieved by the Contractor before use in the works to obtain clean and graded aggregate at no extra cost to the Employer.

Aggregates not in conformity with the specifications shall be rejected and the Contractor shall immediately remove them from the site of work.

4.1.3.2 Coarse Aggregates

Coarse aggregates are the aggregates, which are retained on 4.75 mm IS Sieve. It shall have a specific gravity not less than 2.6 (saturated surface dry basis).

These may be obtained from crushed or uncrushed gravel or stone as per Clause 4.1.3.1 and may be supplied as single sized or graded. The grading of the aggregates shall be as per IS:383 or as required by the mix design, to obtain densest possible concrete. For this purpose, the Contractor shall submit to the Employer at least three sets of mix design and test results, each with different gradings of coarse aggregates, proposed to be used. The Employer may allow “All-in-aggregates” to be used provided they satisfy the requirements of IS:383.

4.1.3.3 Fine Aggregates

Fine aggregates are the aggregates which pass through 4.75 mm IS sieve but not more than ten percent (10%) pass through 150 micron IS sieve.

These shall comply with the requirements of grading zones I, II, III and IV of IS:383. Fine aggregates conforming to grade zone IV shall not be used for reinforced concrete works.

Fine aggregates shall consist of material resulting from natural disintegration of rock and which has been deposited by streams or glacial agencies, or crushed stone sand or gravel sand. Sand from sea shores, creeks or river banks affected by tides, dredged sand shall not be used for filling or concrete works.

4.1.3.4 Sampling and Testing

Storage of all types of aggregates at site of work shall be at Contractor's expense and risk and shall be stored as specified in IS:4082. Aggregates shall in no case be stored near to the excavated earth or directly over ground surface.

Each type and grade of aggregate shall be stored separately on hard, firm surface having adequate slope for drainage of water.

Aggregates delivered at site in wet condition or becoming wet due to rain or any other means, shall not be used for at least 24 hours. The Contractor shall obtain prior approval of the Employer for the use of such aggregates and shall adjust the water content in accordance with IS:2386 to achieve the desired mix. In the absence of test results, and to allow variation in mass of aggregates and water content on account of moisture content, the Contractor can make suitable adjustment in the masses as per IS:456, for preparation of nominal mix concrete only.

4.1.4 Sand

4.1.4.1 Sand for Masonry Mortars

The sand shall consist of natural sand, crushed stone sand or crushed gravel sand or a combination of any of these. The sand shall be hard, durable, clean and free from adherent coatings and organic matter and shall not contain the amount of clay, silt and fine dust more than specified in IS:2116.

The sand shall not contain any harmful impurities such as iron pyrites, alkalies, salts, coal or other organic impurities, mica, shale or similar laminated materials, soft fragments, sea shells in such form or in such quantities as to affect adversely the hardening, strength or durability of the concrete.

Unless found satisfactory as a result of further tests as may be specified by the Employer, or unless evidence of such performance is offered which is satisfactory to him, the maximum quantities of clay, fine silt, fine dust and organic impurities in the sand, when tested in accordance with IS:2386, shall not be more than 5% by mass in natural sand, or crushed gravel sand or crushed stone sand. For organic impurities, when determined in accordance with IS:2386, colour of the liquid shall be lighter than that indicated by the standard solution specified in IS:2386.

4.1.4.2 Grading of Sand

The particle size grading of sand shall be within the limits as specified below: Grading of Sand

IS Sieve Designation	Percentage	Method
IS:460 (Part I)	Passing by Mass	
4.75 mm	100	IS:2386 (Part I)

2.36 mm	90 – 100	
1.18 mm	70 – 100	
600 microns	40 – 100	
300 microns	5 to 70	
150 microns	0 to 15	

In case of a sand whose grading falls outside the specified limits due to excess or deficiency of coarse or fine particles, this shall be processed to comply with the standard by screening through a suitably sized sieve and/or blending with required quantities of suitable sizes of natural sand particles or crushed stone screenings which are by themselves unsuitable. Based on test results and in the light of practical experience with the use of local materials, the Employer subject to the Contract may accept the proposal for change in grading of sand. The various sizes of particles of which the sand is composed shall be uniformly distributed throughout the mass.

4.1.4.3 Sampling and Testing

The method of sampling shall be in accordance with IS:2430. The amount of material required for each test shall be as specified in relevant parts of IS:2386. Any test which the Employer may require in connection with this shall be carried out in accordance with the relevant parts of IS:2386.

If further confirmation as to the satisfactory nature of the material is required, compressive test on cement mortar cubes (1:6) may be made in accordance with IS:2250 using the supplied material in place of standard sand and the strength value so obtained shall be compared with that of another mortar made with a sand of acceptable and comparable quality.

4.1.4.4 Sand for Filling

Sand for filling shall meet the requirements of IS:383 and shall be natural sand, hard, strong, free from any organic and deleterious materials. Any sand proposed for filling, shall be used only after it is approved by the Employer. Sand obtained from sea shores, creeks or river banks affected by tides shall not be used for filling. Fine aggregates suitable for concreting works shall be suitable for filling also. No sand below grading zone-III as per IS-383 shall be allowed for filling.

The excavated material can be used for filling by adding 50% sand to it to assure proper compaction of the backfill.

4.1.5 Cement

Cement to be used, for civil and structural works, shall be minimum 53 grade ordinary Portland cement, as per the relevant IS codes for plain and reinforced concrete works. The Contractor is required to quote on this basis only.

4.1.5.1 Storage at Site

The storage of cement at the site of work shall be at Contractor's expense and risk and shall meet the requirements of IS:4082. The cement shall be stored above ground in a suitable weather tight building or godown and in such a manner so as to permit easy access for proper inspection and also to prevent deterioration due to moisture.

All approved cement shall be arranged in batches with type, brand and date of receipt flagged on them. A maximum of eight bags shall be stacked one over the other. Cement bags shall be used in the same order as received from the manufacturer. The Contractor shall maintain a register, on day-to-

day basis, giving the details of the receipt/consumption, source of supply and type of cement etc. The register shall always be accessible to the Employer for verification.

4.1.5.2 Tests after Delivery

Each consignment of cement procured by the Contractor, shall, after delivery at Site and at the discretion of the Employer, be subjected to any or all of the tests and analyses, required by the relevant Indian Standard Codes.

4.1.5.3 Rejection

The Employer may reject at his discretion any cement, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant IS Codes for testing of cement. He may similarly reject any cement which has deteriorated owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any cement which is considered defective shall not be used and shall be promptly removed from the site by the Contractor.

4.1.6 Bund Materials

4.1.6.1 Gannular Fill Material (Murrum)

The murrum shall be granular with fines smaller than 75 microns not exceeding 15% and shall be free from rubbish, clay and other deleterious material.

The maximum laboratory dry density (IS 2720, Part 8) shall not be less than 1.6 T/cum.

4.1.6.2 Rock Fill Material

This shall consist of quarry run material, free from deleterious matter, of size 100 mm to 450 mm.

4.1.6.3 Rock Armour

Rock armour shall comprise rock of adequate weight and quality to withstand the design wave forces and laid in two layers.

The rock shall meet with the following requirements when tested in accordance with IS:2386.

- Aspect Ratio : >0.5
- Density : 2.6 T/cum
- Water Absorption : <2%
- Compressive Strength : 400 Kg/sq.cm (cylinder)
: 500 Kg/sq.cm (cube)
- Abrasion Resistance : Abrasion value not to exceed 30%
- Impact Resistance : Aggregate impact value not to exceed 30%

4.1.7 Steel

4.1.7.1 General

All steel bars, sections, plates and other miscellaneous steel materials, etc. shall be free from loose mill scales, rust as well as oil, mud, paint or other coatings. The materials, construction specifications such as dimensions, shape, weight, tolerances, testing, etc. for all materials covered under this section, shall conform to respective IS Standards.

4.1.7.2 Reinforcement Bars

Reinforcement bars, to be used for civil and structural works shall be Thermo-mechanically treated corrosion resistant steel of grade equivalent to Fe-500, conforming to IS:1786. Reinforcement steel shall be purchased

only from primary suppliers and that purchased from secondary suppliers shall not be accepted

4.1.7.3 Structural Steel

Structural steel to be used for general structural purposes shall be of grade A conforming to IS:2062.

Structural steel sections shall conform to following IS specifications.

Steel tubes for structural purposes	IS:1161
Mild Steel Tubes, tubulars and other wrought steel fittings	IS:1239
Hollow steel sections for structural use	IS:4923

4.1.7.4 Miscellaneous Steel Materials

Miscellaneous steel materials shall be conforming to the following IS specifications.

Expanded Metal Steel Sheets for General purposes	IS:412
Specification for mild steel and medium tensile steel bars and hard drawn steel wire for concrete reinforcement (grade I) (for mild steel bars of anchor bolts, rungs, metal inserts, grating etc.)	IS:432
Hexagonal head bolts, screws & nuts of product grade C	IS:1363
Cold formed light gauge structural steel sections	IS:811
Technical supply conditions for threaded steel fasteners	IS:1367
Plain washers	IS:2016
Steel wire ropes for general engineering purposes	IS:2266
Thimbles for wire ropes	IS:2315
Bulldog grips	IS:2361
Mild Steel Tubes, tubulars and other wrought steel fittings. (for Hand rail tubular sections).	IS:1239
Drop forged sockets for wire ropes for general engineering purposes	IS:2485
Steel chequered plates	IS:3502
Hexagonal bolts and nuts (M42 to M150)	IS:3138

Anchor Bolts: Material for Anchor Bolts such as MS bars, washers, nuts, pipe sleeves and plates etc. shall be as per relevant IS Codes mentioned above.

4.1.7.5 Storage

The storage of all materials at site of work shall be at the Contractor's expense and risk and shall be done as per the requirements given in IS:4082. The Contractor shall maintain the proper records of receipt/consumption. The records shall always be accessible to the Employer for verification. The reinforcement bars, structural steel sections and other miscellaneous steel materials etc., shall be stored in such a way so as to avoid and prevent deterioration, corrosion, bending, twisting and wrapping.

4.1.7.6 Tests after Delivery

Materials procured by the Contractor, shall, after delivery at site and at the discretion of Employer, be subjected to any or all of the tests, required by the relevant IS Codes. The Contractor shall carry out and bear the cost of such tests. The Contractor shall get himself satisfied regarding its quality before using the same in his works at his own expense.

4.1.7.7 Rejection

The Employer may reject at his direction any material, notwithstanding the manufacturer's certificate, failing to meet the requirements of relevant IS Codes for testing of materials. He may similarly reject any material, which has deteriorated or corroded etc., due to improper storage, handling or transport. Defective materials shall not be used and has to be removed from the site by the Contractor at his own expense.

4.1.8 Bricks

4.1.8.1 General

Bricks for masonry works shall conform to IS:1077–Specification for common burnt clay building bricks and shall be of class 7.5 (with minimum compressive strength of 7.5N/mm^2). Specific requirement for any other class of bricks shall be as shown in drawings or as described in the Contract for a particular site or type of work. Physical requirement, quality, dimensions, tolerances etc. of common burnt clay building bricks shall conform to the requirements of IS:1077.

Bricks shall be hand-moulded or machine moulded and shall be made from suitable soils. The bricks shall have smooth rectangular faces with sharp corners and shall be well burnt, sound, hard, tough and uniform in colour. These shall be free from cracks, chips, flaws, stone or humps of any kind.

4.1.8.2 Tests after Delivery

The Contractor shall make samples of each type of brick as directed by the Employer as per the requirements of IS: 5454 and tests shall be carried out as per IS: 3495. The cost for carrying out any or all the tests shall be borne by the Contractor. The bricks, when tested, as per IS: 3495 shall have a minimum average compressive strength, as given in the Code, for a particular class of brick. Water absorption shall not be more than 20% by its dry weight, when soaked in cold water for 24 hours.

Brick samples so approved shall be deposited with the Employer. All subsequent deliveries shall be upto the standards of the approved samples.

4.1.8.3 Stacking of Bricks

Bricks shall be stored at site as per the requirements given in IS:4082 and shall not be dumped at site. They shall be unloaded from trucks to a place on a levelled surface near to the work site. They shall be stacked in regular tiers even as they are unloaded, to minimise breakages and defacement of bricks. The supply of bricks shall be so arranged that as far as possible, at least two days' requirements of bricks are available at site at any time. Bricks, of different class, shall be stacked separately.

4.1.9 Stones

4.1.9.1 General

All stones used for masonry works shall conform to the requirements of following IS Codes.

Method of identification of natural building stones	IS:1123
Recommendations for dimensions and workmanship of natural building stones for masonry work	IS:1127
Recommendations for dressing of natural building stones	IS:1129

4.1.9.2 Quality of Stones

Stones shall be of approved quality, hard, dense, strong, sound, durable, clean and uniform in colour. They shall also be free from veins, adherent coatings, injurious amount of alkalies, vegetable matters and other deleterious substances such as iron pyrites, coal, lignite, mica, sea shells etc. Unless otherwise approved, stones from one single quarry shall be used for any one work. The strength of stones should be adequate to carry the imposed load and shall meet all the requirements of IS:1905, taking into account the appropriate crushing strength of stone and type of the mortar

used. The percentage of water absorption, when tested in accordance with IS:1124, shall not exceed 5 percent.

Stones normally used, shall be small enough to be lifted and placed by hand. The length of the stone shall not exceed 3 times the height. Width of stone on base shall not be less than 150 mm and in no case exceed $3/4^{\text{th}}$ thickness of the wall. Height of the stone shall not be more than 300 mm.

4.1.9.3 Unloading/Stacking

The stones shall be unloaded from the trucks to a site near to the place of work as defined in IS:4082 and shall be stacked on a firm ground having adequate stop for drainage. The supply of stones shall be so arranged that as far as possible, at least two day's requirements of stone are available at site of at any time.

4.1.10 Admixtures

4.1.10.1 General

All concrete admixtures shall in general comply with the following Indian standards unless otherwise stipulated in this specification.

- Specification for integral cement water proofing compounds :
IS:2645
- Specification for other admixtures for concrete : IS:9103

Generally, admixtures shall have ISI certification marks. However, even in case of BIS certified admixtures, Employer may require the Contractor to carry out and submit any or all the tests (as specified in relevant IS Codes), from approved laboratories, over and above the manufacturer's test certificate, before giving his final approval.

In case, admixtures certified by BIS are not available, the Contractor shall submit to the Employer the type and/or proprietary brand of the admixture from only reputed manufacturers along with necessary test certificates from recognised and approved laboratories or any other document directed by the Employer for the latter's final approval. In such cases, names of at least two manufacturers shall be submitted to the Employer for his selection. In case, both the names are rejected, the Contractor shall submit a fresh list of two manufacturers for approval by the Employer.

The Employer may direct the Contractor to submit test results as required by IS:2645 or IS:9103 for any admixture proposed to be used in the concrete in any approved laboratory at his discretion at any stage of the work. The cost of any/all tests required to satisfy compliance with this specification shall be borne by the Contractor.

In case of non-availability of any IS code for testing and acceptability criteria, relevant British, American or German Code shall be applicable in the order of preference.

Prior approval of the Employer shall be obtained while using water reducing admixtures in the concrete (PCC/RCC) or mortar. Other type of admixtures such as accelerating admixtures, retarding admixtures or air entraining admixtures, shall not be used unless prior approval taken from the Employer. Once approved, utmost care shall be taken at site by the Contractor to maintain the consistency in the quality of admixture and the concrete/mortar so produced.

The suitability and effectiveness of any admixture shall be verified by trial with the designed concrete mixes using cement, aggregates together with any other materials to be actually used in the works as per the direction of Employer. If two or more admixtures are to be used simultaneously in the same concrete mix, the Contractor must submit necessary test results from an approved laboratory to show their interaction and compatibility. Any/all tests specified in IS Codes shall be carried out only with the type of material and mix design, to be actually used in the work site.

No admixture shall impair the durability of the concrete nor combine with the ingredients to form harmful compounds nor increase the risk of corrosion of reinforcement. Use of admixtures shall not reduce the dry density of concrete. Once the proportion of admixture has been established, strict check shall be maintained not to alter the proportions of ingredients and water cement ratio of the Design Mix during execution.

The chloride contents in admixtures shall not exceed 2% by mass of the admixture or 0.03% by mass of the cement.

Admixtures which do not meet the requirements stipulated in this specification shall be rejected and shall not be used.

4.1.10.2 Water Proofing Compounds

The permeability of the specimen with the admixture shall be less than half of the permeability with similar specimen without the use of these compounds. These compounds shall be used in such proportion as

recommended by manufacturer but in no case, it shall exceed 3% by weight of cement.

The initial setting time of the cement with the use of these compounds shall not be less than 30 minutes and final setting time shall not be more than 10 hours. Test shall be carried out in accordance with IS:4031.

Compressive strength of specimen at 3 days shall not be less than 270 kg/sq.cm. nor 90% of the 3 days compressive strength of mortar cubes prepared with same cement and sand only, whichever is higher. Similarly compressive strength at 7 days shall not be less than 370 kg/sq.cm. nor less than 90% of the 7 days compressive strength prepared with the same cement and sand only, whichever is higher. The test to determine the compressive strength shall conform to IS:4031.

4.1.11 Water Bars (Water Stops)

PVC water bars shall be used in reinforced concrete construction of liquid retaining structures or any other structure to safeguard them from hydrostatic pressure and water leakage and any relative movement between two parts of the structure due to thermal loading shrinkage or differential movement of foundations. These shall be pre-formed and shall provide a permanent water tight seal along the entire joint in the poured concrete structures. These shall also be flexible enough to withstand deflection/displacements at joints arising due to variation of temperatures or settlement of foundations. This shall be able to withstand a water head of at least 22.5 metres.

Performance requirements of PVC water bars shall meet the requirements of IS:12200. These shall be of approved make and of ribbed/serrated/plane type with a bulb at the centre. The thickness shall not be less than 5 mm and width less than 150 mm. The joining of the water bars shall be carried out by vulcanising strictly as per the manufacturer's specifications. Lapped joints shall not be allowed under any circumstances.

4.1.12 Bitumen/Bituminous Materials

Bitumen to be used for various types of work shall meet all the requirements of relevant ISCodes as given below:

Specification of Paving Bitumen	IS:73
Specification for bitumen mastic for flooring	IS:1195
Specification for bitumen felts for water proofing and damp proofing	IS:1322
Specification for Bituminous compounds for water proofing and caulking purposes	IS:1834
Specification for preformed fillers for expansion joint in concrete pavements and structures	IS:1838
Specification for bitumen mastic for use in water proofing of roofs	IS:3037
Specification for bitumen primer for use in water proofing and damp proofing	IS:3384
Specification for Bitumen Mastic for Tanking and Damp proofing	IS:5871
Specification for Glass fibre base coal tar pitch & bitumen felts	IS:7193
Code of practice for damp proofing using bitumen mastic	IS:7198
Specification for bitumen Mastic, Anti Static and electrically conducting grade	IS:8374

The type and grade shall be as shown on the drawings or as directed by Employer. Tests and acceptable criteria shall be as per relevant IS Codes.

4.1.13 PVC Pipes

PVC Pipes shall conform to the requirements of IS:4985.

4.1.14 Wood/Timber

Timber required to be used for formwork shall be fairly dry before use. It should maintain its shape during the use and even when it comes into contact with moisture from the concrete. Storage of Wood/Timber shall be as per the requirements of IS:4082.

For proper identification and selection of suitable timber for formwork, following codes shall be referred.

Classification of commercial timbers and their zonal distribution	:IS:399
Specification for ballies for general purposes	:IS:3337
Specification for ply wood for concrete shuttering work	:IS:4990

4.1.15 Paint

4.1.15.1 General

All paints shall be of an approved quality and shall be obtained from only those suppliers and makers who have been in the market for a period of not less than 5 years. All paints shall conform to the appropriate Indian Standards for ready mixed paints where applicable. All paints, undercoats, primers and finishing paint shall be supplied in sealed container. The Employer's Engineer may, if he so wishes, take samples for analysis at the Contractor's expense.

Wood preservative shall be of chemical type comprising copper-chrome-arsenic composition conforming to IS 401-1967.

All paints shall be stored in cool and dry conditions and clear of other stores to the satisfaction of the Employer's Engineer.

4.1.15.2 Painting

All structural steel work and metals including handrails, brackets & exposed surfaces of steel inserts shall be painted except if otherwise specified.

The operations, workmanship, schedules and equipment for painting shall generally comply with the requirements of IS:1477 (Parts I & II) "Code of Practice for Painting of Ferrous Metals in Buildings" except in so far as this Specification modifies it.

All surfaces shall be thoroughly cleaned of all foreign matters adhering to the steel surface to Swedish Standard specification Sa 21/2 by means of blasting with sand. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access. All painting shall be carried out by brushing. Spray and roller application of paint shall not be allowed without the written permission of the Employer's Engineer.

Painting shall generally be done immediately after cleaning. The cleaned surface shall not be allowed to stand overnight before painting. Where galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of copper sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Employer's Engineer.

All steelwork unless specified otherwise, shall be painted as per the following schedule:

- a) Two coats of epoxy base zinc rich primer (92% zinc on dry film) shall be applied. The dry film thickness of two coats shall be 60 microns minimum.
- b) After the application of primer, all surfaces shall receive two coats of coal tar epoxy or any other high build epoxy compatible with the primer. The finish paint shall be applied to establish an enduring protection of the prime coat. It shall be resistant to atmospheric heat, reflect heat and rays and withstand mechanical stresses without crumbling. The total dry film thickness for these 2 coats shall be 200 microns minimum. The colours for the finishing coats shall be as approved by the Employer's Engineer.
- c) Total dry film thickness for the system shall be 260 microns minimum.
- d) For steel work intended to be painted only at Site, a primary coat of Red Oxide Zinc Chromate shall be given at the shop before dispatch.

4.1.16 Polysulphide Sealants

All Polysulphide Sealants shall conform to IS:12118 and be of approved make. Test conditions and requirements shall be as given in the above referred IS code.

4.1.17 Epoxy

Epoxy to be used, for strength the existing concrete structure, and repair works shall be meet the relevant IS Standards.

4.1.17.1 Storage at Site

The storage of epoxy components at the site of work shall be at Contractor's expense and risk and shall meet the requirements of IS:4082. Chemicals shall be stored above ground in a suitable weather tight building or godown and in such a manner so as to permit easy access for proper inspection and also to prevent deterioration due to moisture.

All approved epoxy components shall be arranged in batches with type, brand and date of receipt flagged on them. The Contractor shall maintain a register, on day-to-day basis, giving the details of the receipt/consumption, source of supply and type of cement etc. The register shall always be accessible to the Employer for verification.

4.1.17.2 Tests after Delivery

Each consignment of epoxy resins procured by the Contractor, shall, after delivery at Site and at the discretion of the Employer, be subjected to any or all of the tests and analyses, required by the IS 9162 (1979).

4.1.17.3 Rejection

The Employer may reject at his discretion any epoxy resins, notwithstanding the manufacturer's certificate or failing to meet the requirements of relevant IS Codes for testing of epoxy resins, hardeners and epoxy resin compositions. He may similarly reject any epoxy resins which has degrade owing to inadequate protection from moisture or due to intrusion of foreign matter or any other cause. Any epoxy resins which is considered defective shall not be used and shall be promptly removed from the site by the Contractor.

4.1.17.4 Materials Make

Sr No	Application	Product/Make
1	Rust cleaner of reinforcement	Fosroc/Sika/Pidilite
2	Alkaline Rust Converting Primer	Krishna Conchem -FEOVERT- Alkaline Rust Converting Primer
		Fosroc-Reebaklens RR
3	Anti-corrosive treatment for exposed reinforcement	Krishna Conchem-IPNET-RB
		Master Builder-MasterEmaco P130 Master Builder-MasterEmaco S 348
		Fosroc-Nitozinc Primer

4	Anti-corrosive treatment for unexposed reinforcement	Powrthrow caplets from Krishna Conchem or approved equivalent from BASF, Fosroc, Sika, Pidilite
		Epco Kp 100 of Krishna Conchem Protectosil CIT of Fosroc Ferroguard 903 of Sika Master Protect 8500 CI of BASF
5	Anchorage material for fixing rebar	Hilti, Fischer, Dewalt or equivalent
		HILTI RE 500 V4
		Master Builder-MasterFlow 936
		Lokfix E-77
6	Super Low viscosity high-molecular weight thermoset polymer	Krishna Conchem -MONOPOL
7	Super Low Viscosity Epoxy Injection grouting – Mix viscosity 160 cps	Krishna Conchem -EPCO-KP/HP-250-SLV
		Rohibb Packers – Krishna Conchem
		Master Builder-Master Inject 1315, packer
		Master Builder-Master brace ADH 2200
		Krishna Conchem / Sika Fosroc-Conbextra EP 10
8	Epoxy Bonding agent Long Pot Life – 120 min	Epibond 21 LP - Krishna Conchem
		FOSROC-Nitobond EP STD
		Master Builder-Master Brace 1414
9	Ready to use Corrosion Resistant Micro-concrete	Krishna Conchem -MOLITH MC or MOLITH TTCl
		FOSROC-Renderoc RG
		Master Builder-MasterEmaco S 346
10	Reinforcement steel	Tata/sail/Vizag /JSW or Equivalent Fe 500D
11	Carbon fibre reinforced polymer system	Nitowrap CWS (600 GSM) with 'Nitowrap 30 Primer and 'Nitowrap 410 saturant' Or Master Builder equivalent
12	Vermiculite plaster for waterproof and dehumidifying	Krishna Conchem -ECMAS HARD
13	Polymer modified, cementitious Corrosion Resistant mortar (PMM)	Krishna Conchem- Molith PMM or MOLITH PMM FCI
		FOSROC-Renderoc SP40
		Master Builder--MasterEmaco S 348

4.2 PLAIN AND REINFORCED CONCRETE WORKS

4.2.1 General

The section of the specifications includes requirements for furnishing and placing all plain and reinforced cement concrete including form work,

reinforcement and incidental works required for the completion of this Contract and herein specified.

This specification establishes the materials, mixing, placing, curing, etc. of all types of casts- in-situ and precast concrete used in rigid pavement, crown wall underground and over

ground structures, floors etc. Any special requirements as shown shall supersede over the provisions of this specifications.

Apart from this specification, construction of concrete works shall be in accordance with the Indian Standard Code of Practice for "Plain and Reinforced Concrete" IS:456 and other relevant codes mentioned therein.

In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern.

4.2.2 Materials

Materials for concrete viz cement, sand, coarse aggregate, water, etc. shall be as described in under specification of 'Materials'.

Materials for all reinforcements, embedment, inserts, water bars, etc. shall conform to specification of 'Materials'.

4.2.3 Grades of Concrete

Unless otherwise noted, the grades of concrete shall generally be as per Table 1.

Table 1 – Grades of Concrete

Grade Designation	Characteristic Compressive Strength of 15 cm cube at 28 days (N/mm²)
M 15	15
M20	20

M25	25
M30	30
M35	35
M40	40

The characteristic strength is defined as the strength of material, below which not more than five (5) percent of the test results are expected to fall.

4.2.4 Type of Concrete Mix

Unless otherwise noted all lean and reinforced concrete shall be nominal mix and design mix types respectively.

4.2.4.1 Nominal Mix Concrete

This concrete shall be made (without preliminary tests) by adopting nominal concrete mix with proportions of materials as specified in **Table-1A**.

Table 1A - Proportions for Nominal Mix Concrete

Nominal mix of concrete (by mass)	Quantity of water per 50 Kg of cement (max) / Litres
1:5:0	60
1:4:8	45
1:3:6	34
Note: The proportions of the fine to coarse aggregates should be adjusted from upper limit to lower limit progressively as the grading of the fine aggregates becomes finer and the maximum size of coarse aggregates becomes larger. Graded coarse aggregates shall be used. The cement content of the mix shall be proportionately increased if the quantity of water in a mix has to be increased to overcome the difficulties of placement and compaction, so that the water-cement ratio, as specified, is not exceeded.	

4.2.4.2 Design Mix Concrete

The mix shall be designed to produce the grade of concrete having the required workability and characteristic strength not less than appropriate values given in Table 1 above.

As long as the quality of materials does not change, a mix design done earlier shall be considered adequate for later work. However, in case the quality of materials changes, the Employer may ask for a new design mix.

While designing the mix, the durability requirements as given in IS:456 shall also be taken into account.

4.2.5 Concrete Mix Proportioning

Proportioning, as used in this specification, shall mean the process of determining the proportions of the various ingredients to be used to produce concrete of the required strength, workability, durability and other properties.

The Employer shall verify the strength of the concrete mix, before giving his sanction of its use. However, this does not absolve the Contractor of his responsibility as regards achieving the prescribed strength of the mix. If during the execution of the work, cube tests show lower strengths than required, the Employer shall order fresh trial mixes to be made by the Contractor. Any variation in cement consumption shall be taken into consideration for material reconciliation. Preliminary mix designs shall be established well ahead of start of work. The design mix shall conform to the guidelines of IS:10262.

4.2.5.1 Maximum Density

Suitable proportions of sand and the different sizes of coarse aggregates for grade of concrete shall be selected to give as nearly as practicable the maximum density. This shall be determined by mathematical means, laboratory tests, field trials and suitable changes in aggregate gradation.

The Contractor shall submit to the Employer at least three sets of mix design and corresponding test results after varying the mix proportions and / or grading of aggregate so as to establish the maximum density of any particular grade of concrete.

4.2.5.2 Water-Cement Ratio

Once a mix, including its water-cement ratio, has been determined and approved for use by the Employer, that water-cement ratio shall be maintained. The Contractor shall determine the water content of the aggregates frequently as the work progresses, and the amount of mixing water shall be adjusted so as to maintain the approved water-cement ratio. Maximum water-cement ratio shall never exceed the values given in IS:456 and IS:4651 for various exposures and sulphate attack conditions from durability considerations.

4.2.5.3 Consistency

The concrete shall have a consistency such that it shall be workable in the required position and when properly vibrated it flows around reinforcing steel, all embedded fixtures, etc.

4.2.5.4 Workability

The concrete mix proportion shall be such that the concrete is of adequate workability for the placing condition and can be properly compacted with the means available. Use of plasticiser / super-plasticiser of approved make shall be taken recourse to where required for attaining proper workability as specified in Table 2 below. However, prior written approval of the Employer shall be obtained for any such use of plasticiser / super- plasticiser before submitting the proposed design-mix for approval. Where adequate

workability is difficult to obtain at maximum permissible water-cement ratio, increased cement content shall also be alternatively considered while designing the mix proportions.

The suggested ranges of values of workability of concrete measured in accordance with IS: 1199 are indicated in Table 2 below. However, the actual values to be followed shall be established depending on aggregate sizing, mix proportions, placing conditions, etc. and shall be got approved by the Employer.

Table 2 - Values of Workability

Placing conditions	Degree of workability	Values of workability
Concreting of shallow sections with vibration	Very low	20-10 seconds vee-bee time or 0.75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10-5 seconds vee-bee time or 0.80-0.85 compacting factor
Heavily reinforced sections with vibration	Medium	5-2 seconds vee-bee time or 0.89-0.92 compacting factor or 25-75mm slump for 20mm aggregate

4.2.5.5 Durability

For achieving sufficiently durable concrete, strong, dense aggregates, low water-cement ratio and adequate cement content shall always be used. Workability of concrete shall be such that concrete can be completely compacted with the means available. Leak-proof formwork shall be used so as to ensure no loss of cement-slurry during pouring and compaction. Cover to reinforcement shall be uniform and as per standard codes. Concrete mix design shall always take into account the type of cement, minimum cement content irrespective of the type of cement and maximum water-cement ratio conforming to the exposure conditions as given in Table-2A.

Table 2A - Minimum Cement Content and Maximum Water Cement Ratio
for Durability

Exposure	Type of Cement	Plain Concrete		Reinforced Concrete	
		Minimum Cement Content (Kg./m ³)	Maximum Water-Cement Ratio	Minimum Cement Content (Kg./m ³)	Maximum Water-Cement Ratio
Normal	OPC* PPC* PSC*	Nominal mix	0.6	300	0.55
Moderate	OPC* PPC* PSC'	250	0.6	350	0.50
Severe	SSC* PSC* SRC'	310	0.45	400	0.45

Note:

1. Severe exposure shall include structures exposed to sea or saline water (e.g. tidal rivers, brackish water, estuaries etc.), alternate wetting and drying, freezing whilst wet and subject to heavy condensation or corrosive environment. This shall also include structures exposed to sulphate and/or chloride attack due to presence of these chemicals in Soil and ground water. Total SO₃ content of 0.2% and above in Soil and 300 ppm in ground water shall be considered to constitute severe exposure. Similarly, chloride (as Cl) content exceeding 1500 ppm in ground water or soil shall be considered as severe exposure condition.
2. Structures subjected to aggressive environment below the minimum limits expressed in Note-1 above and/or those in industrial/chemical plants atmosphere shall be considered under moderate exposure. Also, any concrete structure in contact with water or retaining water or any other liquid not usually harmful to concrete shall be considered under moderate exposure.
3. All other environmental conditions not covered under Notes-1&2 shall be categorised under Normal exposure.

* OPC - Ordinary low heat Portland Cement

* PPC - Portland Pozzolana Cement

- * PSC - Portland Slag Cement
- * SRC - Sulphate Resistant Cement
- * SSC - Super Sulphated Cement

4.2.6 Batching

In proportioning concrete, the quantity of both cement and aggregate shall be determined by mass. Where the mass of cement is determined on the basis of mass of cement per bag, a reasonable number of bags shall be weighed periodically to check the net mass. Where the cement is weighed at site and not in bags, it shall be weighed separately from the aggregates. Water shall be either measured by volume in calibrated tanks or weighed. Any solid admixtures that are to be added shall be measured by mass; liquid and paste admixtures shall be measured by volume or mass. Batching plant, where used, shall conform to IS:4925. All measuring equipment shall be maintained in a clean serviceable condition, and their accuracy periodically checked.

Except where it can be shown to the satisfaction of the Employer that supply of properly graded aggregate of uniform quality can be maintained over the period of work, the grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions when required, different sizes being stacked in separate stock piles. The grading of coarse and fine aggregates shall be checked frequently, the frequency for a given job being determined by the Employer to ensure that the approved grading is maintained.

Under special circumstances, change from weigh batching to appropriate volume batching may be permitted by Employer on specific request from

the Contractor. However, in such cases all conversions from mass of ingredients to volume shall be based on actual and appropriate bulk densities physically measured at site and approved by the Employer.

The amount of added water shall be adjusted to compensate for any observed variations in the moisture contents in both fine and coarse aggregates. For the determination of moisture content in the aggregates, IS:2386 (Part-111) may be referred to. To allow for the variation in mass of aggregates due to variation in their moisture content, suitable adjustments in the mass of aggregate shall also be made. In the absence of exact data, only in the case of nominal mixes, the amount of surface water may be estimated from the values given in Table-3.

Table 3 - Surface Water Carried by Aggregate

Aggregate	Approximate Quantity of Surface	
	Percent by mass	Litre / m ³
Very wet sand	7.5	120
Moderately wet sand	5.0	80
Moist sand	2.5	40
Moist Gravel or Crushed Rock	1.25-2.5	20-40

No substitutions in materials used on the work or alterations in the established proportions, except as permitted shall be made without additional tests to show that the quality and strength of concrete are satisfactory. In case the Contractor proposes any change in the already approved mix design, fresh mix design with supportive laboratory tests shall be submitted to the Employer and his approval has to be obtained prior to using the revised mix proportion in the works. However, such proposals for

revision shall only be entertained in case of successive failure of test cubes to achieve the required strength.

4.2.7 Concrete Mixing

The mixing of concrete shall be strictly carried out in an approved type of mechanical concrete mixer. The mixing shall be continued until there is a uniform distribution of the material and the mass is uniform in colour and consistency. If there is segregation, after unloading from the mixer, the concrete shall be remixed.

4.2.7.1 Mixer

Mixers shall comply with IS: 1791 and shall be maintained in satisfactory operating condition. Mixer drum shall be kept free of hardened concrete and blades shall be replaced when worn down more than ten percent (10%) of their depth. Should any mixer at any time produce unsatisfactory results, leak mortar or cause waste of materials, its use shall be promptly discontinued until it is repaired.

4.2.7.2 Mixing Time

Mixing time shall be as indicated in the following table. Excessive mixing requiring additions of water shall not be permitted. Time shall start when all solid materials are poured in the revolving mixer drum, provided that all of the mixing water shall be introduced before one-fourth of the mixing time has elapsed. The Employer may, however, direct a change in the mixing time, if he considers such a change necessary.

Capacity of mixer	Minimum Mixing time
2 m ³ or less	1½ minutes
3m ³	2½ minutes

5m ³	3 minutes
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All records and charts for the batching and mixing operations shall be prepared and maintained by the Contractor as per the instructions of the Employer.

4.2.7.3 Hand Mixing

Hand mixing of concrete shall not be permitted.

4.2.7.4 Admixtures

Admixtures in concrete shall be used only with the prior approval of the Employer. Any admixture used for obtaining proper workability or leak-proofness of concrete or repair/rendering works of concrete due to non-conformance to the specifications, shall not be measured and paid for.

4.2.8 Transportation, Placing and Compaction

The entire concrete placing programme including transportation arrangements, deployment of equipment, lay out, proposed procedures and methods, shall be submitted to the Employer 24 hours prior to concreting, for approval. No concreting shall be placed until his approval has been received. Approval of the Employer for pouring concrete shall be taken as 'conveyed', when the concrete pour card is signed by him.

4.2.8.1 Chuting

The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall be permitted only on written authorization from the Employer. In case an inferior quality of concrete is produced by the use of such conveyors, the Employer may order discontinuance of their use and the substitution of a satisfactory method of placing the concrete. Open troughs and chutes shall be equipped with baffles and be in short lengths to

avoid segregation. Chutes shall be designed so that the concrete is, to some extent, remixed at the lower end by passing down through a runnel shaped pipe or drop chute. Alternatively, they shall discharge into a storage hopper from which the concrete shall be transported to the point of placing by wheel barrows or other means. Where drop chutes are used, a sufficient number of these must be provided, so that the concrete discharged from the chute is not required to flow laterally more than 1.0 metre. Where a drop chute is swung from the vertical, the bottom two sections must be maintained in a vertical position to avoid segregation. The addition of water at any point in the system of transportation, to facilitate the movement of concrete shall not be permitted. All chutes, troughs and pipes, shall be kept clean and free from coatings of hardened concrete by thoroughly flushing them with water after each run; water used for flushing shall be discharged clear of the structure. Concrete shall not be normally permitted to fall freely from a height of more than 1.5 metre nor to strike the forms at an angle. However, a deviation from this normal practice may be allowed provided proper precaution is taken, while placing concrete into the forms to avoid segregation, to the satisfaction of the Employer.

4.2.8.2 Vibrators

Concrete shall be compacted with mechanical vibrating equipment supplemented, if necessary to obtain consolidation, by hand spreading, rodding and tamping. The vibrators shall be of immersion type with operational frequency ranging between 8,000 and 12,000 vibrations per minute. All vibrators shall comply with IS:2505. Screed board concrete vibrators or concreting vibrating tables or form vibrators conforming to

IS:2506, 2514 and 4656, respectively, shall be used where specifically required and directed by Employer.

Immersion type vibrators shall be inserted in a vertical position at intervals of about 600mm, depending upon the mix, the equipment used, and experience on work. The vibrators shall be withdrawn slowly. The spacing shall provide some overlapping of the area vibrated at each insertion. In no case shall vibrators be used to transport concrete inside the forms. Over vibration or under vibration shall not be permitted as both are harmful. Hand tamping in some cases may be allowed subject to the approval of the Employer.

In placing concrete in layers which are advancing horizontally as the work progresses, great care shall be exercised to ensure adequate vibration, bonding and moulding of the concrete between the succeeding batches.

The 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.

Care shall be taken to prevent contact of vibrators against all embedded reinforcing steel or inserts. Vibrators shall not be allowed to come in contact with forms.

The use of form vibrators shall not be permitted for compaction of in-situ concrete without specific authorization of the Employer.

The use of surface vibrators of screed board type shall not be permitted for consolidation of concrete under ordinary conditions. However for thin slabs

(of thickness less than 200mm) surface vibration by such vibrators may be permitted, upon approval of the Employer.

Whenever vibration has to be applied externally, the design of formwork and the disposition of vibrators shall be carefully planned to ensure efficient compaction and to avoid surface blemishes.

4.2.8.3 *Transportation*

All concrete shall be conveyed from the mixer to the place of final deposit as rapidly as possible in suitable buckets with crane, dumpers, boom placer, pumps or conveyors, which shall be mortar leak tight. Care shall be taken to prevent the segregation or loss of the ingredients and maintaining the required workability.

During hot or cold weather, concrete shall be transported in deep containers. Other suitable methods to reduce the loss of water by evaporation in hot weather and heat loss in cold weather may also be adopted. All equipment used for transporting and placing of concrete shall be maintained in clean condition. All buckets, hoppers, chutes, dumpers and other equipment shall be thoroughly cleaned after each use.

4.2.8.4 *Placing and Compaction*

Before placing concrete, all surfaces upon which or against which concrete is to be placed shall be well compacted and free from standing water, mud or debris. The surface of absorptive soil (against which concrete is to be placed) shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete.

Concrete shall not be placed until the formwork, the placement of reinforcing steel, embedded parts, pockets etc. have been inspected and approved by the Employer. Any accumulated water on the surface of the bedding layer shall be removed by suitable means before start of placement. No concrete shall be placed on a water-covered surface.

Concrete shall be discharged by vertical drop only and the drop height shall not normally exceed 1.5m throughout all stages of delivery until the concrete comes to rest in forms. For continuous concreting operation windows of suitable size shall be kept in the formwork or chutes shall be used to avoid segregation of concrete.

Concrete shall be deposited as near as practicable in its final position to avoid rehandling. Concrete shall be placed in successive horizontal layers. The bucket loads, or other units of deposit, shall be placed progressively along the face of the layer with such over-lap as will facilitate spreading the layer of uniform depth and texture with a minimum of hand shoveling. Any tendency to segregation shall be corrected by shoveling coarse aggregates

into mortar rather than mortar on the coarse aggregates. Such a tendency for segregation shall be corrected by redesign of mix, change in process or other means, as directed by the Employer.

All struts, stays and braces (serving temporarily to hold the forms in correct shape and alignment pending the placing of concrete at their locations) shall be removed when the concrete placing has reached an elevation rendering their service unnecessary. These shall not be buried in the

concrete. Concrete shall be thoroughly compacted with vibrators and fully worked around the reinforcement, embedded fixtures and into corners of formwork before setting commences and shall not be subsequently disturbed. Methods of placing shall be such as to preclude segregation. The formation of stone-pockets or mortar bondage in corners and against face 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 Employer. Care shall be taken to avoid displacement of reinforcement and embedded inserts or movement of formwork.

Unless otherwise approved, concrete shall be placed in single operation to the full thickness of foundation rafts, slabs, beams and similar members. Concrete shall be placed continuously until completion of the part of the work between approved construction joints or as directed by the Employer.

The method of placing and compaction employed in any particular section of the work shall be to the entire satisfaction of the Employer.

During hot weather (atmospheric temperature above 40 degree Celsius) or cold weather (atmospheric temperature below 5 degree Celsius), the concreting shall be done as per the procedure set out in IS:7861. Concrete that has set standing and becomes stiffened shall not be used in the work.

1.1.1.1 Items Embedded In Concrete

Concreting shall not be started unless the electrical conduits, pipes, fixtures etc., wherever required, are laid by the concerned agency. The Contractor shall afford all the facilities and maintain co-ordination of work with other

agencies engaged in electrical and such other works as directed by the Employer.

Before concreting, the Contractor shall provide, fabricate and lay in proper position all metal inserts, anchor bolts, pipes etc. (which are required to be embedded in concrete members) as per relevant drawings and directions of Employer.

All embedment, inserts etc. shall be fully held and secured in their respective positions by the concerned agencies to the entire satisfaction of Employer so as to avoid any dislocation or displacement during the concreting operations. The Contractor shall take all possible care during concreting to maintain these embedment/inserts in their exact locations.

4.2.9 Construction Joints

Construction joints shall be provided in position as directed by the Employer. Such joints shall be kept to the minimum. These shall be straight and at right angles to the direction of main reinforcement.

When the work has to be resumed on a surface, which has hardened, such surface shall be cleared of any foreign materials and roughened to expose the tips of the coarse aggregate. It shall then be swept clean and thoroughly washed and wetted before any new concrete is poured. Any set mortar or concrete sticking to the exposed reinforcing rods in and around such joints shall be thoroughly removed. The reinforcements shall be wire brushed and washed just before pouring any cement slurry or mortar. For vertical joints neat cement slurry shall be applied on the surface before it is dry. For horizontal joints the surface shall be covered with a layer of mortar

about 10 to 15mm thick composed of cement and sand in the same ratio as the cement and sand in concrete mix. This layer of cement slurry or mortar shall be freshly mixed and applied immediately before placing new concrete.

Where the concrete has not fully hardened, all laitance shall be removed by scrubbing the wet surface with wire or bristle brushes, care being taken to avoid dislodgment of particles of aggregate. The surface shall be thoroughly wetted and all free water removed. The surface shall then be coated with neat cement slurry. On this surface, layer of concrete not exceeding 150mm in thickness shall first be placed and shall be well rammed against old work, particular attention being paid to corners and close spots; work thereafter shall proceed in normal way.

4.2.10 Contraction Joint

Contraction joint shall be obtained by concreting on one side of the joint first and after the form work is removed a coat of sealing compound conforming to IS:13143 should be applied to prevent adhesion of concrete placed against it.

4.2.11 Expansion Joints/Isolation Joint

Expansion/Isolation joints in structures shall be formed in the positions and to the required shapes. Isolation joints shall be provided around all equipment foundations, columns, pedestals, trenches, etc. on grade.

4.2.12 Water Stops

PVC water stops as per specifications under 'Materials' shall be accurately cut, fitted and integrally joined as per manufacturer's specifications to provide a continuous, watertight diaphragm at all points.

The water stops shall be located and embedded at expansion/contraction/construction joints.

Adequate provision shall be made for the support and protection of water stops during the progress of the work. Damaged water stops shall be replaced and/or repaired as directed.

4.2.13 Protection of Freshly Laid Concrete

Newly placed concrete shall be protected, by approved means, from rain, sun and wind.

4.2.14 Curing

Concrete shall be cured by keeping it continuously moist wet for the specified period of time to ensure complete hydration of cement and its hardening. Curing shall be started after 8 hours of placement of concrete, and in hot weather after 4 hours. The water used for curing shall be of the same quality as that used for making of concrete.

Curing shall be assured by use of an ample water supply under pressure in pipes, with all necessary appliances such as hose, sprinklers etc. A layer of sacking, canvas, hessian, or other approved material, which will hold moisture for long periods and prevent loss of moisture from the concrete, shall be used as covering. Type of covering which would stain,

disfigure, or damage the concrete, during and after the curing period, shall not be used. Only approved covering shall be used for curing.

Exposed surfaces of concrete shall be maintained continuously in a damp or wet condition for at least the first 7 days after placing of concrete, except that high early strength concrete shall be so maintained for at least the first 3 days.

The Contractor shall have all equipment and materials required for curing on hand and ready to use before concrete is placed.

For curing the concrete in pavements, the ponding method of curing is preferred after the expiry of first 24 hours during which (i.e. first 24 hours) the concrete shall be cured by use of wet sacking, canvas, hessian etc. The minimum water depth of 25mm for ponding shall be maintained. The method of containing the ponded water shall be approved by the Employer. The ponded areas shall be kept continuously filled with water, and leaks, if any, shall be promptly repaired. Areas cured by ponding method shall be cleared of all debris and foreign materials after curing is over.

Alternatively, membrane curing may be used in lieu of moist curing with the permission of the Employer. Such compounds shall be applied to all exposed surfaces of the concrete by spraying or brushing as soon as possible after the concrete has set. Minimum film thickness of such curing compounds shall be as per the recommendation of the manufacturer. This film of curing compound shall be fully removed from the concrete surface after the curing period specified earlier. Employer may not allow curing by

curing compounds for those surfaces where use of curing compound may be detrimental to future finishes.

4.2.15 Field Tests

4.2.15.1 Grading Test

Grading test on fine and coarse aggregates shall be carried out as per IS:2386 at intervals specified by the Employer.

The mandatory tests and their frequencies shall be done on sand and stone aggregates as given in Table-4.

Table 4 - Mandatory Tests on Sand & Stone Aggregates

S. No.	Material	Test	Field/Lab Test	Minimum Qty. of Material/ Work for Carrying out the Test	Frequency of Testing
1	Sand	a) Bulking of Sand	Field	20m ³	Every 20 m ³ or part thereof or more frequently as decided by the Employer
		b) Silt content	Field	20m ³	-DO-
		c) Particle size distribution	Field or Lab as decided by the Employer	40 m ³	1) Every 40 m ³ of fine aggregate/sand required in RCC works only 2) Every 80 m ³ of fine aggregate/sand required for other items
2	Store aggregate	a) Percentage of soft or deleterious materials	General visual inspection, laboratory test where required by the Employer or as specified	As required by Employer's Engineer	For all quantities

		b) Particle size distribution	Field or lab as required by Employer	45 m3	For every 45 m3 or part thereof as decided by Employer
		Ten percent Fine value	Laboratory	45m3	Initial test and subsequent test as & when required by Employer.

4.2.15.2 Vee-Bee Test/Slump Test of Concrete

At least one Vee-Bee Test/Slump Test shall be made for every compressive strength test carried out. More frequent tests shall be made if there is a distinct change in working conditions or if required by the Employer.

4.2.15.3 Strength Test of Concrete

Samples from fresh concrete shall be taken as per IS: 1199 and cubes shall be made, cured and tested at 28 days in accordance with IS:516.

In order to get a relatively quicker idea of the quality of concrete, optional tests on beams for modulus of rupture at 72+2 hours or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values given in Table 5 may be taken for general guidance in the case of concrete made with ordinary Portland cement. In all cases, the 28 days compressive strength specified in Table 1 shall alone be the criterion for acceptance or rejection of the concrete from strength consideration. If, however, from tests carried out in a particular work over a reasonably long period, it has been established to the satisfaction of Employer that a suitable ratio between 28 days compressive strength and the modulus of rupture at 72+2 hours or compressive strength at 7 days may be accepted, the Employer may suitably relax the frequency of 28 days compressive strength specified in

Clause 4.2.3, provided the expected strength values at the specified early age are consistently met. However, set of test cubes for 28 days strength test shall always be taken and maintained to cater to any contingencies in the event of failure of 7 days strength.

Table-5 - Test Requirement of Concrete

Grade of Concrete	Compressive strength on 15 cm cubes minimum at 7 days (N/mm ²)	Modulus of Rupture by Beam Test, at minimum	
		72±2 hours (N/mm ²)	7 days (N/mm ²)
M15	10.0	1.5	2.1
M20	13.5	1.7	2.4
M25	17.0	1.9	2.7
M30	20.0	2.1	3.0
M35	23.5	2.3	3.2
M40	27.0	2.5	3.4

4.2.15.4 Procedure

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 cover all mixing units.

4.2.15.5 Frequency of Sampling

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

Quantity of concrete in the work in m ³	Number of samples
1-5	1
6-15	2
16-30	3
31-50	4
51 & above	4 plus one additional sample for each additional 50m ³
	or part thereof
NOTE: At least one sample shall be taken from each shift.	

4.2.15.6 Test Specimen

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing, or to check the testing error. Additional cubes may also be required for testing cubes cured by accelerated methods as described in IS:9013. The specimen shall be tested as described in IS:516.

4.2.15.7 Test Strength of Sample

The test strength of the sample shall be the average of the strength of three specimens. The individual variation should not be more than ± 15 percent of the average.

4.2.15.8 Standard Deviation

- i) Standard deviation based on test results:
 - a) Number of test results: The total number of test results required to constitute an acceptable record for calculation of standard deviation shall be not less than 30. Attempts should be made to obtain the 30 test results, as early as possible, when a mix is used for the first time.
 - b) Standard deviation to be brought up to date: The calculation of the standard deviation shall be brought up to date after every change of mix design and at least once a month.
- ii) Determination of Standard Deviation:
 - a) Concrete of each grade shall be analyzed separately to determine its standard deviation.
 - b) The standard deviation of concrete of a given grade shall be calculated using the following formula from the results of individual tests of concrete of that

grade obtained as specified in 2.15.7 Estimated standard deviation

$$(s) = \sqrt{\sum \Delta^2 / n - 1}$$

Δ = deviation of the individual test strength from the average strength of n samples

n = number of sample test results

c) When significant changes are made in the production of concrete | batches (for example changes in the materials used, mix design, equipment or technical control), the standard deviation value shall be separately calculated for such batches of concrete.

iii) Assumed Standard Deviation: Where sufficient test results for a particular grade of concrete are not available, the value of standard deviation given in Table 6 may be assumed.

Table 6 - Assumed Standard Deviation

Grade of Concrete	Assumed Standard Deviation (N/mm ²)
M 15	3.5
M 20	4.6
M 25	5.3
M 30	6.0
M 35	6.3
M 40	6.6

However, when adequate past records for a similar grade exist and justify to the Employer, a value of standard deviation different from that shown in Table 6, it shall be permissible to use that value.

4.2.15.9 Acceptance Criteria

The acceptance criteria for concrete shall be as per IS456:2000. Concrete shall be assessed daily for compliance.

Concrete is liable to be rejected if it is porous or honey-combed; its placing has been interrupted without providing a proper construction joint; the reinforcement has been displaced beyond the tolerances specified; or construction tolerances have not been met.

4.2.16 Inspection and Testing of Structures

4.2.16.1 Inspection

Immediately after stripping the formwork, all concrete shall be carefully inspected and defective work or small defects, if any, shall either be removed or made good before concrete has thoroughly hardened.

4.2.16.2 Testing of Structures or Parts of Structures

In case the results of work test cubes do not comply with the specified strength requirements or there is reasonable doubt regarding the strength of concrete used, either due to poor workmanship or materials the Employer may instruct the Contractor to perform additional tests as Employer feel necessary and/or load test as specified in Clause

to ascertain the quality of concrete. These tests shall also be required to be carried out in the event the Employer is doubtful regarding the adequacy of strength of the structure due to suspected overloading during construction, premature removal and non-conformance to specification of formwork, improper curing or any other reason. The number and type of tests to be carried out shall be determined by the Employer whose decision shall be final and binding on the Contractor.

4.2.16.3 Load Test

Load test, where directed by the Employer, shall be carried out as soon as possible after expiry of 28 days from the time of placing of concrete. The structure shall be subjected to a load equal to full dead load of the structure (which shall include Self Weight of Structural members plus weight of finishes) plus 1.25 times the imposed load (for which the structure has been designed) for a period of 24 hours and then the imposed load shall be removed. The deflection due to imposed load only shall be recorded. If within 24 hours of removal of the imposed load the structure does not recover at least 75percent of the deflection under imposed load, the test shall be repeated after a lapse of 72 hours. If the recovery is less than 80percent, the structure shall be deemed to be unacceptable.

If the maximum deflection in mm, shown during 24 hours under load is less than $40 L^2/D$, where L is the effective span in meters and D the overall depth of the section in mm, it is not necessary for the recovery to be measured and the recovery provision as given above shall not apply.

The Employer shall be the final Employer for interpreting the results of all tests and shall decide upon the acceptance or otherwise. The decision of the Employer shall be final and binding on the Contractor. In case the results of the tests are unsatisfactory, the Employer may instruct the Contractor to demolish and reconstruct the structure.

4.2.17 Finishing of Concrete

On striking the form work, all surface defects such as bulges, ridges and honey-combing etc. observed shall be brought to the notice of the Employer. The Employer may at his discretion allow rectification by

necessary chipping and packing or grouting with concrete or cement mortar. However, if honey-combing or sagging are of such extent as being undesirable, the Employer may reject the work totally and his decision shall be binding. No extra payment shall be made for rectifying these defects, demolishing and reconstructing the structure. However, quantity of cement actually used for this purpose may be considered for reconciliation of materials. All burrs and uneven faces shall be rubbed smooth with the help of carborundum stone.

The surface of non-shuttered faces shall be smoothened with a wooden float to give a finish similar to that of the rubbed down shuttered faces. Concealed concrete faces shall be left as from the formwork except that honey-combed surface shall be made good as specified above.

4.2.17.1 Repair and Replacement of Unsatisfactory Concrete

Repair shall be made as soon as possible after the forms are removed and before the concrete becomes too hard with prior permission from the Employer, in writing. Stone pockets, segregation patches and damaged areas shall be chipped out and the edges undercut slightly to form a key. All loose material shall be washed out before patching. No excess water shall be left in the cavity, but the concrete shall be damp. A good bond between the patch and parent concrete shall be obtained by sprinkling dry cement on the wet surface or by throwing mortar with force on to the wetted concrete, or by brush in a coat of thick cement grout of about 1:1 (1 cement: 1 Sand) just before applying the patching material. Before this has dried, the remainder of the patch shall be filled with mortar or concrete, depending on the extent of the repair.

Cement concrete/mortar used in repair of exposed surfaces shall be made with cement from the same source as that used in concrete and blended with sufficient amount of white Portland cement to produce the same colour as in the adjoining concrete. The proportions of ingredients shall be same as those used in parent concrete. The mortar shall be as dry as possible and well compacted into the cavity. All filling shall be tightly bonded to the concrete and shall be sound, free from shrinkage cracks after the filling has been cured and dried.

For larger repairs to hardened concrete, necessary formwork bearing tightly at the edges of the cavity shall be provided. Concrete shall be chipped out to a depth of at least 100mm and preferably 150mm. Mortar shall be scrubbed into all surfaces with a wire brush before placing the concrete. Damaged reinforcement shall be adequately spliced with new steel so as to maintain the original strength. Additional reinforcement, if required in the patch, shall be provided as per the instructions of Employer.

In case in the opinion of the Employer defects in the concrete is excessive or beyond repair, the Contractor shall either redo the structure or take other remedial measures as instructed by the Employer. The decision of the Employer shall be final and binding to all in this respect.

Approved epoxy formulation for bonding fresh concrete used for repairs with already hardened concrete shall be used by the Contractor if asked by the Employer. Epoxy shall be applied in strict accordance with manufacturer's specification and instructions.

All repair works due to non-conformance or non-adherence to specification, shall be carried out.

4.2.17.2 Curing of Patched Work

Immediately after patching is completed, the patched area shall be covered with an approved non-staining water saturated material, which shall be kept wet and protected against sun and wind for a period of 12 hours. Thereafter, the patched area shall be kept continuously wet by a fine spray or sprinkling for not less than 10 days.

4.2.18 Cement Wash

If instructed by the Employer, the Contractor shall provide one coat of cement wash over the exposed concrete surfaces of foundations, beams, columns, walls, lintels, soffit of slabs etc. which are not plastered and appearance-wise not upto acceptable standard, as per the sole direction of Employer due to bad workmanship, defective shuttering, honey-combing and other repair works subsequently undertaken by the Contractor. No extra amount shall be paid to the Contractor on this account. However, cement used by the Contractor for providing the cement wash shall be taken into account for material reconciliation purposes.

4.2.19 Form Work

4.2.19.1 General

Forms for concrete shall be of plywood conforming to IS:6461 or steel or as directed by the Employer and shall give smooth and even surface after removal thereof.

If it is desired by the Employer, the Contractor shall prepare, before commencement of actual work, design and drawings for formwork and get them approved by the Employer.

Form work and its supports shall maintain their correct position and be to correct shape and profile so that the final concrete structure is within the limits of dimensional tolerances specified below, unless required otherwise, for functional/aesthetic reasons. The decision of the Employer shall be final and binding in this regard.

- a) Deviation from specified dimensions: -6mm to +12mm of cross section of columns & beams
- b) Deviation from dimensions of footings (see Note below)
 - i) Dimensions in plan: -12mm to +50mm
 - ii) Eccentricity : 0.02 times the width of the footing in the direction of deviation but not more than 50 mm.
 - iii) Thickness : ± 0.05 times the specified thickness.

Note: Tolerances apply to Cast-in-situ concrete dimensions only, not to positioning of vertical reinforcing steel or dowels.

- c) Deviation in length (major dimension of single unit)
 - i) upto 3m : ± 6 mm
 - ii) 3m to 4.5m : ± 9 mm
 - iii) 4.5m to 6m : ± 12 mm

Additional deviation for every subsequent 6m: ± 6 mm

- d) Deviation in straightness or bow (deviation from specified line) for a single or continuous member) e.g. beam, column or slab edge.
 - i) upto 3m : 6mm

- ii) 3m to 6m : 9mm
- iii) 6m to 12m : 12mm
- iv) Additional for every subsequent 6m: 6mm
- e) Deviation in squareness shall be measured taking the longer of two adjacent sides as the base line.

The shorter side shall not vary in its distance from a perpendicular so that the difference between the greatest and shortest dimensions exceeds 6mm. For this purpose, any error due to lack of straightness shall be ignored. Squareness shall be checked with respect to the straight lines that are most nearly parallel with the features being checked. When the nominal angle is other than 90 degrees, the included angle between check lines shall be varied accordingly.

- f) Deviation in twist shall be within a limit such that any corner shall not be more than the limit given below from the plane containing other three corners:

- upto 600mm wide and upto 6m in length - 6mm
- over 600mm wide and for any length - 12mm

Maximum deviation in flatness from a 1.5m straight edge placed in any position on a nominally plain surface shall not exceed 6mm.

4.2.19.2 Form Requirement

The formwork shall be true, rigid and adequately braced both horizontally as well as diagonally. The forms shall have smooth and even surface and be sufficiently strong to carry, without deformation, the dead weight of the green concrete working load, wind load and also the side pressure exerted by the green concrete. As far as practicable, clamps shall be used to hold the forms together. Where use of nails is unavoidable

minimum number of nails shall be used. Projected part of nail shall not be bent or twisted for easy withdrawal.

Where through tie rods are required to be put to hold the formwork and maintain accurate dimension, they shall always be inserted through a precast concrete block (of same mix proportion as is to be used for concreting) with a through hole of bigger diameter. The precast block shall tightly fit against in inner faces of formwork. The holes left after the withdrawal of tie rods shall be fully grouted with cement-sand mortar of same proportion as that used for concrete. However, use of such precast block shall in no case impair the desired appearance or durability of the structure. No such tie rods shall be used in any liquid retaining or basement structure.

Tie wires shall be permitted only upon approval of the Employer and shall be cut off flush with the face of the concrete or counter sunk, filled and finished in the manner specified in Clause 4.2.17.

Form joints shall not permit any leakage. The formwork shall be strong enough to withstand the effect of vibrations practically without any deflection, bulging, distortion or loosening of its components.

Forms for beams and slabs (span more than 6.0m) shall have camber of 1 in 500 so as to offset the deflection and assume correct shape and line after deposition of concrete. For cantilevers, the camber at free end shall be $1/100^{\text{th}}$ of the projected length. Where architectural considerations and adjunctive work are critical, smaller form cambers shall be adopted as decided by the Employer.

All vertical wall forms may be designed and constructed for the following minimum pressure. The pressures listed in Table 7 are intended as guide only and the Contractor shall ensure that the formwork is adequately strong and sturdy.

Table 7 - Minimum Design Pressure for Wall Formwork

Rate of pour in meter/hour	Pressure in kN/m ²	
	at 10° (in Celsius)	at 24° (in Celsius)
0.6	36.0	29.0
0.9	40.0	32.0
1.2	44.0	35.0
1.5	46.0	37.0

All horizontal forms shall be designed and constructed to withstand the dead load of the green concrete, reinforcement, equipment, material, embedment and a minimum liveload of 2.0 kN/Sqm.

4.2.19.3 Inspection of Forms

Temporary openings shall be provided at the base of column and wall forms and other places necessary to facilitate cleaning and inspection. Before concrete is placed, all forms shall be carefully inspected to ensure that they are properly placed, sufficiently rigid and tight, thoroughly cleaned, properly treated and free from foreign material. The complete form work shall be inspected and approved by the Employer before the reinforcement bars are placed in position. When forms appear to be unsatisfactory in any way, either before or during the placing of concrete, the work shall be stopped until the defects have been corrected as per the instructions of the Employer.

4.2.19.4 Treatment of Forms

The surfaces of forms that would come in contact with concrete shall be well treated with approved non- staining release agents such as soft soap, oil, emulsions etc. Care shall be taken that such releasing agents are kept out of contact with the reinforcement.

4.2.19.5 Chamfers and Fillets

All comers and angles shall be formed with 45-degree mouldings to form chamfers or fillets on the finished concrete. The standard dimensions of chamfer and fillets, unless otherwise detailed or specified shall be 25x25mm. For heavier work chamfers or fillets shall be 50x50mm. Care shall be exercised to ensure accurate mouldings. The diagonal face of the moulding shall be planed or surfaced to the same texture as the forms to which it is attached.

4.2.19.6 Reuse of Forms

Before reuse, all forms shall be thoroughly scrapped, cleaned, examined and when necessary, repaired and retreated, before resetting. Formwork shall not be reused, if declared unfit or un-serviceable by the Employer.

4.2.19.7 Removal of Forms / Stripping Time

In the determination of time for removal of forms, consideration shall be given to the location and character of the structures, the weather and other conditions including the setting and curing of the concrete and material used in the mix.

Forms and their supports shall not be removed without the approval of the Employer. The formwork shall be removed without shock and methods of

form removal likely to cause over stressing or damage to the concrete shall not be adopted. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight. In normal circumstances when average air temperature exceeds 16 degree Celsius during the period under consideration after pouring of concrete and where ordinary Portland cement is used, forms may generally be removed after expiry of following periods.

- a) Walls, columns and vertical : 24 to 48 hours may faces of all structural members be decided by the Employer
- b) Slabs (props left under). : 3 days
- c) Beam Soffits (props left under) : 7 days
- d) Removal of props under slabs :
 - Spanning upto 4.5m. : 7 days
 - Spanning over 4.5m. : 14 days
- e) Removal of props under beams and arches:
 - Spanning upto 6m. : 14 days
 - Spanning over 6m and upto 9m: 21 days
 - Spanning over 9m. : 28 days
- f) Cantilever Construction : Formwork shall remain till structures for counter-acting or bearing down have been erected & have attained sufficient strength (minimum 14 days).

Notes:

1. For rapid hardening cement, 3/7 of the above-mentioned periods shall be considered subject to a minimum of 24 hours.
2. For other cements, the stripping time recommended for ordinary

Portland cement shall be suitably modified as per the instructions of the Employer.

3. The number of props left under, their sizes, supporting arrangement, and disposition shall be such as to be able to safely carry the full dead load of the slab, beam or arch as the case may be together with any live load likely to occur during curing or further construction.

4. Where the shape of the element is such that the formwork has re-entrant angles, the formwork shall be removed as soon as possible after the concrete has set, to avoid shrinkage cracking occurring due to the restraint imposed.

4.2.19.8 Staging / Scaffolding

Staging / Scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. The Contractor shall get it reviewed by Employer before commencement of work. While designing and during erection of scaffolding/staging, the following measures shall be considered:

- a) Sufficient sills or under pinnings in addition to base plates shall be provided particularly where scaffolding are erected on soft grounds.
- b) Adjustable bases to compensate for uneven ground shall be used.
- c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.
- d) Horizontal braces shall be provided to prevent the scaffolding / staging from rocking.
- e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.
- f) The scaffolding / staging shall be checked at every stage for plumb line.
- g) Wherever the scaffolding / staging is found to be out of plumb line it shall be dismantled and re-erected afresh and effort shall not be made to

bring it in line with a physical force.

h) All nuts and bolts shall be properly tightened and care shall be taken that all clamps/couplings are firmly tightened to avoid slippage

i) Erection work of a scaffolding/staging under no circumstances shall be left totally to semi-skilled or skilled workmen and shall be carried out under the supervision of a technically qualified civil Engineer of the Contractor.

For smaller works or works in remote areas, wooden ballies may be permitted for scaffolding / staging by the Employer at his sole discretion.

The Contractor must ensure the safety and suitability of such works as described above.

4.2.20 Exposed Concrete Work

4.2.20.1 Form Work

Other things remaining same as per Clause 4.2.19, formwork shall be of high quality. Care shall be taken to arrange the forms so that the joints between forms correspond with the pattern indicated in the Contractor's drawings. The forms shall be butting with each other in straight lines, the comers of the boards being truly at right angles. The joints between the forms shall cross in the two directions at right angles. The size of forms shall be so selected as to exactly match with the pattern of forms impression on the concrete face indicated in the Contractor's drawings. Maximum care shall be taken to make the formwork watertight. Burnt oil shall not be used for treatment of forms. The Contractor shall be permitted reuse of forms brought new on the work for exposed concrete work as specified below.

Such reuses shall be permitted only if forms are properly cared for, stored, repaired and treated after each use.

- a) Plywood Forms: 6 Reuses (Max.)
- b) Steel Forms : 10 Reuses (Max.)

However, in case of steel formwork higher number of reuses could be permitted as long as casting tolerance levels are within acceptable limits.

The Employer may, at his absolute discretion, order removal of any forms considered unfit for use in the work irrespective of the number of uses specified above.

4.2.20.2 Finishing

Repairing to exposed concrete work shall be avoided. Rendering and plastering shall not be done. Minor repairing, if unavoidable shall be done as specified in Clause 4.2.17.1 with the written permission of the Employer.

4.2.20.3 Reinforcement

- a) General

Reinforcement shall be cut, bent to shape and dimensions as shown in the Contractor's bar bending schedules/drawings approved by the Employer's Engineer.

- b) Straightening, Cutting and Bending

Procedure for cutting and bending shall be as given in IS: 2502. In case bars are supplied in coils, they shall be smoothly straightened without any kinks.

Cold twisted deformed bars shall be bent cold. Bars larger than 25mm in size (except cold twisted deformed bars) may be bent hot at cherry red heat to a temperature not exceeding 850° Celsius as per the instructions of the Employer. The bars shall be allowed to cool gradually without quenching.

Bars shall be bent in a slow and regular movement to avoid fractures. Bars which develop cracks or splits after bending shall be rejected. A second bending of reinforcement bars shall be avoided but when reinforcement bars are bent aside at construction joints and afterwards bent back into their original position, care should be taken to ensure that at no time is radius of the bend less than 4 times bar diameter for plain mild steel or 6 times bar diameter for high strength deformed bars. Care shall also be taken when bending back bars to ensure that concrete around the bars is not damaged. All bars shall be properly tagged for easy identification.

4.2.20.4 Placing and Fixing

All reinforcement shall be cleaned to ensure freedom from loose mill scale, loose rust, oil, grease or any other harmful material before placing them in position. Reinforcement shall not be surrounded by concrete unless it is free from all such materials.

All reinforcement shall be fixed in the correct position and shall be properly supported to ensure that displacement will not occur when the concrete is placed and compacted.

The reinforcement bars shall be tied at every intersection by two strands of 16 SWG black soft annealed binding wire (confirming to IS:280). Crossing bars shall not be tack welded

for assembly of reinforcement. Knots in the winding wire shall be placed inside & not in cover Zone. The reinforcement bars shall be kept in position by using the following methods:

- a) In case of beam and slab construction, precast cover blocks (having

the same cement sand contents as the concrete which shall be placed) of size 40 x 40 mm and thickness equal to the specified covers shall be placed firmly in between the bars and forms so as to secure and maintain the specified covers over the reinforcement. When reinforcement bars are placed in two or more layers in beams, the vertical distance between the horizontal bars shall be maintained by introducing spacer bars at 1 to 1.2m center to center.

b) In case of thick rafts & pile caps having two or multi layers of reinforcement, the vertical distance between the horizontal bars shall be maintained by introducing suitable chairs, spacers, etc.

c) In case of columns and walls, the vertical bars shall be kept in position by means of timber templates with slots accurately cut in them. The templates shall be removed after the concreting has been done below it.

d) Exposed portions of reinforcement bars shall not be subjected to impact or rough handling and workmen will not be permitted to climb on extending bars until the concrete has attained sufficient strength so that no movement of the bars in the concrete is possible.

4.2.20.5 Splicing / Overlapping

Only bars of full length shall be used. But where this cannot be done, overlapping of bars shall be done as directed by the Employer. Where practicable, the overlapping bars shall not touch each other, but these shall be kept apart by 25mm or 1.25 times the maximum size of the coarse aggregate whichever is greater. But where this is not possible, the overlapping bars shall be tied with two strands of 16 SWG black soft annealed binding wire (confirming to IS:280). The overlaps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is maximum.

4.2.20.6 Welded Joints

Welding of reinforcing bars shall not be permitted without the written permission of the Employer. Where welding is permitted, it shall be in accordance with the recommendations of IS:2751 and IS:9417. Welded joints shall be located at suitable staggered positions. Tests shall be made as directed by the Employer to prove that the joints are of the full strength of the bars. Maximum one welded joint shall be allowed per bar.

4.2.20.7 Mechanical Connections

The mechanical splices in reinforcement by means of couplers, clamps etc. shall be used

{as per manufacturer's specifications) with the written approval of the Employer. However, tests shall be made as directed by Employer to prove that such connections are of the full strength of the bars on trial joints.

4.2.20.8 Tolerances

Unless otherwise directed by the Employer, reinforcement shall be placed within the following tolerances:

- a) For effective depth 200mm or less : $\pm 10\text{mm}$
- b) For effective depth more than 200mm : $\pm 15\text{mm}$

The cover shall in no case be reduced by more than one third of specified cover or 5mm, whichever is less.

4.2.20.9 Substitution

When indicated diameter of reinforcement bar is not available, the Contractor shall use other diameter of reinforcement bars on written approval of the Employer.

4.2.20.10 Cover

Cover to reinforcement shall be as per standard codes / as directed by the Employer.

4.2.20.11 Precast Concrete

Specifications contained in above regarding concrete, formwork and reinforcement shall apply in addition to the specification given as under. The Contractor shall get the pre-casting bed approved by the Employer.

Necessary lifting hooks of suitable (but not less than 12mm dia) diameter M.S. rounds shall be provided for handling.

Unless otherwise specified, the exposed surfaces of precast members shall be integrally finished smooth. For precast slabs or planks, the top surface shall be finished with 1:3 (1 cement: 3 sand) cement mortar. Surface used as walkways shall be given a non-skid finish.

The precast concrete units shall be marked clearly on top surface with the letter "T" for identification of surfaces at the time of erection and shall be stored properly until required for erection. The precast units shall be handled and erected by methods approved by the Employer to protect them from damage.

The Contractor shall take all necessary precautions for safe handling during the course of erection. The Contractor shall replace all such units, which are damaged during the course of erection.

4.2.21 Concrete Underwater

Where concrete is to be deposited underwater, the greatest care shall be taken to prevent the cement being washed out. The concrete shall be

placed through a tremie pipe with suitable hopper and plunger arrangements. Great care shall be taken to ensure that no segregation of concrete takes place and the Employer shall approve the method of placing.

The discharge end of the tremie tube shall be plugged at the start of the work so as to minimise the entry of water into the tube and it shall be entirely sealed at all times and

kept full of concrete upto the bottom of hopper. Concreting operations once commenced are to be completed in full without break otherwise the structure shall be considered as rejected.

4.2.22 Underground Concrete Work

All reinforced concrete work below ground level or other filled areas shall be protected from the aggressive action of salts and other chemicals contained in all types of earth and rocks, ground water or other materials as follows:

- i) Except where otherwise agreed by the Employer, the underside of all concrete foundations, beams, slabs, ducts, manholes, shall have a layer of at least 75 mm of blinding concrete of an approved mix using sulphate resistant cement. The top face to be finished to take the polythene sheeting material.
- ii) A layer of polythene sheeting material shall be laid prior to concreting under the foundations, beams, slabs, ducts, manholes, etc. and carried up the sides of such members to ground level or other level as defined by the Employer. Laps in the polythene sheeting material shall not be less than 300 mm and securely taped as specified.

Care shall be taken to avoid puncturing or tearing the sheeting and should this occur the puncture or tear shall be repaired to the satisfaction of the Employer or the sheeting replaced.

- i) The surfaces of concrete exposed after the removal of form including top faces of buried members shall be painted with one coat of primer (Bituminous solvent) and two coat of Bituminous (blended together with non-asbestos reinforcing fabric and solvent) applied as manufacturer's instructions and to the satisfaction of the Employer.
- ii) The external surfaces of manholes, cable pits and service pits shall be coated with two coats of a rubber reinforced bitumen emulsion, brush applied. The coatings shall be applied strictly in accordance with the manufacturer's instructions.

4.2.23 Concreting in Inclement Weather

In the event of rainstorm or any other severe conditions arising, concreting shall be stopped and appropriate temporary stop ends, vee grooves, etc. placed as may be necessary. During wet weather, the concrete shall be adequately protected as soon as put into position.

The Contractor shall always have in readiness approved framed sheeting, tarpaulin etc. for the protection of newly placed concrete during inclement weather. Shall any concrete be damaged due to rainstorms or other weather conditions, the Employer may order the cutting out and replacement of the damaged concrete.

4.2.24 Grouting

The base plates of all the steel structures shall be grouted to thickness as shown on the relevant structural drawings of Contractor, after the alignment and approval of the Employer. The grout shall consist of either

- a) 1:2 (1 Cement: 2 Sand) mortar for operating platforms (not supporting Equipment), pipe supports upto 2.5m in height (above concrete top), cross-over, stair cases and ladders. or
- b) Free flow non shrinks Grout (Pre-mix type) of compressive strength not less than 40/mm² for all structures other than those covered in (a) above, as per the instructions / recommendations of the manufacturer.

4.2.25 Continuous Concreting

Continuous concreting shall be done in a single operation as per the requirements of IS:456 and IS:2974. It shall be ensured that Clause 4.2.8.4 of these specifications is not violated in case of continuous concreting. Sufficient "Windows" shall be left in the formwork for walls, columns and other thin sections of significant height for pouring & compaction of concrete and inspection. The concrete to be placed in a manner that will prevent segregation and accumulation of hardened concrete on the formwork or reinforcement above the level of the placed concrete. These windows shall be fixed tight once the level of concrete reaches their levels.

4.3 Repair works

4.3.1 General

This section covers the specification for the repair work of the existing structure.

This specification establishes the materials, mixing, placing, curing, etc. of all types of grouting. crown wall underground and over ground structures, floors etc. Any special requirements as shown shall supersede over the provisions of this specifications.

Apart from this specification, construction of epoxy grouting shall be in accordance with the Indian Standard Code and other relevant codes mentioned therein.

In case of conflict between the clauses mentioned in this specification and those in the Indian Standards, this specification shall govern.

4.3.2 Materials

Materials for repair work viz epoxy, hardener, water, etc. shall be as described in under specification of 'Materials'.

Materials for all reinforcements, embedment, inserts, water bars, etc. shall conform to specification of 'Materials'.

4.3.3 Temporary Support

Contractor shall provide necessary temporary support to release the existing loads from the supporting structure.

4.3.4 Removal of loose concrete

All the loose concrete shall be removed by manually operable chisel and mechanical hammer before commencement of the core of jacketing. The exposed surface shall be cleaned thoroughly with water jet to remove loose particle

4.3.5 Alkaline rust converter

Single pack alkaline water-based rust converting primer which is designed for application on rusted steel surfaces to form a complex iron compound shall be apply as alkaline rust converter. The unique deoxygenating agent formed during application should convert the rust into corrosion resistant, insoluble and adherent layer by reacting with the oxygen present on the

surface. Typical component be Feovert or equivalent. Application procedure alkaline rust converter.

- ✓ Remove loosely held rust using a hand wire brush gently, but leave behind the layer of rust directly attached to the underlying steel.
- ✓ Ensure removal of oil or greasy residues if any with strong detergent and wash with clean water. Allow it to dry.
- ✓ Apply the rust remover using a brush or spray.
- ✓ Apply minimum 1 coat. Preferably two coats when heavy rust is present.
- ✓ Curing time for each coat 6 – 8 hours.

4.3.6 Anti-Corrosive treatment

Anti-corrosive treatment shall be provided and applied to the exposed corroded steel bars after proper cleaning using alkaline based Rust Remover after surface preparation. Epoxy phenolic reinforcement treatment instead of Zn rich epoxy system as the elongation property of epoxy phenolic is near to steel elongation. As protective, anti-corrosive coating 35 to rebar in the construction of RCC structures exposed to aggressive corrosion, to enhance the durability. As anti-corrosive coating to exposed reinforcement bars in embedded concrete (after thorough de-rusting with wire brushes) in repair works. Typical component for anti-corrosive treatment is IPNET-RB or equivalent.

4.3.7 Low viscosity high molecular weight polymer

Low viscosity high molecular weight thermoset polymer shall be applied. Due to its low viscosity, cracks and honeycombs in concrete are filled up to maximum possible depth of concrete. The unique advantage of the chemical treatment is

- a) By virtue of low viscosity high molecular weight polymer penetrates into the concrete even through fine hair cracks and strengthens the matrix.
- b) Seals cracks/honeycombs in concrete under very low pressure of 5 – 10 Psi.
- c) Grouting can be done by gravity pouring/pressure grouting.
- d) Excellent adhesion and chemical resistance.

4.3.8 Epoxy injection grouting

Exposed concrete surface shall be provided with low viscosity injection grouting at a spacing of 300 mm c/c in staggered manner.

Concrete elements shall be injected as per the following procedure

- ✓ Surface preparation
- ✓ Fixing of packers
- ✓ Sealing of cracks using
- ✓ Mixing of injection grout
- ✓ Grouting

4.3.9 Surface Preparation

For Areas where injection of visible cracks is required: Clean the concrete surface, 2cm on either side of the crack to ensure better bonding of sealing material used for crack sealing.

- Where the concrete is found to be weak immediately next to cracks, weak concrete shall be opened up completely.
- For wider cracks, opening of crack in the form of V-Groove, minimum 10mm wide and 10mm deep is ideal.
- For very fine cracks, Cutting V-Groove is not required.
- All loose traces of dust, grease oil, form release agent etc. must be

thoroughly removed mechanically by scrapping, brushing, high pressure water jetting along the crack line.

- Holes of approximately 12mm dia. shall be drilled into the concrete without damaging the embedded reinforcement steel.
- Depth of the drilled holes shall be minimum 50mm to 75mm
- All the dust and loose particles that surrounds the cracks and the dust inside the drilled holes shall be flushed out with clean, dry, compressed air.
- If the concrete along the crack is loose, it should be routed out by cutting a small v-groove and blowing out the dust and loose particles by air pressure.
- For Areas where concrete mass is porous: The holes shall be drilled on the entire surface of the porous concrete as mentioned above.

4.3.10 Fixing of packers

- Injection packers with non-return valve shall be fixed into the drilled holes for injecting grouts at a spacing of not more than 500mmc/c ideally.
- The spacing of the packers shall depend upon the severity of concrete deterioration and shall be ideally decided depending upon the site conditions and the test results if conducted.
- The packers shall be inserted into the drilled holes and fixed in position using non-sag, two component epoxy putty.
- The epoxy putty shall be allowed to cure for couple of hours before the start of injection grout.

4.3.11 Sealing of Cracks

- The opened crack line shall be sealed with epoxy putty, to avoid oozing of the injection grout from between the packers.
- Two component epoxy putty shall be mixed suitably with a slow speed around 300rpm until uniform consistency is achieved.
- The material shall be pressed into the opened-up cracks and levelled at the top in line with the concrete surface using steel trowel.

- The epoxy putty shall be allowed to cure for couple of hours before the start of injection grout.

4.3.12 Mixing of Injection Grout

- Properly Stir each component of epoxy resin separately.
- Combine the base and hardener in a suitably sized container.
- Mix the material using slow speed drill mixing paddle at 300 to 400rpm min for 3 minutes until homogeneous mix is achieved.
- Scrap the sides of the container to ensure full reaction.

4.3.13 Injection Grouting

- The prepared surface should be air dry before the application starts with moisture level $\leq 4\%$.
- The mixed grout shall be injected using a suitable pressure grouting machine and within the pot life of the material.
- The injection pressure to be maintained shall be between 2.5kg/cm² to 6kg/cm².
- Pressure to be maintained at the site shall be gradually increase upward depending upon the site conditions
- The supply line shall be connected to the first packer.
- Pumping of the resin shall then commence.
- The injection process shall continue till the material starts coming out and the concrete stops taking material further.
- The pump pressure shall be maintained for at least 2-5 minutes, allowing the resin to stabilize into crack before the pump is disconnected.
- The injection pump shall be connected to the next immediate packer and the injection process is repeated again till all the packers are finally injected.
- For horizontal cracks: Injection shall start from the widest part and then continued till the last packer is injected.

- For Vertical Crack: Injection should start from the lowest port and continued upwards till the last packer is injected.
- The injected port shall be removed by cutting it at the lowest edge after 24 hrs. and the area shall then be sealed/levelled using epoxy putty.
- Do not apply the material when either the temperature 40°C or humidity is >75% or both.
- The injection grout is self-curing

4.3.14 Provision of shear connector

Drill holes of 12mm diameter and 100 mm depth in concrete surface, clean the drilled holes and fix shear connectors in drilled holes using chemical grout (Hilti or equivalent) at spacing of 200 mm.

However, a detailed condition survey assessment shall be undertaken during the renovation and modernization phase in the dry condition to ascertain the health of the structure. The health assessment shall include NDT test of concrete, concrete block out test, reinforcement mapping, corrosion test, etc.

4.3.15 Fixing of additional rebar

Fix additional main reinforcement bars with the help of shear and transverse reinforcement all around the column. Apply the rebar as per the drawing below. No rebar should be done where roof beam does not exist. Anchoring/rearing should not be done in the slab where there is no beam.

4.3.16 Anti-corrosive treatment to new rebars

Anti-corrosive treatment shall be applied to the new reinforcement bar. Minimum two coat anti corrosive treatment on the steel reinforcement as per point 4.3.6.

4.3.17 Application of bond coat

The prepared concrete substrate shall be given a bonding coat using two components, epoxy bonding agent. Applying a single coat of two component solvent less epoxy resin based bonding coat, complying to ASTM C881 Type 2, Grade 2, and Class B & C having an open time of 6 hours and shall exceed the tensile strength of concrete in terms of its adhesive bond strength using brush or roller to ensure bond between old concrete & new concrete. The bonding agent is applied using either by brush or roller. Care must be taken that the bonding agent has sufficient open time so that it doesn't lose its tackiness. Ensure Long pot free time of 120 minutes at 30oC.

4.3.18 Shuttering & pouring of micro-concrete

After application of bond-coat, shuttering should be completed within 2 hrs. Apply is a free flow, shrinkage compensated, single component micro concrete used in high volume repairs of concrete structures

4.3.19 De-Shuttering

Once the pouring of concrete is done. It is allowed to set for the required period and then it is de shuttered. De-shuttering should be done after 14 days.

4.3.20 Curing

The repaired area shall be kept wet for a minimum period of 7 days for concrete to achieve its strength

4.3.21 Vermiculite waterproof plaster

Providing and applying waterproofing treatment using plaster (such as ECMAS HARD), 100% waterproof, hydrophobic, breathable and drying plaster having maximum water penetration in hardened plaster <1 mm as per EN 1015-18, density of 1680 kg/m³, water vapor permeability coefficient (breathability) less than equal to 12.4, having initial surface absorption of 0 as per BS 1881 part -1970, should be safe to be in contact with clean drinking water, at an average total thickness of 10 mm, pressed with 10 mm, 110 GSM glass fibre mesh while it is still wet, as per manufacturers specification. This includes cleaning of mother concrete surface to remove dust and loosely adhering particles completely. The waterproofing system shall be cured for 5 to 7 days. Apply acrylic paint over the plaster for surface protection.

4.3.22 Compliance

After micro-concrete is done, NDT test should be conducted to ensure design strength is achieved.

4.4 PILE FOUNDATIONS

4.4.1 General

This section of specification includes requirement for furnishing and placing/installation of reinforced concrete bored cast in-situ piles.

4.4.2 Bored cast in-situ Piles

4.4.2.1 General

Piles may be of any type as may be designed by the Contractor for the works or any part thereof. However concrete bored cast in-situ pile types are described in brief.

The Contractor shall furnish materials, labour and equipment necessary to drill or bore and install bored piles in accordance with this specification.

Unless specified the grade of concrete shall be minimum M40 conforming to IS:10262. The cement content for piling work shall be minimum 400 kg/m³ and maximum water cement ratio shall be 0.45.

The properties of cement, reinforcement and fine/coarse aggregates to be used for piles construction shall be in accordance with the specifications under 'Materials'.

Construction of bored piles shall be carried out in accordance with the relevant sections of IS:2911 (Part I/sec 2) and only routine pile load test shall be conducted as per IS:2911 (Part 4) except where otherwise specified, described or directed by the Employer.

4.4.2.2 Programme and Method of Construction

The Contractor must furnish to the Employer, before commencing work, a detailed method of construction he intends to adopt for piling work together with the programme of construction.

4.4.2.3 Boring

Boring shall generally be carried out by recommended procedure as set out in IS:2911 by either rotary or percussion equipment, grabbing equipment or by reverse or direct mud circulation method. If the soil is found to be unstable, the boring tools should be such that suction effects are minimized. Walls of boreholes shall be stabilized by using removable bottom casings with or without drilling fluid depending upon the soil conditions. In soils liable to flow, the bottom casing should be kept ahead of the boring in all

cases to prevent the entry of soil into the bore, so preventing the formation of cavities and settlements in the adjoining ground. Continuous pumping shall not be used for excavating inside the boreholes. While below sub-soil water level, precaution shall be taken so that no boiling of the bottom of the hole occurs due to the difference in hydrostatic head. The size of cutting tool shall not be less than the diameter of pile by more than 75 mm.

Where stabilization of the sides of the boreholes is affected by the use of drilling fluids, the fluid level shall be maintained at a level not less than 1.5 M above the level of the sub- soil water or high-water level as the case may be and the hole shall then always be kept almost full with it till the concreting is completed.

The specific gravity and composition of the fluid shall be such as to suit the requirements of the ground conditions and to maintain the fine materials from the boring in suspension.

Boring of any pile must be completed in one continuous operation without interruption. In case such interruptions are unavoidable, steps shall be taken to prevent the collapse of sides of the boreholes.

The Contractor shall be responsible in the event of bore collapse due to any reason, at the discretion of the Employer, re-boring or additional bores shall be carried out at no extra cost. If additional pile is driven and extra material is consumed due to strengthening of cap etc. such material shall be to Contractor's account.

Boring in rock shall be carried out either by chiselling or by any other approved method. The bottom of the borehole shall be cleaned off by air

lifting all the spills and sediments so that the bases of piles shall be free from loose materials. Rock shall be classified in six grades I through VI in accordance with the classification made in BS 5930. EMPLOYER'S interpretation in this context shall be final and binding.

The Contractor shall be responsible for the prompt removal from the Site of all spoil due to the boring upto a distance of 4 km and at places specified by the Employer. The cost of such disposal shall be deemed to have been included in the price.

Foundation elevation of each pile will be individually approved by the Employer on the basis of the Employer satisfying himself, from observations, designs in supporting of the founding levels and all data including SPT tests at his disposal, of the soundness of the end bearing stratum. However, the piles shall be socketed minimum 1(one) diameter into hard rock. For determining the founding strata, standard penetration tests shall be carried out in the borehole by "Nordmeyer Standard Penetrometer" for 2 piles in every 50 m, as decided by the Employer. Before commencing a penetrometer test, the bottom of the borehole shall be cleaned.

4.4.2.4 Drilling Fluid

Bentonite used in the works shall be of the best quality. Bentonite shall be mixed thoroughly with clean fresh water to make a suspension, which will maintain the stability of the pile excavation for the period, necessary to place concrete and complete construction. The fluid used shall be such as to form a suspension, which remains stable under the worst conditions

likely to be encountered at the Site and suitable in all respects for the construction of marine piles.

Note: Before selection of source, test of bentonite powder shall be made at external approved laboratory to satisfy requirement of relevant IS Code. At site during piling work, test on bentonite mud shall be made to satisfy requirements of IS:2911. At site, laboratory and other required facilities shall be made available.

Control test shall be carried out on the bentonite suspension using suitable apparatus. The frequency of testing the drilling fluid and the method and procedure of sampling shall be as directed by the Employer. The density of freshly mixed bentonite suspension shall be measured daily as a check on the quality of the suspension being formed.

The measuring device shall be calibrated to read to within 0.005 g/ml. Tests to determine density, viscosity, shear strength and pH value shall be applied to bentonite used in the works.

4.4.2.5 Formation of Pile

The concrete to be placed under water or drilling fluid shall be placed by tremie unless otherwise approved and shall not be discharged freely into the water or drilling fluid. Before placing concrete, measures shall be taken to ensure that there is no accumulation of silt or other material at the base of the boring and the Contractor shall ensure that heavily contaminated bentonite suspension, which could impair the free flow of concrete from the pipe of the tremie, has not accumulated in the bottom of the hole.

A sample of the bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.15, the placing of concrete shall not be proceed. In this event, the Contractor shall modify or replace the bentonite as directed by the Employer.

All equipment, material and operations employed in the formation of the piles shall be such as to ensure that the piles remain to the designed cross-section and shall be capable of carrying the specified test load 28 days after concreting.

The concrete shall be properly graded and well compacted without excess water, admixture, soil or other extraneous matter. The concrete shall be placed through a tremie pipe of 20 to 25 cm in dia. with a suitable hopper. The tremie pipes joints shall be airtight and hopper capacity shall be such that it produces a build-up of at least 2 m concrete in the pile. Great care shall be taken in the placement of the first pour using a suitable pig in the pour or a PVC plunger so that the concrete does not come in contact with water. The first pour is eventually brought up through successive pour of concrete and overflow at the end of concreting. The tremie pipe must extend down to the bottom of the borehole at the start and may be withdrawn in sections as the level of the concrete rises in the boreholes, but its discharge end shall at all times be immersed in the concrete to a minimum depth of one metre. Placing of concrete shall be continuous and the tremie pipe shall be held concentric in the hole. Special care shall be taken regarding compaction of concrete in the top section of the pile.

At all stages of work every precaution shall be taken to prevent the formation of voids in the concrete caused by the faulty consolidation or pockets of air trapped within it. The volume of concrete placed shall be checked against calculated volume of pile at the time of placing. Any shortfall in actual consumption of concrete in pile shall not be more than 5% of the theoretical volume.

The tremie pipes and funnel shall be filled and lifted just 15 cm above bottom before releasing the concrete column to facilitate flushing out the bottom. The concrete levels in the tremie shall be checked every few metres in order to note the difference, if any, between the theoretical quantity that should have been placed and actual quantity that has gone in. This is to locate the position of over – cut or caving in during boring.

Placing of concrete should be continuous and the tremie pipe should be held concentric in the hole. Special care shall be taken regarding compaction of concrete in the top section of the pile. Concrete shall be placed and compacted until green concrete is obtained above the cut off level. Any excess concrete above cut off level will be dismantled neatly upto the cut off level, removing all cracked, loose and unbound concrete. Top surface of pile shall be kept rough. The cost of the same is presumed to be included in the rates and prices.

4.4.2.6 Reinforcement

Any reinforcement used shall be made up into stiff cages sufficiently well wired or welded to withstand handling without any distortion or damage. The bars shall be so placed as not to impede the placing of the concrete. They shall be placed correctly in position and be supported away from the

sides of the pile shaft by means of spacer blocks to assume concentric alignment in the shaft. Steps shall be taken to ensure correct positioning during concreting of reinforcement in the piles without any distortion or displacement. Care shall be taken to preserve the correct cover and the alignment of the reinforcement throughout the whole operation of placing the concrete.

Normal lap between reinforcement cages shall be as per I.S. Specifications. The main reinforcing steel shall project for a length sufficient to develop bond above the cut-off level of the pile. The clear concrete cover to main reinforcement shall be 75 mm and suitable spacer blocks shall be provided at intervals not exceeding 2 m and wired to the main reinforcement.

4.4.2.7 MS Liners/Casing

4.4.2.8 Control of Alignment

The pile shall be cast as accurately as possible to the vertical. Any pile deviating from its proper alignment to such an extent that the resulting eccentricity cannot be taken care of by strengthening the pile cap or pile ties shall, at the discretion of the Employer, be replaced or supplemented by additional piles at no extra cost. If any pile is deviated and

extra material is consumed due to strengthening of cap etc. such material shall be to Contractor's account.

4.4.2.9 Obstruction

If any obstruction is encountered, the installation shall cease and Contractor shall notify the Employer and submit for his approval, proposals for overcoming the difficulties. Notwithstanding any such approval, the

Contractor will be entirely responsible for ensuring that the piles are completed to the required line, position and depth.

4.4.2.10 Volume Check

Concreting shall start as soon as possible after completion of boring. The volume of concrete placed shall be observed in the initially cast piles and the average figure obtained shall be used to check whether there is undue deviation in concrete consumption for the subsequent piles. If actual quantity is found to be considerably less, special investigation shall be conducted and appropriate measures taken.

4.4.2.11 Inspection

For bored piles, the Contractor shall have the Employer's inspection to the bore hole for proper plumb, location, compaction of founding surface, pressure of water and other requisites. The depth of the borehole shall be measured by means of a chain to which a plumb weighing not less than 100 g is attached. The Contractor shall provide all the equipment required for the above inspection and he shall co-ordinate this work with the Employer. Concreting shall start only after the Employer has approved the borehole. All facilities, equipment and labour required for inspection by the Employer mentioned above shall be provided by the Contractor promptly and free of cost.

4.4.2.12 Load Tests

Vertical load tests shall be carried out on the specially constructed test piles. Initial load test by static method/reaction loading shall be carried out one on each diameter of land piles. Routine vertical load test by static method/reaction loading shall be carried out one on each diameter of land

piles. In addition to vertical load tests, the Contractor shall carry out horizontal load test on bored piles specially constructed for the purpose. Maximum test loads shall be as determined by the Employer according to I.S. Specifications considering the design horizontal loads.

One static load test shall be carried out on routine pile in river taking help from adjoining permanent piles/additional tension piles or installing soil anchors.

A) Monitoring Instruments

To ensure safety of the existing lock structure during construction and operation of new lock, contractor should install fully automatic monitoring instruments:

I. Piezometers

II. Settlement gauges

III. Inclinometers

These instruments shall provide real time monitoring of the structural safety of existing lock. After the construction of the New lock, such instruments should also be installed at the new lock the following instruments shall be installed:

I. Water level Indicators

II. Piezometers

III. Settlement gauges

IV. Inclinometers

The tentative locations of the monitoring instruments have been indicated in the Drawing No. ENL014

If any settlement / inclination of the lock wall is observed, remedial measures to ensure the structural safety shall be taken. During operation, feed of all the instruments shall be available in the control room.

B) Vertical Load Test

- a) The test shall be carried out by applying a series of loads on the test pile. The load shall be preferably applied by means of hydraulic jacks reacting against a symmetrically erected loaded platform which shall be preloaded to not less than 1½ times the design load carrying capacity of the pile. The hydraulic jack shall be of adequate capacity and shall have a pressure gauge and remote-control pump.
- b) The Contractor shall arrange all the necessary equipment and kentledge with platform at his own expense well in advance of the load test. Detailed proposal together with a sketch for the load test arrangement shall be furnished by the Contractor to the Employer for the latter's checking and approval.
- c) The pile to be tested shall be chipped and dressed to a well-levelled surface. It is important that reinforcing bars of the pile do not project beyond the top surface of the level pile top.
- d) A round plate of suitable thickness and always greater than the diameter of the pile that is to be tested, shall be placed over a fine layer of sand spread over the top of the pile.
- e) A jack or two jacks, depending on the capacity of the jacks and the ultimate test load shall be inserted between the gap formed by the top of the plate resting on the pile and the lower flange of the main RSJs of the loaded platform. The jacks should preferably be connected and operated by one pump.
- f) The Contractor shall submit certificates showing the correctness of the calibration of the pressure gauges and the jacks before use. All jacks shall be fitted with locking devices.
- g) Another plate of suitable thickness shall be placed over the ram of the

jack, which is later raised by operating the hydraulic pump so that the plate on the top of the ram butts against the bottom flange of the main RSJs of the platform.

h) Readings of settlement and rebound shall be recorded with the help of four dial gauges of 0.02 mm sensitivity and resting on diametrically opposite ends of the pile cap.

i) The dial gauges shall be fixed to a datum bar whose ends rest upon non-movable supports. The supports should be at least $5 \times d$ away clear from the pile where “d” is the diameter of the pile. Readings on the dial gauges are to be observed immediately before and after application of loads and immediately before and after release of loads.

j) The test load shall be applied in equal increments of about $1/5$ of the design load until the test load is reached.

k) Each stage of loading and unloading shall be maintained until the rate of movement of the pile top is not more than 0.02 mm per hour. Unloading shall be done as under:

i. Test load to design load

ii. Design load to 50% of the design load

iii. 50% to 25% of the design load

iv. 25% of the design loads to complete unloading

The rebound reading for each decrement shall be noted. The final rebounding shall be recorded 24 hours after the entire load is released. The safe carrying capacity of the pile shall be estimated in accordance with IS:2911.

C) Lateral Load Test on Piles

a) Two test piles shall be installed to the required depth and spacing as specified by the Employer. A hydraulic jack of adequate capacity shall be inserted in between them to apply the lateral load at the approximate cut-off level of the pile. Thrust pieces shall be inserted on either end of the jack to

make up the gap. Lateral deflections shall be measured at the thrust level by means of dial gauges fixed to immovable supports.

- b) The loading shall be applied in one half tonne increments till the rate of deflection reduces to 0.02 mm/hour and a load deflection curve shall be plotted.
- c) The loading shall be continued till the deflection of the pile top reaches the estimated value or the estimated safe load whichever is earlier.
- d) When the full test load is applied it shall be kept on for 24 hours with observations made every hour and then released in 3 stages.

D) Plant and Equipment

All temporary work, plant equipment, kentledge for applying the load and all necessary instruments for measurement of loads, deflection, etc. shall be provided by the Contractor. The equipment provided shall be capable of slowly applying and maintaining the required test loads to within an accuracy of 0.02 mm. The Contractor shall submit for approval of the Employer his detailed proposal for carrying out the load test.

E) Cost of Delay

The Contractor shall be deemed to have allowed in the construction programme the time required for testing of piles. No claim shall be entertained for any delay due to the testing programme.

F) Records

The Contractor shall submit to the Employer the following records of the tests:

- i. Make and specification of jack, pressure gauge and dial gauges;
- ii. Calibration of pressure and dial gauges
- iii. Design load of pile, description of location and identification marks of pile

the readings for settlement and rebound shall be entered in the following form:

Time	Load	Dial	Settlement	Dial	Settlement	Mean Set	Remarks
1	2	3	4	5	6	7	8

G) Interpretation of Test Results

The pile shall be deemed to be acceptable under the following conditions:

Total settlement under the test load does not exceed 12 mm plus allowance for normal elastic deformation.

The increase in settlement between two consecutive increments of loading does not exceed 6 mm plus allowance for elastic deformation.

The elastic deformation is defined as shortening of the pile within the elastic limit of the materials forming the ingredients.

H) Standard of Acceptance

The piles shall be approved as satisfactory only when the work has been executed in accordance with the Specification and to the satisfaction of the Employer and the standards stated below.

- a) The head of the pile shall be within 75 mm of the specified position
- b) The pile shall not be out of plumb by more than 2%
- c) The toe of the pile shall be at the approved bearing level in each case
- d) The total volume of concrete shall not be less than 95% and not more than 120% of the calculated volume. The calculated volume for this purpose shall be cross sectional area inside the casing multiplied by the length of the shaft
- e) The concrete shall be of the design strength

Should a pile fail to meet the standard of approval specified above the Employer may take one of the following decisions:

- a) Instruct the Contractor to carry out additional tests to ensure the soundness of pile.
- b) Accept the work and allow the Contractor to make suitable alternation in the construction of piles/pile cap/and beams. The cost of modification in the pile/pile beams shall be borne by the Contractor.
- c) Reject the pile/piles and instruct the Contractor to install additional piles at Contractor's expense.

The piles which fail to fulfill the standard of approval specified under Para (f) above shall be rejected and the Contractor, at his own cost, shall install additional piles as directed by the Employer.

I) Integrity Testing

Non-destructive integrity testing of bored piles, for 100% of piles, shall be conducted using the low strain sonic diagnostic system consisting of hammer, low 'g' accelerometer with amplifier, pile integrity tester, portable computer system, graphics printer etc. all complete. The test shall be conducted by the qualified and experienced specialists in this field. Employer's decision shall be final regarding approval of piles passing integrity test but of questionable workmanship.

4.4.2.13 Defective Piles

Piles, which have been declared defective by the Employer, shall either be removed or left in position as judged convenient by the Employer. If left in place, the cost of any modifications required in the pile/pile caps shall be borne by the Contractor in addition to the cost of construction of any replacement piles. If removed, all costs related to this shall be borne by the Contractor.

4.4.2.14 Finishing Pile Heads

The top of the piles shall be brought up above the finished level to permit all laitance and weak concrete to be removed and to ensure that it can be properly keyed into the cap. Any defective concrete in the head of the completed pile shall be cut away and made good with new concrete and bonded into the old.

4.5 SITE GRADING

4.5.1 General

The Contractor shall first clear the area of any obstructions or old structures and carry out a detailed topographic survey of the whole area. Formation level shall be such that there shall be no flooding of the site. It is proposed to provide the formation level of +28.44 m within the lock compound, upto the boundary wall of the lock compound, road area and locations where buildings have to be constructed.

4.5.2 Material

4.5.2.1 Acceptable Fill Material

Fill material shall be granular, non-cohesive, naturally occurring and shall be free from organic and deleterious matter.

4.5.2.2 Unsuitable Material

Material, which has been deposited in reclamation areas and does not comply with the specification requirements for filling, shall be removed by the Contractor and replaced with suitable fill.

4.5.2.3 Testing

Contractor shall carry out testing in the reclamation fill to determine whether or not the materials placed conform to the requirement of the specification.

The results shall be in a form and give such information as the Employer may direct.

4.5.2.4 Sampling

Unless directed otherwise by the Employer, sampling shall be carried out as follows:

- i) Bag samples (large) (25kg)

Every day during the progress of filling, the Contractor shall take two bag samples of the materials placed in reclamation at locations directed by the Employer. Samples shall be taken at a maximum depth of 0.5m.

The Contractor shall carry out all of the following tests on each of the bag samples:

- a) Sieve analysis (BS1377 Part 2 - Section 9.2)
- b) Particle size distribution by hydrometer (BS1377 Part 2 - Section 9.5)
- c) Specific gravity (BS1377 Part 2 - Section 8)
- d) Bulk density (BS1377 Part 2 - Section 7)

4.5.2.5 Standards

Unless stated otherwise, testing of fill materials shall be carried out in accordance with BS812 and BS1377. The Relative Density of the reclamation fill shall be as defined in ASTM D4253 and the Contractor's attention is drawn to the requirement for both wet and dry methods of compaction to establish the maximum dry density. Alternative methods of assessing relative density, or density index as defined in Clause 4.6 of BS1377: Part 4: 1990, will be considered provided the Contractor undertakes comparative tests.

4.5.3 Compaction

4.5.3.1 General

During the reclamation process the Contractor shall place approved material within the reclamation area to achieve an in-situ density not less than 90% of the Maximum Dry

Density (MDD) throughout the full thickness and lateral extent of the fill. The latter is defined in Clauses 3.5 & 3.6 of BS1377: Part 4: 1990 - Determination of the dry density/moisture content relationship using the 4.5kg rammer.

The uppermost zone of fill shall be placed and treated to ensure that the top 900mm of the fill has an in-situ density not less than 95% MDD.

The in-situ density shall be measured using the appropriate method described in Clause 2.1 of BS1377: Part 9: 1990 or similar approved.

4.5.3.2 Testing

The presence of pockets and layers of fine material and the degree of compaction achieved from placing fill shall be established by drilling boreholes through the fill. Boreholes shall be carried out to the required depth on an average of one in every 40,000m² or as directed by the Employer. In each borehole continuous undisturbed sampling shall be performed using a good quality sampler that will ensure a high recovery ratio. The Contractor shall propose a sampler and shall seek approval from the Employer prior to its use. Immediately upon extraction, each sample shall be subjected to a bulk density determination.

Around each borehole position three static cone penetrometer soundings shall be made, approximately 1.5m away from the borehole. The cone penetrometer soundings shall be made before the drilling of boreholes. The penetrometer equipment shall record data electronically and the data shall be made available to the Employer in approved format.

Each sample shall be subjected to minimum and maximum density determinations in accordance with ASTM D4254 and ASTM D4253 standard tests respectively and to Maximum Dry Density testing in accordance with Clause 3.5 and 3.6 of BS1377 : Part : 1990. When available quantities of fill material from individual samples are less than specified for the particular tests, mixing from immediately adjacent samples shall be permitted with the specific approval of the Employer. From the above tests the relative density, as defined in ASTM D4254, corresponding to 90% MDD shall be established for each sample.

At each borehole location the Contractor shall establish a correlation between cone resistance and relative density and shall prepare a relationship between cone resistance and depth for fill having a Relative Density corresponding to 90% MDD. Once this relationship has been agreed with the Employer the cone resistance depth profile shall be used to monitor the density of the whole fill.

The Contractor shall perform static cone penetrometer soundings on a square grid of 25m for the whole extent and depth of the reclamation that has been filled with dredged material. There shall be an agreed time interval between filling and sounding to allow for the equilibration of in situ water pressures. Where the soundings show cone resistance values less

than the agreed profile the Contractor shall submit his proposals for improving the density of the fill. Repeat soundings shall be undertaken following any ground improvement

The Contractor may wish to submit alternative methods for demonstrating that the Fill has achieved the specified density, these shall be submitted as an alternative and he shall submit a detailed method statement for evaluation.

In situ density testing shall be carried out on the upper 900mm of fill in reclamation area to determine the degree of compaction achieved. The rate of testing shall be one test per nominal 2,500m² and the Employer shall select any depth within the upper 900mm of Fill.

The in-situ density of the upper 900mm shall be determined in accordance with the method described in BS1377: Part 9 - Section 2.1 or 2.2.

Laboratory tests to determine the moisture content/dry density relationship shall be performed on a representative sample of the fill material for each 5,000m² of fill placed in reclamation area. The location and depth of the test sample shall be determined on site by the Employer.

Additional testing shall be carried out on the top 300mm of fill in reclamation area as follows:

Test	Test Frequency (Not less than one test per)
Dry density	600 m ²
Moisture content/maximum dry density relationship	2000 m ²
Particle size distribution	2000 m ²
Atterberg limits	2000 m ²
Linear shrinkage	2000 m ²

CBR	2000 m ²
Sulphate content	2000 m ²
Chloride content	2000 m ²

4.5.3.3 Acceptance of Works

The Contractor shall undertake post-construction survey of the entire site so graded to confirm that the area has been developed to the required levels. The Employer shall not accept the Work unless the Contractor has carried out all the required tests with satisfactory results. The entire area of the graded site shall be taken over completely by the Employer upon completion. The Employer shall not take over part of the area.

Interim payment for reclamation fill shall be based on quantities measured net using the calculated difference between the agreed ground levels from the surveys and upto date ground levels from interim surveys. Simpson's formula shall be used for computing fill volumes.

4.6 ROAD & PAVEMENT WORKS

4.6.1 General

This section covers the specification for the construction of internal roads, ramps and paved open areas.

These specifications include the requirements for the preparation of base and surfacing courses in accordance with these specifications and in conformity with the dimensions shown in the drawings and with the lines and grades established by the Contractor at site subject to approval by the Employer.

The pavements such as flexible pavement, concrete block pavement, concrete pavement with easy maintenance shall be provided as required.

These pavements must be laid over sub-base courses that will distribute and transmit the loads to the under-laying soil causing the least possible differential settlements.

The pavement shall be graded to allow the cargo handling equipment to operate at their ***optimum*** rates and to allow for storm water to the drainage system.

4.6.2 Water Bound Macadam Layers for Roads & Flexible Pavements

4.6.2.1 General

This specification covers the material and construction details for earthwork in filling for embankments, filling with sand/murum, WBM sub-base, WBM base course and shoulders for roads and flexible pavements.

4.6.2.2 Reference Codes and Standards

- B.I.S Specifications.
- IS:2720- Methods of Test of Soil
- Indian Road Congress Standards.
- IRC:19 - Standard Specification and Code of Practice for Water Bound Macadam

4.6.2.3 Earth Work in Filling

A. Materials

Only material considered suitable by the Employer shall be used for the construction and that considered unsuitable shall be disposed-off as directed by Employer at the Contractor's own cost and no claim for compensation will be entertained. The Contractor shall give the samples of earth, he proposes to use for filling along with the following characteristics of the sample to the Employer for approval, prior to collection and use.

- i) Mechanical analysis or grain size analysis as per IS:2720 Part IV.
- ii) Liquid limit as per IS:2720 Part V.
- iii) Plastic limit as per IS:2720 Part V.
- iv) Moisture density relationship as per IS:2720 Part VIII.

The material (soil) used for filling shall be free from boulders, lumps, trees roots, rubbish or any organic deleterious matter.

Soil having laboratory maximum dry density of less than 1.5gm/cc shall not be used.

Care shall be taken to see that unsuitable waste material is disposed-off in such a manner that there is no likelihood of its getting mixed with the materials proposed to be used for filling.

The work shall be so planned and executed such that the best available material (soil) is reserved for the top portion of embankments.

B. Filling for Embankments and Shoulders

The area where filling is to be placed must be cleared of all loose material and virgin soil must be exposed. Such exposed surface must be consolidated properly to obtain 90% of maximum laboratory dry density of the soil. All soft patches must be worked out to remove the soft soil and selected approved earth must be filled back and compacted.

Approved fill material shall be spread in uniform layers of thickness not exceeding 20 cm for embankment filling. Shoulder construction shall be so organised as to keep pace with the construction of different layers. All clods, lumps etc. shall be broken before compaction.

In general, the soil shall be spread uniformly over the entire width of embankment or shoulder as the case may be. For large embankments, the spreading of soil shall be as directed by Employer.

Successive layers of filling shall not be placed until the layer under construction has been thoroughly compacted to satisfy the requirements laid down in this specification.

Prior to rolling, the moisture content of material shall be brought to within plus or minus 2% of the optimum moisture content as described in IS:2720 - Part-VIII. The moisture content shall preferably be on the wet side for potentially expansive soils.

After adjusting the moisture content as described above, the layers shall be thoroughly compacted by means of rollers till 90% of maximum laboratory dry density is obtained as per IS:2720 part VIII.

Each layer shall be tested in field for density and accepted by Employer subject to achieving the required density before laying the next layer. A minimum of one test per 500m² area for each layer shall be conducted.

The type of rollers that should be employed for compaction shall be as per direction of Employer.

If any layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of construction altered as directed by Employer to obtain the required density.

The filling shall be finished in conformity with alignment, levels, cross-sections and dimensions as approved by the Employer.

Extra material shall be removed and disposed off as directed by Employer.

C. Tolerance

Embankment and shoulders for roads, units etc. shall be carried to within a tolerance of 3 cm. from final lines but shall be to the required grades and slopes.

D. Filling with Sand/Murum

Sand for filling shall preferably be locally available sand, clean and free from any chemical or other impurities. Murum for filling shall be clean and well graded. Sand/Murum shall not contain any vegetation, organic, clayey or other material and shall be obtained from a source approved by Employer.

Murum/Sand shall be spread in layers of thickness not exceeding 15 cm over the areas. Each layer shall be uniform in density, quality of material and moisture content before compaction. The moisture content shall be within two percent of the optimum moisture content as per IS:2720 Part VIII.

In case of pure sand, flooding with water is permissible.

Compaction of each layer shall be by mechanical means as per directions of Employer. Only inaccessible reaches shall be worked manually. Each layer shall be uniformly compacted to obtain 90% of maximum laboratory dry density of the material. If the material fails to achieve the required density, the layer shall be reworked with necessary alteration in compaction, so that the required compaction is obtained. A minimum of one test per 500 m² area for each layer shall be conducted.

Subsequent layers shall be placed only after the layer already laid has been compacted to the required density and approved by Employer.

The finished surface must be dressed to required grade and slope. Excess material must be removed from compaction site, as directed by Employer.

4.6.2.4 Sub Base and Base Course

The sub-base course shall consist of one or more layers, each of 100 mm compacted thickness.

The base course shall consist of one or more layers, each of 75 mm compacted thickness.

4.6.2.5 Stone Aggregate for WBM

The coarse aggregates shall be hard, crushed or broken stone metal from quarries approved by Employer. It shall be hard, durable and free from flat, elongated, soft and disintegrated particles. It shall not contain dirt and other objectionable matter. The quality, size and grading of the coarse aggregate shall be conforming to IRC 19: Standard Specification and code of practice for WBM.

Samples of test shall be representative of the material to be used and collected as per I.S.2430.

The aggregates shall be stacked at the roadside on firm, well-drained ground in regular stacks, as directed by Employer. The various grades shall be stacked separately, and contamination by earth and other extraneous matter shall be prevented effectively.

A. Binding Material Murrum

The binding material shall be clean, dry murrum free from leaves, organic matter and any deleterious material.

It shall be obtained from quarries approved by Employer.

B. Spreading Coarse Aggregates

The sub grade or sub-base to receive WBM coarse shall be prepared to the required grade and camber. Before starting with WBM construction, side shoulders shall be constructed in advance to a thickness corresponding to the compacted layer of the WBM coarse for lateral confinement of aggregate. After shoulders are ready, the inside edge shall be trimmed vertical to receive the aggregate. The practice of constructing WBM in a trench section excavated on the embankment/formation must be avoided.

The coarse aggregate shall be spread uniformly and evenly on the prepared base in required quantities from the stacks. The aggregate shall be spread to proper profiles by using templates across the road at about 6m apart.

The surface of the aggregate spread shall be carefully and all high or low spots remedied by removing or adding aggregate as may be required. The surface shall be checked from time to time, during the spreading and rolling of the coarse aggregate to ensure a finished surface without variation greater than 12 mm, when a 3 m long straight edge is laid parallel to centre line of the road.

The WBM layer shall be tested by depth blocks. No segregation on large or fine particles shall be allowed and the coarse aggregate as spread shall be of uniform gradation with no pocket of fine materials.

The coarse aggregate shall not be spread in lengths more than 3 days average work in advance of the rolling, spreading murrum and bonding of the preceding section.

4.6.3 Rolling Road Metal

Immediately following the spreading of the coarse aggregates, it shall be compacted to full width by rolling with either three wheeled power roller of 8 to 10 T weight or equivalent vibratory roller true to the line and camber as shown in the drawing. The course shall not be rolled when the sub-grade is soft or yielding or the rolling causes a wave-like motion in the base course or sub-grade. When rolling develops irregularities that exceed 12mm when tested with a 3 metre straight edge, the irregular surface shall be loosened and then aggregate added to or removed from it as required and the area rolled until it gives uniform surface conforming to the desired cross-section and grade. The surface shall also

be checked transversely by template and any irregularities corrected as above. The use of murrum to make up depression shall not be permitted.

The rolling shall begin from edges with roller running forward and backward until the edges have been firmly compacted. The rolling shall then progress gradually from edges to the centre parallel to the centre line of the road lapping uniformly each preceding rear wheel track by one half width and shall continue until the entire area of the course has been rolled by the rear wheel. On the super elevated portions of road, the rolling shall commence from the lower edge and progress gradually towards the upper edge of the road.

Rolling shall be discontinued when aggregates are thoroughly keyed. Slight sprinkling of water may be done if required.

4.6.4 Screenings

4.6.4.1 Material

Screenings to fill the voids in the coarse aggregates shall, as far as possible be the same material as the coarse aggregates. Where it is decided by the Employer to use other materials, the same shall be predominantly non-plastic materials such as Kankar nodules, gravel (other than river-borne rounded aggregate) or murrum, provided that the liquid limit and plasticity index of such material is below 20 and 6 respectively, and the fraction passing 75 micron sieve does not exceed 10 per cent

4.6.4.2 Grading Requirements of Screenings

Size of Screening	Sieve Designation (IS: 460)	% by Weight Passing the Sieve
13.2 mm	13.2 mm	100
	11.2 mm	95-100
	5.6 mm	15-35
	180 Microns	0-10

This grading, however, shall not be mandatory, in case either murrum or gravel is used as screenings.

4.6.4.3 Application of Screenings

After the coarse aggregate has been rolled as described in Clause 4.6.3, screenings shall be applied uniformly and gradually over the surface to completely fill the interstices. Dry rolling shall be continued while the screenings are being spread so that the jarring effect of the roller will cause them to settle into the voids of the coarse aggregates.

The screenings shall not be dumped in piles on coarse aggregate but shall be spread uniformly in successive thin layers either by the spreading motion of hand shovels or by mechanical spreaders.

The screenings shall be applied at a uniform and slow rate (in three or more applications) so as to ensure filling of all voids. Rolling and brooming shall continue with the spreading of the screenings. Either mechanical brooms or hand brooms or both may be used. In no case shall the screenings be applied as fast and thick as to form cakes or ridges on the surface making the filling of voids difficult or preventing the direct bearings of the roller on the coarse aggregates. The spreading, rolling and brooming of screenings shall be performed on sections which can be completed within one day's operation and shall continue until no more screenings can be forced into the voids of the coarse aggregates. Damp and wet screenings shall not be used under any circumstances.

The quantity of screenings used shall be such as to fill all voids in the water bound macadam- courses.

4.6.4.4 Sprinkling and Grouting

After spreading the screenings, the surface shall be copiously sprinkled with water, swept and rolled. Hand brooms shall be used to sweep the wet screenings into voids and to distribute them evenly. The sprinkling, sweeping and rolling shall be continued and additional screenings applied where necessary until the coarse aggregates are well compacted and grout of screenings and water form a wave ahead of wheels of the roller. Care shall be taken to see that the base of sub-grade does not get damaged due to the addition of the excessive quantity of water during the construction.

4.6.4.5 Binding Material

Binding material, to prevent revelling of WBM shall consist of fine grained material possessing P.I Value upto 6. Application of binding material shall not be necessary where murrum or gravel is used as screenings.

Binding material shall be obtained from quarries/sources approved by the Employer.

4.6.4.6 Application of Binding Material

After the application of screenings as described above, the binding material shall be applied at a uniform and slow rate (in two or more successive thin layers) so as to ensure filling of all voids.

After each application of binding material, the surface shall be copiously sprinkled with water and the resulting slurry swept in with hand brooms/mechanical brooms or both so as to fill the voids properly. This shall be followed by rolling with a 6 -10 tonne roller during which water shall be applied to the wheels to wash down the binding material that may get stuck to them. The spreading, rolling and brooming of binding material shall be performed on sections which can be completed within one day's operation and shall continue until no more binding material can be forced into the voids of the coarse aggregates and until the slurry of binding material and water forms a wave ahead of the wheels of moving roller. Damp and wet binding material shall not be used under any circumstances.

The quantity of binding material used shall be such as to fill all voids in the water bound macadam.

4.6.4.7 Subsequent Layers of WBM

Before laying the subsequent layers of WBM, the surface shall be scarified and reshaped to the required camber and profile, and all ruts, depressions, pot holes etc. made good. The second layer shall be laid after the surface preparation is approved by Employer. The specification for subsequent layers of WBM will be similar to that described before.

4.6.4.8 Construction of Shoulders or Berms

After the WBM course is laid and compacted, the existing surface at side berms or shoulders of the roadway must be scarified. Fresh quantity of approved earth must be spread in layers for building up of berms upto the required level and scope.

The earth must be consolidated by at least three passes of an 8-10 tonne road roller. The edges must be well consolidated by suitable means to prevent edge slips and the work properly trimmed and dressed.

4.6.5 Flexible Pavements

4.6.5.1 General

This specification establishes material and construction requirements for the flexible pavement with Bitumen Premix Carpet.

4.6.5.2 Bitumen Premix Carpet

Material

- i) **Coarse aggregate:** The aggregate shall consist of crushed stone of clean, hard, tough, durable rock of uniform quality and shall be clean, free from excess of dust, flat or elongated pieces, soft or disintegrated stone, clay or other deleterious matter. The size of aggregate shall be as

mentioned in the drawings.

ii) **Sand:** The sand shall consist of clean hard, durable, uncoated, coarse dry particles and shall be free from injurious amounts of dust, soft or flaky particles, organic matter or other deleterious substances.

iii) **Binder:** The binder shall be bitumen of penetration 80/100 conforming to IS:73. The bitumen shall be stored in drums at roadside. Any drum leaking or damaged shall not be accepted.

4.6.5.3 Quantities of Materials

Material	For Premix Carpet per 100 m ²	For seal Coat per 100 m ²
For Premix Carpet 20mm thick		
Coarse Aggregate 12mm	2.75 m ³	and down size.
Bitumen 80/100	150 kg.	68.3 kg.
Coarse sand as sealing aggregate	-	0.6m ³
For Premix Carpet 25mm thick		
Coarse Aggregate 12mm and down size	3.5m ³	
Bitumen 80/100	185 kg.	68.3 kg
Coarse sand as sealing compound	0.6 m ³	
For Premix Carpet 50 mm thick		
Coarse Aggregate 25mm and down size. (For 35mm thick carpet layer)	5.5m ³	
Coarse Aggregate 12 mm and down size (for 15mm thick carpet layer)	2.0 m ³	
Bitumen 80/100		
For 35mm thick Carpet (I layer)	269 kg.	68.3 kg
For 15mm thick Carpet (II layer)	110 kg.	
Coarse sand and sealing aggregates	0.6m ³	
For Premix Carpet 75 mm thick		
Coarse Aggregate 25mm and down size (for 50mm thick layer)	8.5m ³	
Coarse Aggregate 12mm and down thick II (layer)	3.5m ³	
Bitumen 80/100		
a) For 50 thick I layer	375kg.	68.3kg.

b) For 25 thick II layer	185kg.	
Coarse sand as sealing aggregate	0.6 m ³	

4.6.5.4 Laying

A) Preparation of Road Surface

The existing surface shall be thoroughly cleaned of dust, loose materials, caked mud and other foreign matter with the help of wire brush, chisel, picks etc. before laying the tack course. The cleaning shall be carried out in such a manner as to expose the stone metal to a depth of 1 to 2 mm without dislodging the interlocking of the metal. All dust and other material thus removed shall be carried away and dumped at suitable places as directed by the Employer.

If potholes or ruts are found on the existing road surface, these irregularities must be filled in with premix chippings and well rammed about a week before the carpet is laid.

B) Tack Coat

The bitumen shall be heated in asphalt boilers to 177°-188°C and shall be spread uniformly at the rate of 1 kg / m² by means of sprayers. The applied binder shall be evenly brushed.

The tack coat shall be applied just ahead, keeping pace with laying of premix carpet.

4.6.5.5 Preparation of Premix

Mechanical mixers shall be generally used for preparation of premix. Improvised hand mixing drums may be used if permitted by the Employer.

Stone chippings of specified size shall be thoroughly mixed dry in the mixer at the rate indicated above. Binder heated at temperature suitable for the

grade of bitumen is added to the mixer drum at the specified rate per 100m² of surface and thoroughly mixed till the stone chips are completely coated with the binder.

The premix shall be emptied on to wheelbarrows or stretchers and carried to work site.

A) Spreading of Premix

Immediately after applying the tack coat the premix shall be spread with rakes to the required thickness and distributed evenly by means of a drag spreader. The camber shall be checked by means of camber board and the unevenness shall be rectified.

B) Rolling

When the premix has been laid for a length of 15-20 meters, rolling shall be commenced with tandem rollers (8 to 10 tones) Rolling should commence from edges and proceed towards the center longitudinally.

The wheels of the roller shall be continuously moistened to prevent the premix adhering to the wheels and being picked up.

After the preliminary rolling and honeycombing, high spot or depressions shall be rectified by adding or removing the premix as per requirements and the surface shall be rolled again to compaction. Camber shall be checked at every stage and any defects found shall be rectified, Excessive rolling shall be avoided.

4.6.5.6 Seal Coat

The material requirement for seal coat in high rainfall areas is as under:

Binder 80/100 = 98 kg/100m² of road surface

Coarse aggregates = 6.3mm passing IS. 10mm

Square mesh retained on IS sieve 2.36mm = 0.9m³/100m² of road surface.

A liquid seal coat, preferably with chippings as above (though coarse sand can also be used) should be applied after laying the carpet. The binder, heated to permissible temperature, should be applied to the cleaned surface, blinded with chippings and rolled.

Traffic may be allowed on the road preferably 24 hours after providing the seal coat.

4.6.6 Lean Concrete Base

4.6.6.1 Materials

The materials used for lean concrete base shall be natural or crushed gravel or crushed rock complying with IS:383 except as detailed below.

Aggregates shall have a maximum nominal size not more than 40 mm or less than 20 mm. Cement shall be ordinary Portland cement complying with IS:269

Water shall comply with the requirements of the Specification - Plain and Reinforced Concrete.

4.6.6.2 Mixing Lean Concrete

Lean concrete shall be mixed in batch mixer complying with the relevant clauses of the Specification for Plain and Reinforced Concrete. Alternatively, it may be mixed in a continuous mixer provided that the proportioning of the mix is entirely by weight and the mixing is as satisfactory as mixing in a batch mixer. In both cases, the Contractor shall maintain the mixer in good working condition.

A. Laying Lean Concrete Base

Lean concrete base shall be laid by plant capable of distributing material in a layer of uniform thickness without segregation. Compaction shall be completed within one hour of adding water to the material. Care shall be taken to compact effectively at joints in layers and adjacent to structures, using small compactors, if necessary, in confined spaces.

4.6.6.3 Quality Control

Samples of the mixed material shall be taken from the hopper of the spreader or paver at random intervals and at the rate of five samples for every 1000 m² of base laid. From each sample the Contractor shall prepare two 150 mm cubes. The cubes shall be made, cured and tested in accordance with IS:516 except that they shall be compacted as described in Specification - Plain and Reinforced Concrete.

The average strength of each group of five samples tested at seven days shall be not less than 6 N/mm² or more than 16 N/mm². If more than one average group strength in five falls outside these limits the cement content of the mix shall immediately be altered to ensure compliance with the strength requirement.

4.6.6.4 Rectification of Surfaces

Any area of lean concrete base which is outside the tolerance of + 6 mm shall be rectified as follows:

Provided not more than two hours have elapsed from the time of mixing, areas, which are high, shall be scarified to a depth of not less than 75 mm,

the surplus material removed and the area re-compacted to comply with the Specification.

If the material has been mixed for longer than two hours, the material shall be removed to the full depth of the layer over the operating width of the paving machine and over a length sufficient to enable the paving machine to relay the area. The area shall then be re-laid to comply with the Specification.

Areas which are low lying shall be removed to a depth of the layer over the operating width of the paving machine and over a length sufficient to enable the paving machine to relay the area. The area shall then be re-laid to comply with the Specification.

4.6.7 Traffic Markings

4.6.7.1 General

This work shall consist of the painting of white or yellow lines, chevron striping, arrows and lettering on road, pavements and painting on kerbs.

4.6.7.2 Material

Thermoplastic material for road markings shall comply with specification for road and bridge works published by IRC.

Road markings shall be white or they shall be yellow complying with IRC specifications and as directed by the Employer.

Chlorinated rubber paint for painting kerbs shall be plasticised and drying shall be by solvent evaporation alone. It shall have the properties given in Table II given below.

Epoxy resin adhesive shall comply with AASHTO M237

Table II: Paint for Kerbs

Property	Allowable Limits
Relative density	1.48 minimum
Viscosity at 21°C	65 to 70 KU
Drying Time	Approx. 10 –15 min
Coverage	3 m ² per litre maximum
Brightness	80 minimum
Flexibility	Passes around 12 mm diameter mandrel
Chlorinated rubber content	9.0%

4.6.7.3 Quality Assurance

The quality and workmanship of the completed marking installation shall conform to the best modern practice.

The complete marking installation shall be warranted to the Employer from the date of issuance of certificate of final completion against peeling, chipping, flaking, delaminating and shoving for a period of one year or until the markings are normally worn away by traffic.

The Contractor shall submit his programme schedule, catalogues, manufacturer's specifications and test data of products proposed to use in this work to the Employer.

4.6.7.4 Construction Requirements

A) General

Traffic shall be kept off markings until the installation has fully cured.

B) Road Marking

Spraying equipment shall consist of a motor-powered self-propelled machine with compressor. A minimum line width of 100 mm shall be sprayed in one pass. The bead gun shall be synchronized to spray glass

spheres immediately onto the hot thermoplastic. An automatic skip mechanism shall be fitted to produce broken and dotted lines without pre-measurement.

If hand methods are used the Contractor shall provide stencils, specialised labour and anything necessary so that the results obtained match in quality and finish the mechanically sprayed work to the satisfaction of the Employer.

Lines, chevron striping, arrows and lettering shall be provided to the size and in the location as per approved Drawings and in accordance with the Indian Road Congress Standards.

Kerbs shall be painted alternately black and yellow covering the entire exposed surface. Changes in colours shall be made at joints between kerbs.

The surface to be painted shall be clean and dry. Pre-marking for painting shall be done manually on straight lines and curves using a 100 m long string. On straight the pre- marking shall consist of 1 dot mark every 3 m, and on curves every 1 m. The pre-marking dot shall be a circle of 40 mm diameter cut into an equal part by a gap of 100 mm. Longitudinal changes in lines types shall be within 300 mm of the location as per the approved Drawings.

Paint shall be applied 1.5 mm thick for broken, dotted and continuous lines, striping, pedestrian crossings, stop lines, special letters, arrows and symbols shall be 3 mm thick. In addition to the ballotini premixed in the

material, a further quantity shall be sprayed onto the hot spray-plastic markings at a rate of application of 400 – 500 g/m².

C) Road Sign

Road sign to be supplied and fixed in accordance with the specification for road and bridge works published by Indian Road Congress or as directed by the Employer. The entire work of the installation and materials shall meet the approval of the Employer.

4.7 STORM WATER DRAINAGE

4.7.1 General

The intent is to drain the storm water of entire Lock compound area without any undue pooling and finally water to be let in the river.

4.7.2 Scope

The schematic layout of drainage system is shown in drawings.

Storm drainage consists of furnishing transportation, labour, equipment and materials to construct storm drainage system in accordance with Contractor own Design and Drawings complying Indian standards. The work includes construction and installation of the following:

- a) Reinforced concrete pipe for storm water conveyance.
- b) Open Concrete drain as well as box drains for collection and conveyance of stormwater.
- c) Storm drains outlets into river including flap gates and related features.
- d) Sewage Collection & Transfer system

4.7.3 Materials

4.7.3.1 Precast Concrete Pipe and Fittings

All reinforced concrete pipes shall be class NP3 conforming to IS: 458.

RCC pipe shall be of NP4 type shall be used below road.

4.7.3.2 Flap Gate

The drainage gate shall be designed to allow free outflow and prevent backflow for maximum seating heads up to 7.6 meters (25ft). The gate shall be provided with adjustable, double pivoted hinge links so designed to permit complete seating, full opening, and with stops or other arrangements to prevent cover from rotating sufficiently to become wedged in the open position. Pivot lugs mounted to frame shall be adjustable to allow adjustment of hinge links without having to remove cover from gate. The hinge links shall be bronze-bushed, structural steel (or high strength ductile iron, cast manganese bronze or wrought stainless steel). All assembly hardware shall be stainless steel.

The frame shall be cast iron, cast in one piece, with reinforcing ribs and a cast on lining eye shall be provided for manual operation. The frame shall have a machined seating surface inclined from vertical at minimum of 2.5 degrees to assure positive closure.

All cast iron shall be painted with manufacturer's standard shop coat paint (or special paint). Structural steel hinge links shall be galvanized. All bronze and stainless steel parts do not require further finish.

4.7.4 Execution

4.7.4.1 Installation of Pipe, Fittings and Appurtenances

Excavation, trenching, installation, compacting soil and finishing operations for all pipe and soil materials shall conform to the Indian standards. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe. Provide all required equipment for lowering pipe safely into the trenches. The details of catch pit, drainage channel are shown in drawings.

4.7.4.2 Pipe Joints

All pipe joints shall be watertight and of such design as to remain sealed after possible settlement.

Pressure Testing: The length of pipe shall be tested as per Indian Standard.

4.7.4.3 Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

4.7.4.4 Storm Drain Cleaning

Prior to final acceptance and final catch basin-to-catch basin inspection of the storm drain system by Employer, flush and clean all parts of the system. Remove all accumulated construction debris, rocks, gravel, sand, silt, and other foreign material from the storm drain at or near the closest downstream manhole. If necessary, use mechanical rodding or bucketing equipment.

Upon Employer's Engineer's final catch basin-to-catch basin inspection of the storm drain system, if any foreign matter is still present in the system, reflush and clean the sections and portions of the lines as required.

4.7.4.5 Tolerances

Pipe Inverts: Plus 10 mm, minus 10 mm

Catch Basin Grates: Plus 0.00 mm, minus 10 mm

4.7.5 Inspection

Prior to final approval of any pipe installation, a thorough inspection shall be made of entire installation. Any indication of defects in material or workmanship, or obstruction to flow in the pipe system, shall be further investigated and corrected as necessary by the Contractor at no additional cost to the Employer.

4.7.6 Construction of Catch Basins and Trench Drains

4.7.6.1 Excavation and Backfill

Excavation and backfill as required accomplishing the construction. Backfill shall be as specified for the adjoining pipe trench.

Install catch basins and trench drains at the locations based on IS code and as specified herein. Construct forms to the dimensions and elevations required for cast-in-place units. Forms shall be tight and well braced.

4.7.6.2 Concrete Work

A) Cast-In-Place Concrete

Prior to placing formwork compact existing insitu soil and provide a layer of compacted bedding material.

Prior to placing the concrete, remove all water and debris from the forms. Place the concrete and screed the top surface of exposed slabs and walls. When the initial water has been absorbed, float the surfaces with a wood float and lightly trowel with a steel trowel to a smooth finish free from marks or irregularities. Finish exposed edges with a steel- edging tool. Remove forms and patch any defects in the concrete as required.

Cure concrete by preventing the loss of moisture for a period of 7 days. Accomplish with a membrane-forming curing compound. Apply the curing compound immediately after removal of forms or finishing of the slabs. Protect concrete from damage during the 7-day curing period.

B) Precast Units

Prior to placing precast units compact existing in-situ soil and provide a layer of compacted bedding material.

4.7.6.3 Extensions

Extensions to be installed as per requirement. Lay risers in mortar with sides plumb and tops to grade. Joints shall be sealed with mortar, with interior and exterior trowelled smooth. Prevent mortar from drying out and cure by applying a curing compound. Extensions shall be watertight.

4.7.6.4 Installation of Frames and Grates

Set frames and grates at elevations indicated or as determined in the field and in conformance with the design and Drawings. Frames may be cast in, or shall be set in mortar.

4.7.6.5 Cleaning

Upon completion, clean each structure of all silt, debris, and foreign matter.

4.7.6.6 Final Grades for Field Inlets

The final finish grades of top of grate on all storm water inlets and trench drains shall be adjusted to receive surface flows without pooling. No inlets will be acceptable if it protrudes above the finish-paving surface.

4.7.7 Installation of Flap Gate

Install flap gates at locations as per manufacturer's recommendations.

4.7.8 Rain Water Harvesting System

Rain water harvesting system shall be provided for all the buildings in the terminal. **Design shall be carried out as per guidelines of Rain water Harvesting Manual of CPWD.**

4.8 EARTHWORK

4.8.1 General

This section of the specifications includes requirements for accomplishing all earthworks including filling, anti-termite treatment, riprap and yard grading for this Contract.

4.8.2 Nature of the Ground

The Contractor shall judge for himself the nature of the ground and shall be fully responsible for ascertaining all necessary information concerning permanent water table period of rainfall, flooding of the site and all matters affecting the excavation & foundation work.

4.8.3 Earthwork Method

The Contractor shall not undertake any earthwork; including the operation of any borrow area or quarry, without having obtained the EMPLOYER'S prior approval to the methods which he proposes to employ. He shall not thereafter modify such methods without the consent of the Employer.

4.8.4 Correct Widths and Depths of Excavations

In the event of excavation being made larger than the sizes shown on the drawings, the Contractor shall fill in the excavated void to the correct profile with mass concrete as described under specification for 'Plain and Reinforced Concrete' or other approved compacted material at his own expense.

4.8.5 Method of Excavation

Excavation may be carried out by machine or any other method approved by the Employer. In soil, excavations shall be taken to within 150 mm of the formation or foundation level and all subsequent excavation in any section must be carried out by hand not more than 24 hours before the commencement of construction in that section unless agreed otherwise by the Employer.

As soon as possible after inspection by the Employer, the bottom level of the excavation shall be sealed with blinding if specified and the required construction shall commence. No excavation for foundations shall be filled in or covered with concrete until the Contractor has notified the Employer that it is ready for inspection and has received

sanction to proceed with the works. The Contractor shall give a minimum of 24 hours' notice of any inspection.

He shall take care that slope for excavation is stable and shall take the employer's approval thereof. Wherever required, he shall construct a coffer dam or leave a berm of suitable width between water surface and excavation area to prevent risk of flooding. Appropriate dewatering

arrangement shall be made to remove seepage water from the excavated area.

4.8.6 Shoring Excavations

The Contractor shall to the satisfaction of the Employer, shore the sides of the excavations for structures, trenches and pits to prevent them from slipping or falling. Should any slips, falls or settlement nevertheless occur they shall be made good by the Contractor at his own expense with selected fill or with mass concrete as may be directed by the Employer.

In removing shoring from the sides of excavations, care shall be taken to avoid loads on to any concrete until it has hardened sufficiently to carry such loads.

Timber or other materials used for shoring the sides of excavations shall be removed as the work proceeds except when ordered to be left in by the Employer.

The Contractor shall submit to the Employer for inspection calculations and working drawings for the proposed scheme of strutting and retaining the sides of the excavations not later than four weeks before commencing any excavations and shall not proceed with the appropriate section of the works until receipt of the EMPLOYER'S written consent.

The receipt of such consent shall not relieve the Contractor of any of his duties and responsibilities under the Contract.

4.8.7 Staking

The earthwork operations comprise the establishment of layout plans and staking for the installations at the start of the work, in conformity with the construction plans. The general staking plan shall be submitted by the Contractor to the Employer for his approval before the start of the work. All of the topographical references as well as any other supplementary references which are deemed necessary for proper execution of the work shall be marked out on the drawings and established on the ground by visible and stable landmarks.

Additional supplementary staking shall be established as may be necessary for horizontal and vertical reference points subject to approval by the Employer.

The Employer reserves the right to make changes in grade to suit developed conditions.

4.8.8 Filling & Backfilling Generally

During compaction the backfill as specified in Clauses 4.8.8.1 & 4.8.8.2 below shall have uniform moisture content within 2% of the optimum for the compaction plant employed or as may be directed by the Employer after tests. Where necessary the Contractor shall adjust the moisture content of the backfill material either by drying out or by adding water. After such drying out or adding of water, the backfill shall be thoroughly mixed until the moisture content is uniform. Should the material being placed as filling or as backfilling while acceptable at the time of selection, become unacceptable to the Employer due to exposure to weather conditions or due to flooding or have become puddled, soft or segregated during the process of the works,

the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material. When placing the filling or backfilling the Contractor shall make due allowance for any settlement that may occur before the end of the Period of Maintenance remove any excess material or make up any deficiency of backfilling to the specified levels.

4.8.8.1 Backfilling with Excavated Material

Foundation trenches, column bases and the like may be backfilled with selected excavated material if approved by the Employer, these being well rammed and consolidated by hand or compacted by an approved vibratory 5 ton roller or other approved vibratory equipment to the satisfaction of the Employer in layers not exceeding 150 mm thick, to achieve a dry density not less than the maximum dry density obtained as per IS 2720 (Part 8).

4.8.8.2 Selected Granular Fill

Where directed by the Employer or where the drawings indicate the use of selected granular fill, this shall comprise well graded non-plastic granular material, placed in layers not exceeding 150 mm. Each layer being well compacted by an approved vibratory 5 ton roller or other approved vibratory equipment before the next layer is placed. The density after compaction shall not be less than the maximum dry density obtained as per IS 2720 (Part 8).

Selected granular fill shall be obtained from an approved source and shall comply with Clause 4.8.8.3 below.

4.8.8.3 Suitable Material

- i) It shall be the responsibility of the Contractor to locate suitable material and carry out such tests as the Employer may require demonstrating the suitability of the fill to be supplied.
- ii) The fill shall have minimum stone 75 mm, liquid limit not exceeding 25% and plasticity index not exceeding 6. Total water soluble salts shall not exceed 3%.
- iii) Material shall have a CBR not less than 30% at 95% maximum dry density.

4.8.8.4 Underwater Placement of Fill Material

The method of operation for underwater placement of material obtained from borrow locations, duly approved by the Employer is subject to the approval by the Employer. The methods of fill placement shall be designed so as not to result in any detrimental pollution of the waterway.

4.8.8.5 Compaction

Compaction methods and layers shall be submitted to the Employer for approval.

Compactions shall be performed with approved vibratory compaction equipment well suited to the soil being compacted. Material shall be moisture or aerated as necessary to provide the moisture content that will readily facilitate obtaining the specified compaction. Finished slope fill shall be stable before placing slope protection.

4.8.8.6 Tolerance

After installation and compaction of fill and backfills the levelling tolerances will be as follows:

- 2 cm from the levels indicated on the drawings
- ½% on any plane

On slope or vertical tolerance of ± 10 cm at any point will be permitted before placing slope protection.

If these tolerances are not achieved the works will be corrected to the EMPLOYER'S satisfaction at the Contractor's expenses.

4.8.9 Trimming of Slopes

The slopes of cuttings & embankments shall be trimmed by hand or by approved mechanical means to uniform batters as directed by the Employer.

Any rock or boulder appearing in the face of a cutting shall be trimmed back to within the tolerance specified above and in addition any such rock or boulder which in the opinion of the Employer is unstable shall be completely removed and the resulting void filled with compacted material with the approval of the Employer.

4.8.10 Draining of Excavation

All excavations shall be kept free of water at all times and the Contractor shall provide efficient appliances and drains for dealing with water to the satisfaction of the Employer.

Particular care shall be taken to keep dry, rock and other surfaces against or upon which concrete may be deposited and proper precautions shall be taken to prevent the leaching out of cement or otherwise damaging unset concrete.

4.8.11 Existing Levels

Before work commences at the site the Contractor shall agree to the existing ground levels with the Employer.

4.8.12 Disposal of Surplus Excavated Material

Subject to provision of this specification all materials arising from site clearance which are surplus or unsuitable for use in the Works shall become the property of the Contractor

and shall be disposed of by him either off the site or to an approved tip off of if agreed by the Employer on the Site in an approved manner.

The Contractor shall propose two sites for disposal of unsuitable or surplus material, one of which shall be specified as having priority and which must be filled before the second is used, together with a separate location where hard debris, such as concrete, kerbing etc. shall be disposed of. The Contractor shall seek approval for all nominated sites from the concerned local Employer before work commences.

4.8.13 Trench Excavation

The Contractor shall execute to the required alignment and depth separate trenches unless otherwise indicated, for each utility run. The trench shall be sufficiently wide for the proper laying of the utility and shall be excavated to a depth that provides necessary cover.

The bottom of all trenches may be over excavated to a minimum of 15 cm to allow for bedding material. Condition in the trench shall be such that connections can be accomplished without getting mud, silt, gravel or other materials to the joint. The trench shall be adequately dewatered before laying bedding.

The bottom of utility trenches shall be graded to secure the required slope and tamped as necessary to provide a firm bed. Backfilling in the trenches shall be well compacted to the satisfaction of the Employer.

When trench excavation is required across existing surfaced roads as well used tracks, the Contractor shall provide and maintain a suitable graded diversion complete with adequate signs, all to the satisfaction of the Employer. Such excavations shall be backfilled in accordance with Clause 4.8.8.0 & 4.8.8.1. Where road has a sealed surface this shall be replaced after the backfill has been suitably consolidated to the satisfaction of the Employer and approved.

4.8.14 Protection of Services

The Contractor shall ascertain for himself the location of all permanent main services, and shall maintain and protect these where affected by the works and shall in no way interfere with these permanent services without receiving the written permission of the Employer.

4.8.15 Trenches not to be Left Open

Trench excavations shall be carried out expeditiously and subject to any specified requirements of the Contract, the backfilling and surface reinstatement of the trench shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and joined.

4.8.16 Polythene Sheeting

Polythene sheeting where necessary shall be of 1000 gauge and of approved manufacture supplied in rolls and laid by rolling over the prepared base at the levels and in the areas shown on the drawings. Where a joint is

necessary at the side or at the end of a sheet, this shall be double welt folded joint made by placing the edges together & folding over twice.

The joint shall be prevented from opening prior to concreting by blocks placed at intervals on top of the joints.

The Contractor shall protect the sheets from damage during laying and subsequent operations and shall replace all damaged sheets to the satisfaction of the Employer.

4.8.17 Anti-Termite Treatment

The treatment shall be carried out by an approved specialist sub-contractor.

The chemicals used shall conform to IS:8944.

4.8.17.1 Treatment to Soil under Slabs at Plinth Level & Ground Floor

After earth filling and before the dry rubble or core packing, the centre surface of the filled earth will be treated with a chemical emulsion recommended by the specialist sub-contractor at the rate specified by the manufacturer. Light rodding shall be done to facilitate spraying and absorption.

4.8.17.2 Treatment to Junction of Wall & Floors

Rodding to be carried out along the junction of plinth beams and earth filling at 15 cm intervals and recommended chemical emulsion sprayed at the rate of 2 litres per linear meter so as to mix intimately with the soil.

Above clauses 4.8.17.1 and 4.8.17.2 shall be carried out simultaneously to establish the chemical barrier.

4.8.17.3 Treatment to Soil along the External Wall Perimeter

After levelling and before flagging or plinth protection is laid, soil along the external wall perimeter of the building upto a depth of 30 cm shall be treated at the rate of 4.5 litres emulsion per linear meter of plinth walls. If necessary rodding at 30 cm intervals shall be carried out to facilitate spraying and absorption.

A. Treatment of Critical Areas

Soils under piers, utility pipe openings, floor drains and electrical conduit entry joints shall be thoroughly flooded with the chemical emulsion at an approximate rate of 25 to 30 litres per square meter. If drainage pipes are laid along the walls and the chemical barrier laid as per paragraph 4.7.17.2 is disturbed/broken, additional treatment to such areas will be necessary.

4.8.17.4 Guarantee for 5 Years

The specialist agency shall provide a guarantee that buildings shall be free from termite infestation for a period of 5 years from the expiry of defects liability period. The form of guarantee to be provided is given at the end of this section in Appendix I.

4.8.17.5 Precautions

Precautions shall be taken not to disturb the treated areas by levelling, digging or earth filling, as this will break the chemical barrier. In case such situation arises, the area is to be treated again to restore the chemical barrier

4.9 BRICK MASONRY WORKS

4.9.1 General

This specification establishes the materials, dressing, laying, joining, curing, workmanship etc. for brick masonry works. Brick masonry shall also comply with all the requirements of IS:2212.

4.9.2 Materials

Refer specifications under 'Materials'.

4.9.2.1 Cement Mortar

Cement mortar shall meet the requirements of IS:2250 and shall be prepared by mixing cement and sand by volume. Proportion of cement and sand shall be 1:6 (1 part of cement and 6 parts of sand), or as directed by the Employer for brick masonry of one brick thickness or more, while 1:4 cement mortar (1 part of cement and 4 parts of sand) shall be used for brick masonry of half brick thickness. The sand being used for mortar shall be sieved. The mortar shall be used as soon as possible after mixing and before it has begun to set and in any case within initial setting time of cement after water is added to the dry mixture. Mortar unused for more than initial setting time of cement, shall be rejected and removed from the site of work.

4.9.2.2 Proportioning

The unit of measurement for cement shall be a bag of cement weighing 50 kg and this shall be taken as 0.035 cubic metre. Sand shall be measured in boxes of suitable size on the basis of its dry volume. In case of damp sand, its quantity shall be increased suitably to allow for bulkage.

4.9.2.3 Mixing

The mixing of mortar shall be done in a mechanical mixer operated by power.

A) Mixing in Mechanical Mixer

Cement and sand in specified proportions, by volume, shall be thoroughly mixed dry in a mixer. Water shall then be added gradually and wet mixing continued for at least one minute. Care shall be taken not to add more water than that which shall bring the mortar to the consistency of stiff paste. Wet mix from the mixer shall be unloaded on water-tight masonry platform, made adjacent to the mixer. Platform shall be at least 150 mm above the levelled ground to avoid contact of surrounding earth with the mix. Size of the platform shall be such that it shall extend at least 300mm all-round the loaded wet mix area. Wet mix, so prepared, shall be utilised within initial setting time (thirty (30) minutes for ordinary Portland cement conforming to IS:269 after addition of water. Mixer shall be cleaned with water each time before suspending the work.

4.9.3 Construction Procedure

4.9.3.1 Soaking of Bricks

Bricks shall be soaked in water before use for a period that is sufficient for the water to just penetrate the whole depth of bricks as well as to remove dirt, dust and sand. Proper soaking of bricks shall prevent the suction of water from the wet mortar, as otherwise mortar will dry out soon and crumble before attaining any strength. The bricks shall not be too wet at the time of use as they are likely to slip on mortar bed and there will be difficulty in achieving the plumbness of wall as well as proper adhesion of

bricks to mortar. The period of soaking shall be determined at site by a field test by immersing the bricks in water for different periods and then breaking the bricks to find the extent of water penetration. The least period that corresponds to complete soaking, will be the one, to be allowed for in the construction work.

The soaked bricks shall be removed from the tank, sufficient early, so that at the time of laying, they are skin dry. The soaked bricks shall be stacked over a clean place, wooden planks or masonry platforms to avoid earth, dirt being smeared on them.

4.9.3.2 Laying

A) Brick Work (one or more brick thickness)

Brick work (one or more brick thickness) shall be laid in English Bond unless otherwise specified. Half or cut bricks shall not be used except when needed to complete the bond. In no case the defective bricks shall be used.

A layer of average thickness of 10mm of cement mortar shall be spread on full width over a suitable length of lower course or the concrete surface. In order to check and achieve uniformity in masonry, the thickness of bed joints shall be such that four courses and three joints taken consecutively shall measure equal to four times the actual thickness of the brick plus 30mm. Each brick with frog upward, shall be properly bedded and set in position by gently tapping with the handle of trowel or wooden mallet. Its inside faces shall be buttered with mortar before the next brick is laid and pressed against it. After completion of the course, all vertical joint shall be filled from top with mortar.

All brick courses shall be taken up truly plumb; if battered, the batter is to be truly maintained. All courses shall be laid truly horizontal and vertical joints shall be truly vertical. The level and verticality of work in walls shall be checked up at every 1 m interval.

The masonry walls of structures shall be carried up progressively, leaving no panel one meter lower than the other. If this cannot be adhered to, the brick work shall be raked back according to bond (and not left toothed) at an angle not more than 45 degrees but raking back shall not start within 60 cm of a corner. In all cases returns, buttresses, counter forts, pillars etc. shall be built up carefully course by course, and properly bonded with the main walls. The brick work shall not be raised more than fourteen (14) courses per day.

At the junction of any two walls, the bricks shall at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work.

The courses at the top of plinth and sills, at the top of the wall just below the soffit of the roof slab or roof beam and at the top of the parapet, shall be laid with bricks on edge. Brick on edge course shall be so arranged as to tightly fit under the soffit of the roof beam or roof slab, restricting the mortar layer thickness upto 12mm, however, any gap between the finished brick work and soffit of roof slab /beam shall be suitably sealed with the mortar.

B) Brick Work (half brick thickness)

For brick walls of half brick thickness, all courses shall be laid with stretchers. Wall shall be reinforced with 2 nos. - 6mm diameter mild steel reinforcement bars, placed at every fourth course. The reinforcement bars,

shall be straightened and thoroughly cleaned. Half the mortar thickness for the bedding joint shall be laid first and mild steel reinforcement, one on each face of the wall, shall be embedded, keeping a side cover of 12mm mortar. Subsequently, the other half of the mortar thickness shall be laid over the reinforcement covering it fully.

The reinforcement bars shall be carried at least 150mm into the adjoining walls or RCC columns. In case the adjoining wall being of half brick thickness, the length of bars shall be achieved by bending the bars in plan. During casting of reinforced concrete columns, 6mm dia. M.S. reinforcing bar shall be placed at every fourth course of brick masonry. At the junction of two walls, the brick shall, at each alternate course, be carried into each of the respective walls so as to thoroughly unite the work. The brick masonry work shall not be raised more than 14 courses per day.

Brick course under the soffit of beam or slab, shall be laid by restricting the mortar thickness to 12mm. However, any gap between the finished brickwork and soffit of slab/beam, shall be suitably sealed with the mortar.

C) Cavity Walls

Brick work in cavity walls shall be included with general brickwork. It shall consist of one wall of one or more brick thickness while the other wall shall be of half brick thickness at a clear gap of 50mm. The brick work on either side of cavity shall conform to the specifications already stated under sub section 8.3.2.1 and 8.3.2.2. At the base of the cavity wall, the walls shall be solidly constructed upto 300mm above the ground level. The cavity wall shall be terminated 300mm below the soffit of roof slab/beam and the courses over this shall be continued in solid brickwork.

Cavity should be continuous and free from obstructions. Mortar droppings shall be prevented from falling down the cavity by the use of laths or by hayhands which shall be drawn up the cavity as the work proceeds. Any mortar which may unavoidably fall on the wall-ties, shall be removed daily and temporary openings shall be provided to permit the daily removal of mortar droppings from the bottom of the cavity.

The outer and inner leaves shall be tied by means of wall ties. Ties shall be of mild steel round bars of 8mm dia. 200 long with hooks at both the ends. These shall be placed not more than 750mm c/c horizontally and not more than 300mm vertically, and staggered. Additional ties shall be provided near the openings. There shall at least, be 5 ties per square metre of surface area of the wall. Ties shall be given a bituminous coat before placement, to protect them from corrosion.

In order to keep the cavity dry, air slots shall be provided in the cavity walls at bottom as well as top to the extent of 50 sq.cm area of vents to every 2.0 sq. metre area of the wall.

D) Circular Brick Work

The detailed specification for brick work covered under sub section 8.3.2.1 and 8.3.2.2 shall apply, in so far as these are applicable. Bricks forming skew backs, shall be dressed or cut so as to give proper radial bearing. Defects in dressing of bricks shall not be covered up by extravagant use of mortar, nor shall the use of chips etc, be permitted.

The circular brick work shall be carried up from both ends simultaneously and keyed in the centre. The bricks shall be flushed with mortar and well

pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall be between 5mm and 15mm.

4.9.4 Jointing

Joints shall be restricted to a width of 10mm with brickwork of any classification. All bed joints shall be normal to the pressure upon them i.e. horizontal in vertical walls, radial in circular brick masonry and at right angles to the face in the battered retaining walls. The vertical joints in alternate courses shall come directly one over the other and shall be truly vertical. Care shall be taken that all the joints are full of mortar, well flushed up. In case no pointing is to be done, cement mortar shall be neatly struck as the work proceeds. The joints in faces which are to be plastered or pointed shall be squarely raked out to a depth of 12mm while the mortar is still green. The rake joints shall be brushed to remove loose particles. After the day's work, the faces of the brick work shall be cleaned on the same day with wire brush and all mortar droppings removed.

4.9.5 Curing

Green work shall be protected from rain or any other running water or accumulated water from any source, by suitable means. Masonry work, as it progresses, shall be kept thoroughly wet by sprinkling water at regular intervals, on all faces. Curing shall be done after 24 hours of completion of day's work and shall be done for at least 10 days after completion. Proper watering cans with spray nozzles, rubber or PVC pipes shall be used for this purpose.

4.9.6 Staging / Scaffolding

Staging/scaffolding shall be properly planned and designed by the Contractor. Use of only steel tubes is permitted for staging/scaffolding. Design of staging/scaffolding shall be submitted for approval of the Employer, before commencement of work.

Single scaffolding having one set of vertical support, shall be used and other end of the horizontal scaffolding member shall rest in a hole provided in the header course. The support shall be sound and strongly clamped with the horizontal pieces over which the scaffolding planks shall be fixed. The holes left in the masonry work for supporting the scaffolding shall be filled and made good with plain cement concrete of grade 1:3:6 during plastering. Suitable access shall be provided to the working platform area. The scaffolding shall be strong enough to withstand all loads likely to come upon it and shall also meet the requirements specified in IS:2750.

Double scaffolding shall be provided for pillars less than one metre in width or for the first-class masonry or for a building having more than two storeys.

The following measures shall also be considered during erection of the scaffolding/staging.

- a) Sufficient sills or underpinnings, in addition to base plates, shall be provided, particularly, where scaffoldings are erected on soft grounds.
- b) Adjustable bases to compensate for uneven ground shall be used.
- c) Proper anchoring of the scaffolding/staging at reasonable intervals shall be provided in each direction with the main structure wherever available.
- d) Horizontal braces shall be provided to prevent the scaffolding from

rocking.

- e) Diagonal braces shall be provided continuously from bottom to top between two adjacent rows of uprights.
- f) The scaffolding/staging shall be checked at every stage for plumb line.
- g) Wherever the scaffolding/staging is found to be out of plumb line, it shall be dismantled and re-erected afresh. Efforts shall not be made to bring it in line with a physical force.
- h) All nuts and bolts shall be the clamps/couplings are firmly tightened to avoid slippage.
- i) Erection work of a scaffolding/staging, under no circumstance shall be left totally to semiskilled or skilled workmen and shall be carried out under the supervision of Contractor's technically qualified civil Employer.

For smaller works or works in remote areas wooden ballies may be permitted for scaffolding/staging by the Employer at his sole discretion.

4.9.7 Embedment of Fixtures

All fixtures, pipes, conduits, holdfasts of doors and windows etc. required to be built in walls, shall be embedded in plain cement concrete block of grade 1:3:6, at the required positions, as the work proceeds.

4.9.8 Compressible Joint Fillers

Soft board shall be used where specified at joints requested by the Employer. Filler shall be cut to exact widths and shall have all edges neatly trimmed. Fixing of filler shall be strictly in accordance with the manufacturer's printed instructions.

4.9.9 Polysulphide Sealant for Joints

Polysulphide joint sealer or other equal and approved shall be used.

Application shall be strictly in accordance with the manufacturer's instructions.

4.9.10 Galvanised Mild Steel Butterfly Wall Ties

For all vertical joints between brick work and concrete galvanised mild steel butterfly pattern wall ties are to be cast in concrete at 400 mm vertical spacing and then built into the mortar bed joints of the wall.

Where specified, both skins of cavity walls are to be built in brickwall, the skins shall be tied together with galvanised mild steel butterfly pattern wall ties and spaced at the rate of one every 600 mm horizontally and 400 mm vertically, staggered every 400 mm vertically at ends jambs and quoins.

4.10 PCC BLOCKS

4.10.1 Preparation of Formation

The bed for the PCC blocks shall be excavated to the required depths and compacted, trimmed and shaped to the entire satisfaction of the Employer's Engineer.

When over excavation occurs, it shall be back-filled with compacted gravel with the approval of Employer's Engineer at the expense of contractor.

4.10.2 Laying of Filter Material

The filter material shall consist of approved clean, hard natural gravel or broken stone well graded from 50 mm to 10 mm and shall be laid to the required thickness underneath pitching on slopes.

4.10.3 Laying of PCC Blocks Pitching

The PCC blocks pitching unless otherwise directed shall be started from ground level and shall be placed in layers manually or other methods approved by the Employer's Engineer, all to secure a stable mass. Surface irregularities of the slope shall not vary more than 8 cm (3 inches) along the intended slope. All interstices, hollows and inequalities between PCC blocks shall be filled with sand, small pieces and wedged up tight with spawl driven in with slight hammering to the satisfaction of the Employer's Engineer.

The PCC Blocks of required size shall be laid in launching apron to the required depth and approved by the Employer's Engineer, for free drainage of pore water PCC blocks should be placed at a gap of 10mm on all the sides. All interstices, and gaps between PCC blocks shall be filled with sand.

4.11 STRUCTURAL STEEL WORK

4.11.1 General

This section includes requirements of all structural steel work required for the completion of the Works, as shown on the drawings and as specified herein.

All structural steel used by the Contractor for the construction shall conform to relevant IS codes or equivalent as approved by the Employer and described in these specifications. If deviation or a substitution of material is sought, the Contractor shall submit written request to Employer along with necessary supporting documents including test results, manufacturer's certificate, etc. along with reasonable time for evaluation without disruption of the construction schedule. It shall be the Contractor's responsibility to

satisfy the Employer that his proposed deviation or substitution will in no way be detrimental to the quality of the works intended in the Contract. In case of any doubt the Employer may ask for additional information, testing or retesting which the Employer may feel necessary, which the Contractor shall carry out to the Employer satisfaction and with no impact on the construction schedule.

It shall be noted that site fabrication and painting of steel members shall not be allowed. The Contractor has to make his arrangements accordingly.

4.11.2 Structural Steel

4.11.2.1 Steel Grades

Unless otherwise stated all steel shall conform to one of the following grades.

- a) Carbon Steel: ASTM A 36 or approved equivalent (F_y=36 Ksi) IS 2062 Gr A
- b) Intermediate strength steel: BS 7191 Gr 355D, API Spec.2 H Gr 50 or APPROVED EQUIVALENT (F_y=50kSI)

Steel supply to specifications equivalent to those listed above shall be considered as substitution and shall require written approval by Employer to this effect.

4.11.2.2 Structural Steel Types

A) Rolled Shapes and Plates

All rolled shapes and plates shall be carbon steel grades as defined and unless otherwise specified.

B) Tubulars

All Tubulars shall be fabricated in accordance with API Spec. 2B, from plates which should conform to one of the steel grades indicated in Clause 4.11.2.1 above.

Mill - manufactured line pipes, where acceptable shall be of prime quality and shall conform to API 5L Gr. B or equivalent, seamless.

The use of spirally welded and electric resistance welded pipes shall not be permitted for any load bearing structural member.

I.Usage

The usage of different grades of steels shall be as determined by design. For jacket type structures (if used by Contractor), the guidelines of API RP 2A shall be followed for material usage.

II.General Requirements

a. Process

The steel shall be manufactured by the basic open hearth, electric furnace or basic oxygen process. No rimmed or capped steel shall be used.

b. Delivery, Storage and Handling

All rolled shapes and plates are to be delivered in accordance with ASTM A6, "Standard Specifications for General Requirement for Rolled Plates, Shapes sheet piling and bars for structural use".

Fabricated Tubulars shall conform to the dimensional tolerances of API Spec. 2B, "Specifications for Fabricated Structural Steel Pipe".

For mill manufactured pipes, where permitted for use, dimensional tolerances of API Spec. 5L, "Specification for Line Pipe", shall apply with additional requirements for straightness listed in API Spec. 2B.

All structural steel shall be stored and covered in a manner which will ensure that no damage shall occur to it from moisture, dirt, grease or any other cause which might impair bond with concrete.

a. Identification

A sufficient supply of approved structural steel shall be stored at the site at all times to ensure that there will be no delay of the work.

Steel will be reasonably free from defects, mill scale and rust.

Structural steel shall be bundled and tagged with grades, size and suitable identification mark for checking, sorting and placing size and mark numbers. Tags and markings shall be waterproof and shall not be removed until steel is placed.

b. Mill Tests

All mandatory inspection and testing listed in ASTM A6, "Standard Specification for General Requirements for Rolled Steel Plates, Shapes, Sheet piling, and Bars for Structural Use", shall apply.

Supplementary inspection and tests when specified in individual specifications shall also apply.

In addition to above for all steel materials the following are mandatory requirements:

Product Analysis: One sample per heat. Acceptability standards as specified in ASTM designation A6 shall apply for all elements.

In addition, a field weldability test shall be performed in accordance with the requirements of relevant IS codes or equivalent with a heat input of 15–20 kJ/cm and the results of the test shall meet the requirements specified for

the base material. This requirement shall be a prerequisite for the acceptance of the material.

c. Mill Certificates

Contractor shall supply the Employer with a certificate indicating the process of manufacture, results of chemical and mechanical tests including specified supplementary tests for the material. Each test certificate shall bear the heat number and other identification marks such that the same can be correlated with the material. These certificates shall be signed by manufacturer's representative and furnished alongwith material.

When any steel is supplied from stock, the Contractor shall satisfy the Employer that the steel has been manufactured and tested and complies with all the tests and requirements of the specification under which the steel is being furnished with necessary documentary proof of original manufacturers. The heat numbers on mill certificates should be correlated with markings on the material. Steel material without acceptable mill certificates shall not be used.

i. Special Requirements

a. Carbon Steel

All carbon steel material shall meet the following:

Max. Carbon (C_{max}) = 0.22%

Max. Carbon Equivalent (CE) = 0.45 (For CE formula refer 2.5.2)

b. Intermediate Strength Steel

The carbon equivalent shall be a maximum of 0.43 (ladle analysis) as determined from the following formula:

$$CE = C + Cr + Mo + \frac{V}{5} + \frac{Cu + Ni + Mn}{15} \leq 6$$

V less than or equal to 0.08% Nb less than or equal to 0.05% V+Nb less than or equal to 0.10%.

i. Other Requirements

All plates shall be ultrasonically inspected for defects and discontinuities in accordance with ASTM A578. Acceptance Standard shall be level II.

If intended to use plates having defects requiring repair for welding procedure qualification, these plates shall be shipped clearly marked "For Welding Procedure Qualification Only".

ii. Heat Treatment

Heat Treatment shall be performed on all elements where properties have been degraded by forming and fabrication.

The use of furnaces is desirable for all heat treatments. When local heat treatments are deemed necessary, a detailed procedure shall be submitted to the Employer for approval prior to performing such heat treatments.

a. Stress Relief

Stress relief heat treatment shall be performed on all materials subject to the following conditions:

- Elements subjected to press or roll forming where the temperature of the steel is above 38°C or less than 427°C during the forming operation.
- Elements subjected to press or roll forming where the outer fiber strain exceeds five

(5) percent as defined by the formula:

$$\text{Percent Strain} = 100 t / D$$

Where

t = thickness of element

D = outside diameter

- Welded assemblies containing one or more elements with the thickness exceeding 65mm.

C) Stress Relief Temperatures

All stress relief shall be achieved by thermal methods by heating the element or assembly to a temperature between 590°C to 620°C for carbon steel and intermediate strength steel.

4.11.3 Quality Control

The Contractor shall establish and maintain quality control procedures for different items of work and materials to the extent he deems necessary to ensure that all work is performed in accordance with this specification. Materials or workmanship shall meet with the provisions of specifications and approval of Employer.

Before start of work, Contractor shall submit a detailed quality control plan of fabrication and erection for EMPLOYER'S approval. Such QC plan shall include inter alia, the welding process proposed, type of electrodes to be used, acceptable criteria to be used for error in erection etc.

The quality control procedure/operations shall cover but not be limited to the following items of work:

- Bolts, Nuts and Washers: Manufacturer's, certificate, dimension checks, material testing
- Electrodes: Manufacturer's certificate, thickness and quality of flux coating

- Welders: Qualifying Tests
- Welding Sets: Performance Tests
- Paints: Manufacturer's certificate, physical inspection reports regarding quality of paints, primers & thinners.
- Erection: Lines, levels, grades, plumbs, joint characteristics including tightness of bolts.
- Grouting: Cleaning and roughness of foundation, quality of materials used for grouting, admixtures, consistency and strength of grout.
- Painting: Preparation of surface for painting, application and uniformity of coats.

4.11.4 Fabrication

The Contractor shall prepare detailed drawings giving complete information necessary for the fabrication of the steel works. All information should be clearly given and the drawings shall be in conformity with the best modern practice. A marking diagram allotting distinct identification marks to each separate piece of steel work shall be prepared in sufficient detail to ensure convenient assembly and erection. Symbols for welding used on the drawings shall be in accordance with IS:813 "Scheme of Symbols for Welding".

The Contractor shall prepare comprehensive bill of material sheets for each shop drawing giving therein all the items shown on the drawings together with their weights, mark numbers, cutting lengths, etc.

All fabrication shall be in accordance with IS:800 "Code of Practice for use of Structural Steel in General Building Construction".

4.11.5 Welding

Metal arc process shall be used for welding in all cases, unless otherwise specified by the Employer. The welding procedure shall be in accordance with the requirements of IS:816 “Code of Practice for Use of Metal Arc Welding for General Constructions in Mild Steel”. The symbols for welding as shown on the drawings will be interpreted in accordance with IS:813.

Electrodes used for hand welding or for automatic welding machine shall conform to IS:814 “Covered Electrodes for Metal Arc Welding of Structural Steel”.

4.11.6 Galvanising

Galvanising where specified shall be of the best quality conforming to IS:2629 “Recommended Practice for Hot Dip Galvanising of iron and Steel”.

4.11.7 Installation

Install in locations shown, as indicated on Contractor’s drawings, to line, plumb, and level, rigidly attached in placed with all connections to other work neatly made and drawing up tight. Joints caulked to provide weather-proof installation. Erection equipment shall be suitable and safe for the workmen. Errors in shop fabrication or deformations resulting from handling and transportation that prevent the proper assembly and fitting of parts shall be reported immediately to the Employer and approval of the method of correction shall be obtained.

Anchor bolts and anchors shall be properly located. After assembly the various parts of a completed frame or structure shall be aligned and adjusted accurately before being fastened. As erection progresses, the

work shall be accurate fastened to take care of all dead loads, wind and erection stresses. Unless removal is required all erection bolts used in welded construction may be tightened securely and left in place. Drilling may be used in such a manner as not to distort or damage the metal. The use of gas-cutting torches in the field for connecting fabrication errors will not be permitted on any major member of the structural framing.

4.11.8 Bolting

Bolts shall be driven accurately in holes without damaging the thread. Bolt heads shall be protected from damage during driving. Bolt heads and nuts shall rest squarely against the metal. Where bolts are to be used on bevelled surfaces, bevelled washers shall be provided to give full bearing to the head or nut.

4.11.9 Shop Painting

Paint all surfaces, except those to be embedded in concrete with exterior ferrous metal primer on properly prepared surfaces, as specified under 'Painting'. Surfaces which will be embedded in concrete shall not be painted but shall be cleaned as required for painting.

4.11.10 Inspection & Testing

The Contractor shall provide free of charge, such labour, materials, electricity, fuel, water, stores, tools and plant, apparatus and instruments as may be required by the Employer to carry out inspection and/or tests in accordance with the Contract.

The Contractor shall guarantee compliance with the provisions of this specification.

The Contractor shall carry out sampling and testing in accordance with the relevant British Standards or equivalent as directed by the Employer, unless otherwise specified in the Contract. The Contractor shall get the specimens tested in a laboratory approved by the Employer and submit to Employer the test results in triplicate within 3 (three) days after completion of the test.

4.12 STEEL /ALUMINIUM DOORS, WINDOWS AND VENTILATORS

4.12.1 General

This section of the specification includes the requirements necessary to provide in place all steel / Aluminium doors, windows and ventilators.

4.12.1.1 Indian Standards

IS 6248	Specification for metal rolling shutters and rolling grill
IS 1081	Code of practice for fixing and glazing of metal (steel and Aluminium)
	doors, windows and ventilators.
IS 4351	Specifications for steel door frames.
IS 1948	Specifications for Aluminium doors, windows and ventilators.
IS 1361	Specifications for steel windows for Industrial buildings.
IS 1038	Specifications for steel doors/windows and ventilators.
IS 1200 (Part XIV)	Method of measurement of glazing.
IS 3614	Specifications for fire check doors.
IS 7452	Specification for hot rolled steel sections for doors, windows and ventilators.
IS 2835	Flat transparent sheet glass.
IS 5437	Wired and Figured glass.
IS 25583	Safety glass.

4.12.1.2 Pressed Steel Door/Window/Ventilator Frame

Pressed steel door/window/ventilator frame shall confirm to IS:4351.

The frames shall be made of 16gauge pressed steel bent to shape using bending machine, and mitred with square edges. The frames shall be

provided with spacers by welding 50 mm x 5 mm flats to the portion of the frame in contact with the wall jambs @ 600 mm vertical spacing.

The frame shall be fixed to the masonry by means of 300 mm x 25mm x 6mm hold fast welded to the spacers and grouted with M-20 grade concrete in minimum 350 mm x 100 mm x 100 mm sized hole in the masonry.

In case of concrete, the frames shall be fixed by 96 mm long, 12 mm dia metallic counter sunk type dash fasteners through the frame and spacers.

Provisions for hinges, locking arrangement and other hardware shall be provided in the frames by machine cutting required size cutout on the frame body and welded / screwed to 3 mm thick M.S. pad plates-already welded over the cut out from behind.

The frame surface shall be thoroughly cleaned of rust, mill scale, dirt, oil etc. and then finished with painting (by priming with red oxide zinc chromate primer conforming to 1S:2074 and painting on forming to 1S:1477 Part (II) or by approved shade electrostatic powder coating (25 micron).

4.12.2 Pressed Steel Door Shutter

Pressed steel shutters shall be hollow type with 18gauge pressed steel welded at meeting of the sheets with pad plate of M.S flat 3 mm thick all along perimeter. The cavity shall be packed with rigid phenolic foam board adequately cut into shape to fully fit into the box cavity without gaps.

The shutter shall be formed by machine bending of 18 gauge (as specified in item) pressed steel sheet in form of hollow box making an overall thickness of 40mm forming truly square edge in accordance with the shutter profile. It shall further be braced with channel shaped horizontal stiffeners

formed by folding 16 gauge MS sheets (35mm wide) @ 500 mm max. And fixed by flush riveting. 3mm thick M.S. pad plates shall be welded inside at required locations for fixing of hardware's such as tower bolt, aldrop etc.

For double shutter doors, an M.S. angle 25mm x 45mm x 3 mm thick shall be welded to one of the shutters providing a minimum 25mm wide rebate for the other shutter at the meeting point during closed condition.

The shutter surfaces shall be painted with electrostatically powder coating/two coats of synthetic enamel paint over a priming coat of red oxide zinc chromate conforming to IS 2074/IS 1477 (Part-11). The shutters shall be fixed to the door frame by means of heavy-duty MS butt hinges of 150mm size conforming to table 6 of IS 1341 @ 600mm max.

In case of air tight door shutters, approved quality continuous neoprene rubber beading shall be provided continuously along the door frame rebate fixed with neoprene rubber adhesive of approved make.

In case of partly glazed door shutter. Glassas specified shall be fixed with glazing clips and solid drawn 10 mm x 10 mm, MS beading backed with putty and fixed by countersunk screws. Necessary rebate for fixing the glass shall be provided by arranging the shutter bracing accordingly.

The shutters shall be provided with locking device, handles and other hardware's as specified.

4.12.3 Steel Windows & Ventilator

Steel windows, ventilators shall in general conform to IS 1081, IS 1038, IS 7452.

4.12.3.1 Materials

D) Rolled Steel Sections

Rolled steel sections for the fabrication of steel windows, ventilators shall conform to IS 7452.

E) Glass Panes

Glass panes for glazing purpose shall be as specified in item description.

All glass panes shall have property squared corners and straight edges.

Glass panes shall be of following types in accordance with item description:

- i) 4 mm thick transparent sheet glass conforming to IS 2835 (wt. 7.2 kg/m)
- ii) 5.5 mm thick wired glass conforming to IS 5437.
- iii) 6.3 mm thick laminated safety glass conforming to IS 2553.

F) Workmanship

The profile and type of windows, ventilators (glazed, partly glazed/louvered, side hung/top hung/fixed shutter, composite) shall be as per Contractor's drawings.

The frames shall be fabricated of sections cut to size and metered. Corners shall be welded to form a fused welded joint. Process of welding shall be flash butt welding. The welded joints shall be grinded to square and flat edges.

Where larger units are to be formed by coupling individual units, the mullions, transoms shall be bedded in mastic to ensure weather tightness. Mastic shall be applied liberally to the channels of the outside frame sections before assembly, and the two units being coupled shall be drawn

together tight with clamps, the mastic being squeezed out and cut off neatly when the units shall be screwed together tight.

Where fixed glazing units are placed over openable units a push fit weather bar shall be provided.

Before glazing, all opening parts shall be checked for their operational smoothness. The frame shall be completely cleaned and bedding putty shall be placed in the rebate before glazing. Glass then shall be cushioned into the bedding and shall be fronted with front putty in a manner so as to enable the painting to be done upto the sight line. The back putty oozing out over the glazing rebate shall be cut off square and smoothed down.

For panes exceeding 600 x 300 mm in size, glass shall be secured by special glazing clips inserted in holes already provided in the steel sections, before applying the front putty.

For glazing of very large areas, rust proof steel beading with metered corners shall be provided with screws @ 10 cm. from each corner and @ 20 cm. apart from each other. Putty shall be provided to the face of the bead in contact with glass, in addition to back putty.

Side hung shutters shall be connected to the frame by means of friction hinges. The handle for side hung shutters shall be of pressed brass mounted on a steel handle plate welded to the opening shutter frame and shall not be removable easily after glazing. The handle shall have a two point nose which shall engage with a brass striking plate on the fixed frame in aslightly openas well as in a fixed position.

Top hung shutters shall be provided with steel butt hinges welded to the fixed frame after cutting a slot in it. Top hung casements shall be provided with peg stay of 3 holes of pressed brass, 300 mm long which when closed shall be held tightly by the locking bracket fitted to the fixed frame or to the window.

Before fixing the frames, the size of the opening shall first be checked and cleaned of all obstructions. The positions of the unit in the reveal shall be taken off and shall be marked on the reveal at the jambs using a plumb line. In case of fixing with masonry, holes for fixing the lugs/hold fasts shall be cut at required locations. In case of concrete or stone, the frames shall be fixed by means of dash fasteners. In case of masonry, the lugs shall be grouted in the holes with cement concrete, M-15 Grade when fixing to steel work, mastic shall be applied to the sill of the opening and the unit shall be placed on it with the jambs and head buttered with mastic and the unit shall be fixed with special fixing dips or with nuts and bolts.

The windows/ventilators shall be checked to ensure smooth operation, perfect level and plumb.

All the steel surfaces shall be thoroughly cleaned free of rust, mill scale, dirt, off etc. by sand and shot blasting and then finished with painting by priming with red oxide zinc chromate primer conforming to IS 2074 and painting conforming to IS 1477 (Part II) or by hot dipped galvanizing conforming to IS 1477 Part (I). Putty shall also be provided with painting in a manner so as to seal the putty glass junction. Surfaces not meant for painting shall be cleaned of any strains of paint.

4.12.4 Rolling Shutters

4.12.4.1 General

Rolling shutters shall be of best quality conforming to IS 6248 - 1979 and obtained from approved make. These shall include necessary locking arrangement and handles, fixing bolts, safety devices, anchoring rods etc. These shall be suitable for fixing in position as specified i.e. outside or below lintel or between jambs of the opening. The door shall be push and pull type and also operated with chain crank as required. Electrically operated rolling shutters shall be used wherever specified.

4.12.4.2 Galvanising

All M.S. materials including lath sections, clips, guides, lock plate, guide channel, bracket plate, suspension shaft hood cover & other components shall be hot dip galvanised with a zinc coating containing not less than 97.5 percent pure zinc. The weight of the zinc coating shall be not less than 750 mm/m² both sides and the coating shall be free from flaking or peeling conforming to IS:1477-1977 (Part I & II).

4.12.4.3 Shutters

The shutters shall consist of M.S. lath sections conforming to IS 513-1986, 1.25 mm thick and 75 mm wide unless otherwise specified. The laths shall be machine rolled and straightened with an effective bridge depth of not less than 16 mm and shall be interlocked together throughout their entire length and joined together at the end with end locks by means of cast iron or galvanised mild steel clips conforming to IS 2108-1977 riveted at either end which shall prevent lateral movement of the individual lath sections.

These shall be mounted on specifically designed pipe shaft. Each lath section shall be a continuous single strip piece without any joint.

4.12.4.4 Springs

The springs shall be, preferably of coiled type. The spring shall be manufactured from high tensile spring steel wire conforming to grade 2 of IS 4454-1981 or strip of adequate strength to balance the shutters in all positions. The spring pipe shaft etc. shall be supported on strong mild steel brackets.

4.8.1.2 Guide Channels

The guide channels shall be of mild steel deep channel section and of rolled, pressed or built-up construction. The thickness of the sheet used shall not be less than 3.15 mm. The minimum depth of guide channels shall be 60 mm for clear width of shutters upto 3.5 m and 75 mm for 3.5 m and above guide.

The gap between the two legs of the guide channel shall be sufficient to allow free movement of the curtain and at the same time close enough to prevent rattling of the curtain due to wind.

Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to the walls or columns by means of heavy duty bolts or screws.

The guide channels shall be attached to jambs, in plumb either in the overlapping or projecting torsion or embedded in grooves, depending on method of fixing to the approval of the Employer.

4.8.1.3 Fixing

Brackets shall be fixed on the lintel or under the lintel as shown with metal fasteners, screws, bolts, etc. The shaft along with the spring shall then be fixed to the brackets.

The shutters shall be laid on the ground and the side guide channels shall be bound with it with ropes etc. The shutter shall then be placed in position and top fixed with pipe shaft with bolts and nuts. The side guide channels and the cover frame shall then be fixed to the walls through the plate welded to the guides.

Fixing shall be done accurately in workmen's-like manner so that the operation of the shutter is easy and smooth.

4.8.1.4 Grilled Curtain

Wherever specified rolling shutter shall be provided with grilled curtain partly or fully, as required.

4.8.1.5 Electrical Devices

Suitable electrical devices, push buttons, etc. shall be provided at suitable location to control the opening and closing the rolling shutter. Suitable limit switches shall be provided to automatically stop motor when shutter reach the fully open and closed positions. The control switchgear, cabling, etc. should be of reputed make, conforming to relevant IS codes.

4.12.5 Aluminium Glazed Doors/Windows/Ventilators

4.12.5.1 General

Aluminium glazed doors/windows/ventilators shall be of specified sectional size, dimension and profile as per Contractor's drawing.

4.12.5.2 Materials

All Aluminium sections shall be extruded sections of INDAL aluminium alloy as per IS:733 and 18:1285. Aluminium sections shall be anodised as per IS : 7088 to min. 25 microns.

Glass used for glazing shall be of following type in accordance with item description.

- i) 5.5 mm thick wired glass conforming to IS 5437.
- ii) 6.3 mm thick laminated safety glass conforming to IS2553.
- iii) 5.5 mm thick transparent sheet glass conforming to IS 2835 (wt. 72 kg/sq.M)

4.12.5.3 Workmanship

Frames shall be square and flat, the corner of the frame being fabricated to true right angles. Details of construction of frames, shutters etc. shall be as per drgs.

Side hung window shutters shall either be fixed to the frame with pivots, or aluminium alloy hinges. For fixing the hinges, slots shall be cut in the fixed frames and the hinges inserted inside may be riveted to the frame. The hinges shall normally be of the projecting type conforming to IS designation A-5-M of IS 617, IS 733. In which case Peg stay of 300 mm long complete with Locking bracket and conforming to IS codes same as for hinges shall be provided. Friction hinges may also be provided in which case peg stays are not required.

The handles for side hung shutters shall be of cast aluminium conforming to IS designation A-5-M of IS 617 and shall be mounted on a handle plate rivetted to the opening frames. The handle shall have anodised finish with

minimum anodic film thickness of 25 micron or electro colour finish. The handle shall have a two-point nose which shall engage with an aluminium striking plate on the fixed frame. The striking plate shall be finished in the same manner as for the handle.

In case of top hung shutters, aluminium alloy cast hinges and peg stays (same as per side hung shutters) shall be provided.

Centre hung shutters shall be hung on the two pairs of cup pivots of aluminium alloy of IS designation NS-4 of IS 737 and IS designation A-5-M of IS 617 or chromium/cadmium plated brass/bronze cup pivots riveted to the outer and inner frames to permit to swing through an angle of 85°. Cast aluminium (conforming to IS designation A-5-M of IS 617) or chromium/cadmium plated bronze spring catches shall be fitted in the centre of the top bar of the shutter. The spring catch shall be secured to the frame by screwing/riveting to the frame and shall close into an aluminium catch plate riveted/welded to the outside of the outer shutter frame bar. Aluminium or cadmium plated brass chord pulley wheel in an aluminium bracket shall be fitted at the sill of the shutter with Aluminium or galvanized/cadmium plated steel screws.

The door shutters shall be fitted with pivots as specified. The handle for doors shall be of Aluminium and as per design. The door shutters shall be provided with locking device, floor spring, O/H door closer and any other hardwares, specified in item.

In case of composite Door/window/ventilator units, the units shall be coupled. Weather bar shall be provided whenever a coupling member is fitted over an external opening shutter.

Glazing shall be fixed to the extruded sections by means of extruded aluminium beading. Glass panes shall be provided with rubber lining before fixing.

The aluminium frames shall be fixed to the masonry by means of aluminum lugs fixed to the frame (by counter sunk galvanized machine screws) and grouted with M-15 grade concrete in the hole in the masonry. In case of concrete wall, the frames shall be fixed by 96 mm long, 12 mm dia metallic dash fasteners. Any steel material coming in contact with aluminium shall be galvanised.

The windows/ventilators/doors shall be checked to ensure smooth operation, perfect level and plumb.

4.13 WOOD WORK

4.13.1 General

This section of the specification includes requirements for furnishing and installing all wood work including ironmongery as specified for the completion of all of the work of the Contract.

The Contractor shall supply all timber, fittings, ancillary materials for fixing such as glue, screws, bolts, hold fasts etc. required for the works all in accordance with dimensions and sizes required.

The Contractor shall ensure that any timber entering the site for incorporation in the permanent works is of an approved quality.

Pre-fabricated & assemble doors, windows and / or any other unit shall on arrival at the site, be subjected to a thorough inspection and approval by the Employer.

Timber for joinery work shall be wrought to the exact sizes and all surfaces shall be rubbeddown and left clean for painting or staining.

4.13.1.1 Indian Standards

IS:2202-Part I	Specification for wooden flush door shutters (solid core type) plywoodface panels
IS:2202-Part II	Specification for wooden flush door shutters (Solid core type) practiceboard and hard board face panels.
IS:1003 Part I	Specification for Timber panelled and glazed shutters -Door shutters
IS:3087	Specification for wood particle boards (medium density) for generalpurposes
IS:3097	Specification for Veneered particles board
IS:848	Specification for synthetic Resin Adhesives for plywood (phenolic andAmino plastic)
S:205	Specification for nonferrous metal butt hinges
IS:2338	Code of Practice for finishing of wood and wood-based materials (Part-1 & Part-11)
IS:1341	Specification for steel butt hinges
IS:4021	Specification for timber door, window and ventilator frames
IS:303	Specification for plywood for general purpose

4.13.2 Material

4.13.2.1 Timber

A) Teakwood

Teakwood shall be second class Indian Teakwood conforming to IS:4021 of good quality, well-seasoned and free from defects such as cracks, dead knots, sapwood etc. No individual hard and sound knot shall be more than 15 sq.cm in size and the aggregate area of such knots shall not exceed 2%

of the areas of the piece. The timber shall be fairly close grained having not less than 2 growth rings per cm, width in cross-section.

B) Hard Wood

Hard wood shall be first class wood conforming to IS:4021 of good quality, well-seasoned and free from defects such as dead knots, cracks, sapwood etc. No individual hard and sound knot shall exceed 6 sq. cm in size with no dimension more than 50 mm and the aggregate area of such knots shall not be more than 1% of the area of the piece. There shall not be less than 5 growth rings per cm, width in cross-sections.

C) Moisture Content in Timber

The maximum permissible percentage of moisture content for well-seasoned timber shall be as per IS 287.

D) Workmanship of Wood Work

Workmanship for wood and joinery shall be as per IS:1200 and IS:4021.

E) Painting / Polishing of Wood Work

Painting/polishing of wood work shall be in accordance with specifications under 'Painting'.

4.13.3 Wooden Door / Window Frame

Wooden Door / Window frame shall be made of specified wood as per item description and shall be in accordance with detailed drawings of Contractor.

The wooden members of the frame shall be planed smooth and accurate to the full dimensions. Rebates, rounding, moulding etc. shall be done before the members are jointed into frames

Joints in the frame work shall be perfect with square edges and shall be pinned with hard wood/bamboo pins of 10 to 15 mm dia.

Wood work shall be painted/polished or otherwise treated as specified. All exposed portions shall be coated with wood primer and concealed surface by bituminous paints as per specifications under 'Painting'.

Before any surface treatment is applied, the wood work shall be got approved by the Employer. The frames shall be fixed only after acceptance by the Employer. The frames shall be fixed to the masonry by 300 mm x 25 mm x 6 mm MS hold fasts embedded. In M- 15 grade concrete block of 350 mm x 100 mm x 100 mm in the hole of the masonry. In case of concrete, frames shall be fixed by 96 mm long 12 mm dia metallic dash fasteners.

4.13.3.1 Shutters

F) Particle Board Flush Shutter

Particle board flush shutter shall in general conform to IS:2202.

G) Materials

i) Particle Board

Particle board shall conform to IS 3097 and shall be three-layer flat pressed teakwood based and of exterior grade (Grade-1), type-1, BWP type bonded with phenol Formaldehyde synthetic resin conforming to IS 848.

ii) Veneers

Veneers shall conform to class-I of IS:303 and (BS:476 Part-7)

iii) Teakwood

Specification of Teakwood shall be same as specified in Clause 4.13.2.1 of this section.

iv) Hinges

Hinges shall be of Extruded Aluminium Alloy and butt type conforming to IS:205. Size of hinges shall be in accordance with shutter width and as per IS:205.

H) Workmanship

The particle board of required size and thickness shall be lipped on all the edges with T- type teakwood lipping. The overall board lipping composition shall be of uniform and specified thickness and shall be property sized in view of the operation of shutter.

All the four edges of the door shutter shall be square. The shutter shall be free from twist or warp in its plane. In case of double leaf shutters, the meeting of the stiles shall be rebated by one third the thickness of shutter. The rebating shall be splayed.

The shutter then shall be veneered on both faces by gluing approved shade and textured commercial type 0.5 mm thick veneering conforming to class 1 of IS 303.

The veneering shall be done by gluing the veneer with BWP type, phenol formaldehyde synthetic resin conforming to IS 848 by hot press process on the shutter. Workmanship and finish of the veneering shall conform to IS 303.

The exposed surfaces of the lipping of the edges shall be French polished in accordance with specifications under 'Painting'.

The shutter shall be fixed to the door frame, by means of hinges @ minimum 3 hinges per leaf. Maximum spacing of hinges being 600 mm with suitable sized screws.

The shutter when fitted to the frame shall satisfy all operational aspects of the door like smooth movement, proper closing against the door frame etc.

4.13.3.2 Medium Density Fibre Board Panel Shutter

MDF board panelled shutter shall in general conform to IS: 1003.

I) Materials

i) MDR-board

Medium density fibreboard shall conform to IS: 12406 Exterior grade (EGSB). It shall be dense, homogeneous and manufactured from agro based lingo-cellulosic fibres bonded with BWP type phenol formaldehyde synthetic resin conforming to IS:848. It shall be categorised as class I for Surfaces of very low flame spread as per IS-1642.

ii) Teakwood

Specifications of Teakwood shall be same as specified in Clause 4.13.2.1 of this section.

iii) Synthetic Enamel Paint and Primer

Synthetic Enamel paint conforming to IS:1932 of approved brand and manufacturer and of the required colour shall be used for the top coat and undercoat of shade to match the top coat as recommended by the manufacturer and specified under 'Painting'.

iv) Hinges

Specification of hinges shall be same as specified in Clause 4.13.3.1 (iv)

J) Workmanship

Teakwood stiles, top rail and bottom rail of specified thickness and size shall be provided with suitable rebate.

The MDF board shall be fitted in by means of teakwood moulded beading of appropriate cross section. The beading shall be fixed by means of approved make neoprene based adhesive and nailing.

All the four edges of the door shutter shall be square. The shutter shall be free from twist or warp in its plane. In case of double leaf shutters, the meeting of the stiles shall be rebated by one third the thickness of shutter. The rebating shall be splayed. The surface of the teakwood stiles and rails shall be coated with 2 layers of approved quality polyurethane transparent coat with strainer to achieve the desired shade.

The shutter shall be fixed to the door frame by means of hinges @ minimum 3 hinges per leaf, maximum spacing of hinges being 600 mm. with suitable sized screws.

The shutter when fitted to the frame shall satisfy all operational aspects of door like smooth movement, proper closing against the door frame etc.

The joints between stiles / rails and the panel shall be properly finished. Extra neoprene adhesive shall be removed and no gap between panel and stiles/rails shall be permitted. Any stain of paint on the panel surface shall be properly removed.

4.13.3.3 Glazed Wooden Door Shutter**K) Materials****i) Wood**

Teakwood for various members like stiles, rails, etc. shall be as specified-in Clause 4.13.2.1 of this section.

ii) Glazing

Glass sheets for glazing shall be

- a) 4 mm thick plain glass (wt. 7.2 kg/m²) conforming IS:2835, or
- b) 5.5 mm thick wired glass conforming to IS:5437 or
- c) 6.3 mm thick laminated glass conforming to IS:2553 as the case may be as per item description or
- d) 5.5 mm thick toughened glass.

Glass sheets shall be free from flaws, scratches, cracks, bubbles etc.

iii) Hinges

Hinges shall be as specified in Clause 4.13.3.1 (iv)

L) Workmanship

Teakwood stiles and rails of size as specified in item description shall be cut accurately and planed smoothly to required dimensions. The stiles and rails shall be provided with rebates for fixing the glazing and shall be joined together to form the profile of the shutter. The joinery work shall be as approved by Employer. Only after such approval, the joints shall be coated with white lead, pressed and secured by hardwood pins of about 6 mm dia. All the four edges of the shutter shall be square. In case of double leaf doors, rebates shall be provided at the meeting of stiles. Rebates shall be splayed type and one third the thickness of the stiles.

The glass sheets for glazing shall be fixed by teak wood beading having mitred joints and shall be fixed by means of approved neoprene based

adhesive and nailing, the spacing between the nails being no more than 300 mm.

All wooden surfaces shall be coated with 2 coats of approved make polyurethane with strainer mixed to achieve desired shade.

The shutter shall be fixed to the door frame, by means of hinge @ minimum 3 hinges per leaf, maximum spacing of hinges being 600 mm with suitable sized screws.

The shutter when fitted to the frame shall satisfy all operational aspects of the door like smooth movement, proper closing against the door frame etc.

4.13.3.4 Flymesh Shutter for Door and Window

Specifications for Flymesh shutter shall be similar to specification for wooden glazed door, excepting following features:

- i) In place of glass, net of galvanised MS wire-mesh of IS gauge designation 856 wire and dia 0.56 mm shall be fixed to the shutter frame with teakwood beading.
- ii) Flymesh shutter shall be for both doors as well as windows.
- iii) All wooden surfaces shall be painted with synthetic enamel paint of approved shade in two coats over a priming coat in place of French polishing.

4.13.3.5 Fire Resisting Door

A) Frame

Door frame with heat activated intumescent fire seal strips of size 12 mm x 4 mm (for smoke sealing) mounted in the groove in frame suitable for mounting 60/30 minutes fire rated shutters with one coat of anti-termite fire retardant primer.

B) Shutters / Panels

The shutters of the door shall be of approved make conforming to IS:3614 (Part I) shall be so designed so as to provide the specified fire resistance when tested as per IS:3614 (Part 2) and BS:2750 to suit the specified requirement and the manufacturer must produce certificates of the recognised laboratory to the satisfaction of the Employer.

Asbestos free composite fire/smoke check shutters of 60 min, fire resistance rating, conforming to BS:476 part 22/IS:3614 Part 2) and shall comprise two non-combustible boards each 12 mm thick sandwiching 20 mm thick fire-resistant insulation faced with 3 mm commercial ply veneering on both faces and seasoned teak wood lipping around the shutters with heat activated intumescent fire seal strips of size 12 mm x 4 mm mounted in the grooves in the shutters/panels on all sides except bottom.

C) Seal

A heat activated intumescent seal of approved quality and make conform to BS:476 (Part 8) shall be provided on all edges of doors to check the spread of smoke in case of fire.

D) Paint

The door frame and panel/shutter shall be treated with ready mixed silicate type fire retardant anti-terminal primer & paint of approved shade and manufacturer as per IS: 162 (BS:476-Part I)

4.13.3.6 Hold Fast

Hold fasts for use with wooden doors shall be made from mild steel flats not less than 5 mm thick in accordance to IS: 7196 and shall be galvanised.

The shutter shall be supported by hinges as specified in Clause 4.13.3.1 (iv).

Hold fasts shall be fixed with the timber frame by steel screws only. The framed in masonry wall shall be fixed in cement concrete blocks as directed by Employer.

Iron Mongery

The Contractor shall submit a complete schedule of iron mongery for approval by the Employer. The schedule of iron mongery shall indicate the manufacturer's catalogue number, function, material, finish and other information required.

The Contractor shall supply and fix all iron mongery including cutting all necessary mortices rebates and the like.

a. Cargo Doors

All hardware by manufacturer. No lockset, padlocks shall be of the pin tubular type with solid or laminated brass case and steel hardened shackles.

b. Personnel Doors:

Hardware assembly No. 1 : Exterior doors double leaf

3 pairs butts : 12 cm x 12 cm

2 each flush bolt :

1 each lockset

1 each stop

Hardware assembly No. 2 : Exterior doors single leaf 1

½ pair butts : 12 cm x 12 cm

1 each lockset

1 each stop

Hardware assembly No. 3 : Interior doors (except toilets)

1½ pair butts : 12 cm x 12 cm

1 each lockset

1 each stop

Hardware assembly No. 4 : Toilet doors (0.70 x 2.00)

1 pair butt : 12 cm x 12 cm

1 each lockset

1 each stop

c. Windows / Ventilators

Hardware assembly No. 5 : Leaf opening windows

Non-ferrous metal holders and 1 latch set

1 pair hinge

Hardware assembly No. 6 : Sliding Windows

Roller

1 latch set

1 lockset

Operated door locks shall be cored and three keys for each lock and six master keys shall be furnished. Each key shall have a blank bow, one side for stamping purposes. Locks shall be keyed individually and in groups and

master keyed in one series as directed by the Employer. The master keys shall be delivered directly to the Employer.

4.14 ROOFING TREATMENT

4.14.1 General

This section of the specifications includes the requirements to provide, in place, all roofing treatments specified herein, or as required to provide a complete installation.

4.14.2 Material

The material shall consist of 2 pack clear / pigmented aliphatic polyurethane using polyether polyols, with isocyanurate for rendering flame resistant characteristic. The 2 pack system, consisting of pigment and the solvent (Xylene/Toluene, no filler) shall be mixed in definite ratio by weight strictly as per approved manufacturer's specification, for preparing the coating for application. The coating shall have physical features like high resistance to impact, abrasion and cracking, superior tensile strength (80 kg/cm² after 4 weeks at ambient temp.), and perfectly smooth, dust free, glossy finish retained at least upto 3 years. It should also be resistant to acid, alkalies and have a very low water absorption rate (0.5% max. at ambient temp. after 7 days). The packs shall not be older than 9 months after the date of manufacture and packing.

4.14.3 Workmanship

4.14.3.1 Preparation of Surface

The roof surface shall be thoroughly cleaned with a wire brush and all foreign matter etc. shall be removed. Well defined cracks on the surface shall be cut to 'V' section, cleaned and filled up flush with a paste of 2

component polyurethane-based crack filling compound and white cement in a ratio of 1:2.

4.14.3.2 Primer Coat

It shall consist of 2 pack polyurethane. Primer coat shall be mixed in the ratio as per manufacturer's specification. A single coat of this primer shall be applied by brush over the prepared bed as an adhesion coat.

The primer shall be allowed to dry for a min. of 8 hrs. time before the successive finishing coats are applied Finishing coats.

4.14.3.3 Finishing Coats

The finishing coats shall consist of three successive pigmented sealing coats each of 2 pack polyurethane mixed in the ratio as per manufacturer's spec. Application shall be with brush, to a smooth and even finish. The overall dry film thickness shall be 450 microns or min. covering capacity shall be 200gms/m² per coat.

Each coat shall be allowed to dry for min. 12 hours before applying next coat. Care shall be taken for quick application after mixing the 2 pack primer in view of short pot life of the mix and shall be fully consumed within the stipulated period as per manufacturer's spec (Max. 60 minutes at 30°C)

The finishing coating shall be continued up the parapets/walls for a min. of 150mm over the finished roof surface. It shall be continued into rain water pipes by at least 100mm.

4.14.3.4 Cement Screed

The final finishing coat when tacky shall be sprinkled with 300 micron layer of clean sand. Plain cement concrete (1:2:4) of 25mm min. thickness with

24 SWG chicken wire mesh shall be laid to slope in panels not exceeding 6 M² area per panel over this. The joints between panels shall be raked out neatly (after stipulated curing period) to a min. 6mm x 6mm v-groove and filled up with an approved quality elastomeric compound sealant. Drain outlet shall be provided for all spouts/rain water pipes by suitable rounding, filling and sloping of PCC. At the junction of the roof and parapet or any other vertical surface, a fillet of 75mm radius shall be formed in cement mortar (1 cement: 4 coarse sand).

4.14.4 Guarantee

The applicator shall execute a form of Roofing Treatment Guarantee.

4.15 PLASTERING AND POINTING

4.15.1 General

This section shall cover all plastering (internal/external) and painting works as specified herein. Before commencing the work sample of works shall be made in accordance with the specification and got approved by the Employer.

4.15.2 Materials

4.15.2.1 Cement

Cement shall conform to specifications under 'Material' unless otherwise specified.

4.15.2.2 Sand

Sand for plastering and pointing shall conform to IS 1542. Sand shall be hard, durable, dean and free from adherent coatings and organic matter and shall not contain any appreciable amount of silt, day balls or pellets.

Sand shall not contain harmful impurities such as iron pyrites, coal particles, lignite, mica shale etc.

Sand whose grading falls outside the limits of IS 460 due to excess or deficiency of coarse or fine particles shall be processed to comply with the standards.

Fine sand shall be obtained from river beds not affected by tidal water of the sea and shall be clean, sharp and free from excessive deleterious matter. The sand shall not contain more than 8 per cent of mud and silt as determined by field test with a measuring cylinder.

4.15.2.3 Water

Water for plastering and pointing shall conform to specifications under 'Material'.

4.15.2.4 Cement Mortar

Preparation of cement mortar shall conform to specifications under 'Brick Masonry' unless otherwise mentioned.

4.15.3 Cement Mortar with Waterproofing Compound

Waterproof compound shall conform to IS 2645 of approved make. The compound shall be well mixed with dry cement in the proportion of 3% by weight or as recommended by manufacturer. Further procedures for preparation of cement mortar shall be as per Clause 4.15.2.4 above.

4.15.4 Workmanship

4.15.4.1 Preparation of Background Surface

The surface shall be cleaned off all dust, loose mortar droppings, traces of algae, efflorescence and other foreign matter by water or by brushing.

Smooth surfaces shall be roughened by wire brushing or hacking for non-hard and hard surfaces respectively.

Projections on surfaces shall be trimmed wherever necessary to get even surfaces. In case of brick/stone masonry, raking of joints shall be carried out wherever necessary. The masonry shall be allowed to dry out for sufficient period before carrying out the plasterwork. The masonry shall not be soaked but only damped evenly thereafter before applying the plaster.

In case of concrete work, projecting burrs of mortar formed due to the gaps of joints in shuttering shall be removed. Such surface shall be scrubbed clean with wire brushes. The surface shall be pock marked with a pointed tool at spacing of not more than 50 mm centers, the pocks being made not less than 3 mm deep to ensure a proper key for the plaster. The surface shall be washed off and cleaned of all oil, grease etc. and well wetted before the plaster is applied.

4.15.4.2 Sequence of Operation

For external plaster, the plastering operations shall be started from the top floor and carried downwards. For internal plaster, the plastering may be started wherever the building frame, roofing, and brickwork are ready.

The surfaces to be plastered, shall first be prepared as described in Preparation of background surface in Clause 4.15.4.1 above.

The first underlay shall then be applied to ceilings. After the ceiling plaster to complete and scaffolding for the same removed, plastering on wall shall be started.

After a suitable time interval as detailed under various types of plaster in subsequent paras, depending upon the type of mortar, the secondary layers if required shall be applied. After a further suitable time interval as detailed under various type of plaster in subsequent paras, the finishing coat shall be applied first to the ceiling and then to the walls.

Plastering of cornices, decorative features, etc., shall be completed before the finishing coat is applied. Unless otherwise specified Corners and edges shall be rounded off to a radius of 25mm, such rounding off shall be completed along with the finishing coat to prevent any joint marks showing out later.

4.15.4.3 Scaffolding/Staging

Scaffolding/staging for plastering/pointing shall be as per specification under Brick Masonry, Clause no. 4.9.6 of Specification.

4.15.4.4 Damage Rectification

Any cracks, damages, any part of work which sound hollow when tapped or found damaged or defective otherwise shall be cut out in rectangular shape and redone as directed by Employer.

4.15.5 Plain Cement Plaster

4.15.5.1 Preparation of Mortars

The mortars of specified mix shall be used as per the specifications of "Cement Mortar" described in Clause 4.15.2.4 above.

4.15.5.2 Application of Plaster

A) One Layer Plaster Work

To ensure even, specified thickness, plaster of 150 mm x 150 mm shall be first applied horizontally and vertically at not more than 2 meter interval over the entire surface to serve as gauges. The surface of these gauged areas shall be truly in the plane of the finished plaster surface. The mortar shall be brought to true surface by working with a wooden straight edge reaching across the gauges with small upward and sideways movements at a time. Finally the surface shall be finished off true with a trowel or wooden float to obtain a smooth texture. Excessive trowelling or overworking the float shall be avoided. All corners, arises, angles and junctions shall be truly vertical/horizontal and shall be carefully finished. Rounding or chamfering of corners, arises, junctions etc., shall be carried out with proper templates to the size required.

In suspending the work, the plaster shall be left, cut clean to line, both horizontally and vertically. When recommencing the plastering, the edge of the old work shall be scrapped clean and wetted before plastering the adjoining area. Plastering work shall be closed on the border of the wall and nearer than 150 mm to any corners or arises and shall not be closed on the body of the features such as plaster bands, cornices nor at the comers or arises.

B) Two Layer Plaster Work

First or under layer

The first or underlay of the specified thickness shall be applied as described above in Clause 4.15.5.2. Before the first coat hardens, surface of it shall be beaten up by edges of wooden tapers and close dents shall be made on the surface. The subsequent coat shall be applied after this coat has been

allowed to set for 3 to 5 days depending upon weather conditions. The surface shall not be allowed to dry during this period.

Second or finishing layer

The second layer shall be complete to the specified thickness in the same manner as for first layer.

4.15.5.3 Curing

Curing shall be started 24 hours after finishing the plaster. The plaster shall be kept wet for a period of 7 days. During this period the plaster shall be suitably protected from all damages by such means as approved by the Employer. The date of execution of plastering shall be marked on the plastering to ensure the proper duration of curing

4.15.6 Sand Face Plaster

4.15.6.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 4.15.2.4.

A) Application of Plaster

Sand face plaster shall consist of 13 mm thick (1 cement: 4 coarse sand by vol) underlayer and 7 mm thick (1 cement: 2 coarse sand by volume) top layer. Application of plaster shall be as described in 'two coat plaster work' in Clause 4.15.5.2 above.

The surface of the sand face plaster shall be finished rough with sponge or as directed by the Employer.

B) Curing

Curing shall be as described above in Clause 4.15.5.3.

4.15.7 Exposed Aggregate Finish Plaster

4.15.7.1 Preparation of Mortar

The mortar of specified mix shall be used as per the specifications of cement mortar described above in Clause 4.15.2.4. White and coloured marble chips shall be of 6 mm to 12mm size out of Makrana/Ambaji, grade 1 or Dongri Chittor Brown/Rajnagar/Abu green grade-1 quality. Marble dust shall be obtained from crushing hard marble stone. It shall not be less than 1.0.

4.15.7.2 Application of Plaster

Exposed aggregate finish plaster shall consist of 12mm thick plain cement plaster underlayer (1cement: 4 coarse sand by volume) finished rough and 20 mm thick top layer. Underlayer shall be applied in accordance with "One layer plaster work" described above in Clause 4.15.5.2.

Top layer shall be 20 mm thick admixture of white cement and grey cement (mix. ratio 1:1 by volume) mixed with white/coloured marble chips/pebbles of 6mm to 12mm nominal size as per item description. Mix ratio shall be 1cement: 1 marble chips/pebbles by volume Marble dust @ 15% by volume shall be added to the admixture. The pebbles to be used shall be well washed and drained. The admixture shall be thrown wet on to the under layer while it is still plastic using strong whipping motion at right angles to the face of the wall. One coat of neat cement slurry @ 2.75 kg cement per square metre of area shall be applied on to the underlayer to receive the top layer The whole plastering laid in panels with 12mm x 20mm grooves in between formed by holding removable wooden battens of 12mm x 25mm size over the under layer.

The top layer admixture pressed flat over the underlayer filling uncovered parts by hand, so that the finished surface represents a homogeneous surface. Loose mortar etc. on the top surface shall be cleaned/removed by brushing/washing /spraying with water jet after initial setting of mortar.

4.15.7.3 Curing

Curing shall be as described above in Clause No. 4.15.5.3.

4.15.8 Pointing

Pointing shall be of the type specified such as flush, cut or weather struck, raised and cut etc.

4.15.8.1 Preparation of Base Surface

The joints shall be raked to such a depth that the minimum depth of the new mortar measured from either the sunken surface of the finished pointing or from the edge of the brick shall be less than 20 mm.

A) Mortar

Mortar shall be in accordance with the specifications of cement mortar described above in Clause 4.15.2.4.

B) Application of Mortar and Finishing

The mortar shall be pressed into the raked-out joints with a pointing trowel according to the type of pointing specified. The mortar shall be spread over the corner edges or surfaces of the masonry. The pointing shall then be finished with the pointed tool.

The superfluous mortar shall be cut off from the edges.

C) Flush Pointing

The mortar shall be pressed into joints and shall be finished off flush and leveled. The edges shall be neatly trimmed with trowel and straight edges.

D) Cut or Weather Struck Pointing

The mortar shall first be pressed into joints. The top of the horizontal joints shall then be neatly pressed back by about 15 mm with the pointing tool so that the joint is sloping from top to bottom. The vertical joint shall also be similarly pointed. The junctions of vertical joints with the horizontal joints shall be at true right angles in case of brick & coursed rubble masonry.

E) Raised and Cut Pointing

This type of pointing shall project from the wall facing with its edges cut parallel so as to have a uniformly raised band about 6 mm and width 10 mm more as directed. The pointing shall be finished to a smooth but hard surface.

F) Curing

Curing shall be as described above in Clause 4.15.5.3

4.16 FLOOR FINISHING

4.16.1 General

This section shall cover all flooring and wall tiling work and specified herein. No work under this section shall be started until specifically allowed by the Employer and until all other major works such as plastering, embedding of conduits and pipes channels, window fixing etc. have been completed. Samples of basic materials and work of adequate size representing the nature of variation including quality, size, texture after finishing to be used in the flooring work shall be prepared for all work and got approved by the Employer sufficiently prior to ordering. The approved

samples shall be retained upto the end of the project. The works shall be got done by skilled and specialised workmen experienced in the respective trade of work.

Reference shall be made to the following Indian Standards:

IS: 4971 Recommendations for selection of Industrial floor finishes

IS: 2114 Code of practice for laying insitu terrazzo floor finish.

IS: 1237 Specification for Cement concrete flooring tiles

IS: 777 Specification for glazed earthenware wall tiles

IS: 2571 Code of practice for laying in situ cement concrete flooring

IS: 4631 Code of practice for laying of epoxy resin floor toppings.

IS: 3462 Code of practice for unbaked flexible PVC flooring

IS: 5318 Code of practice for laying of flexible PVC sheet and tile flooring

IS: 3461 Spec for PVC asbestos floor tiles

IS: 1443 Code of practice for laying in situ granolithic concrete floor topping

IS: 5491 Code of practice for laying in situ granolithic concrete floor topping

IS: 4441 Code of practice for use of silicate type Chemical resistant mortars

IS: 4443 Code of practice for use of resin type chemical resistant mortar

IS: 1196 Code of practice for laying Bitumen Mastic flooring

4.16.2 Cement Concrete Flooring General

4.16.2.1 General

Cement concrete flooring shall in general conform to IS 2571. Cement concrete flooring shall consist of a sub base (laid on the compacted earth or sand fill In case of ground floor only) a base course laid on the sub-base and then finishing layer of floor finishing. Where the cement concrete flooring is to be laid directly on the RCC slab, the surface of RCC slab shall be cleaned and the laitance shall be removed and a coat of cement slurry at 2 kg. of cement per sq.m. shall be applied, so as to get good bond between RCC slab and concrete floor. In case of ground floor, the filled and compacted bed on which the sub-base is to be laid, shall be as per specifications.

The bed for flooring shall be prepared either level or sloped as instructed by Employer.

4.16.2.2 Workmanship

a. Sub-base

The sub-base which shall be laid on the prepared bed shall be of specified thickness as per specifications.

The sub-base shall be of cement concrete. In case of upper floors, the structural RCC slab shall be treated as sub-base.

b. Base Course

Base course shall be of cement concrete of specified mix and of specified thickness/item descriptions and shall generally conform to specification (Plain and Reinforced Cement Concrete).

The floor space on which base course is to be laid shall be divided into square/ rectangular or as per designed panels to prevent cracks in the floor finish. No dimension of the panels shall exceed 2m and length of the panel shall not exceed 1.5 times its breadth. Base course shall be laid on alternate panels. The borders of the panels shall have mitred joints at the corners of the room and intermediate joints shall be in straight line with panel joints.

The panels shall be bound by MS strips/PVC strips etc. These shall be fixed in position with their top at proper level, giving slope wherever required.

The flooring shall butt against masonry of wall which shall not be plastered.

When the base course is to be laid on hardened base, the sub-base shall be roughened by steel wire brushing and cleaned. Before laying the base course, neat cement slurry shall be brushed into the prepared surface.

Cement concrete shall be placed in position and beaten with trowel and finished smooth. Beating shall cease as soon as surface is found covered with cream of mortar. Necessary slope shall be provided.

c. Floor Finishing

Finishing of the surface shall follow immediately after the completion of base course. The base course shall be free of excessive moisture before starting the floor finishing. Use of dry cement, cement sand mixture sprinkled on the surface to stiffen the concrete or absorb excessive moisture shall not be permitted.

While the concrete is still green, cement @ 2.75 kg per square meter of floor area shall be mixed with water to form a thick slurry and spread over

the surface. It shall be pressed twice by means of iron floats, once when the slurry is applied and second time when the cement starts setting.

The junction of floor with wall plaster, cladding, skirting shall be rounded off uniformly upto a radius of 25mm unless otherwise mentioned.

d. Curing

Each finished portion of floor, on completion shall be kept wet with ponding for a minimum period of 7 days.

4.16.3 Precast Hydraulically Pressed Terrazzo Tile Flooring

4.16.3.1 Materials

a. Terrazzo Tiles

Terrazzo tiles shall be of specified thickness and shade and shall generally conform in all respects to IS-1237.

b. Pigment

Pigments to be admixed with mortar or for grouting shall conform to table 1 of IS:2114.

c. Cement Mortar

Refer Clause 4.16.2.4 above.

d. Workmanship

Workmanship shall in general conform to IS -2114. Terrazzo flooring shall be of specified thickness and shall be laid in two layers and in panels. Under layer or base course shall be of cement concrete laid over sub-base and top layer shall be of terrazzo floor finish.

Top layer shall consist of mix of white cement, marble powder, marble chips, water and pigments. Cement and marble powder mix proportion shall

be 3:1 by weight. Cement, marble powder mix shall be mixed with marble chips in the proportion of 4:7 by volume. Quality and shade of chips and powder shall be as specified with a view to avoid variation in colour. Sufficient quantity of white cement shall be added in the cement mix to obtain the desired shade. Mixing shall be done in a trough or tub and complete quantities of white cement and pigment for a particular unit of job shall be dry mixed with aggregates. Water shall be added in small quantities to this dry mix to get a proper consistency. The mix shall be plastic but not so wet to flow. The mix shall be used within 30 minutes of its preparation.

The base course/under layer shall be divided in panels with dividing strips (G.I./Aluminium Alloy /PVC) upto the finished surface levels. The sub-base shall be cleaned of all dust, dirt or any loose material. It shall then be wetted with water, mopped and smeared with neat cement slurry . Terrazzo topping shall be laid while the underlayer is still plastic but has hardened enough which is normally achieved between 18-24 hours after laying the underlayer. A cement slurry pigmented with the same colour as the topping be brushed on the surface immediately before laying the topping. The terrazzo mix shall be laid to a uniform thickness and be compacted thoroughly by tamping or rolling and trowelled and brought true to required level by a straight edge and steel floats so that the maximum amount of marble chips come up and spreaded uniformly over the surface and no part of the surface is left without the chips.

e. Curing

The surface shall be left dry for air curing for a period of 12-18 hours. Thereafter water shall be allowed to stand overnight in pools for a period of minimum four days.

f. Grinding and Polishing

Grinding and polishing shall be done with machines and shall start after 7 days of laying. First grinding shall be done with carborundum stone of 60 grit size. The surface shall then be washed clean and grouted with a grout of cement and/or colouring matter in same mix and proportion as the topping in order to fill any pin notes that appear. It shall then be allowed to dry for 24 hours and wet cured in the same manner as mentioned above in Clause 4.16.3.1. The second grinding shall be done with carborundum stone of 80 grit size. The surface shall then be prepared as after first grinding.

The third grinding shall be done with carborundum stone of 120 to 150 grit size. The surface shall then be prepared again as after first grinding.

The fourth grinding shall be done with carborundum stone of 320 to 400 grit size. The surface shall then be washed clean and rubbed hard with felt and slightly moistened oxalic acid powder @ 33 gms per square metre of floor surface. After the finishing works are over, the surface shall be washed with dilute oxalic acid solution and dried. Floor polishing machine fitted with felt on hessian bobs shall then be run over it until the floor shines.

In case of polishing, wax polish shall be applied on the surface with the help of soft linen over a clean and dry surface. Then the polishing machine fitted

with bobs shall be run over it. Clean saw dust shall be spread over the floor surface and polishing machine again operated to remove excess wax.

4.16.4 Terrazzo Tiles in Risers of Steps, Skirting and Dado

4.16.4.1 Material

a. Terrazzo Tiles

Same as in Clause 4.16.3.1 above. The average thickness of tiles shall however be 20mm.

b. Pigments

Same as in Clause 4.16.3.1 above.

c. Cement Mortar

Same as in Clause 4.16.2.4 above.

4.16.4.2 Workmanship

In case of brick masonry wall, the joints shall be raked out to a depth of at least 15mm while the masonry is being laid. In case of concrete work, the surface shall be hauled and roughened with wire brushes.

The wall surface shall be uniformly and evenly covered with 12mm thick backing of cement mortar 1:3 (1 cement: 3 coarse sand by volume). Before hardening of the cushioning mortar, back of each tile shall be covered with a neat layer of cement slurry @ 4.4.kg of cement per Sq.M. and edges with white cement with or without pigment to match the shade of tiles and the tiles then shall be pressed on the backing and tapped.

The tiles shall be corrected to proper planes with joints truly vertical in required pattern and butt jointed. The fixing shall be done from bottom upward. The top of skirting and dado shall be truly horizontal.

- a. Curing, Grinding and Polishing

Same as in Clause 4.16.3.1 above.

4.16.5 Glazed Tiles Work

4.16.5.1 Material

- a. Tiles

Glazed tiles shall conform to IS: 777 and shall be of specified shade, size and of approved manufacturer.

- b. Pigments

Same as in Clause 4.16.3.1 above.

- c. Cement Mortar

Same as in Clause 4.16.2.4 above.

- d. Workmanship

The tiles shall be laid over a coating of specified adhesive (as per approved manufacturer's specification) laid on base floor/ wall plaster. The joints of the tiles shall be flush pointed with cement paste (white cement and pigment conforming to IS-2114, Table-1) matching the shade of colours.

- e. Curing

Same as in Clause 4.16.3.1 above.

4.16.6 Glazed Tiles in Risers of Steps, Skirting and Dado

- a. Materials

Same as in Clause 4.16.3.1 above.

- b. Workmanship

Same as in Clause 4.16.3.1 above.

- c. Curing

Same as in Clause 4.16.3.1 above.

4.16.7 Kota Stone Flooring

4.16.7.1 Materials

The slabs shall be of selected quality and shade, hard, sound, dense, homogenous in texture, free from cracks, decay, weathering and flakes. These shall be machine cut to the requisite size and thickness and chisel dressed.

The slabs shall have the top (exposed) face polished before being brought to site. Before starting the work, the Contractor shall get the samples of slabs approved by the Employer.

4.16.7.2 Workmanship

Each slab shall be machine cut to the required size and shape and fine chisel dressed at all edges to full depth and machine rubbed to a smooth surface finish. All angles and edges of the slabs shall be true square and free from chippings carving a plane and smooth surface.

a. Preparation of Surface

Cement mortar 1:6 (1 cement: 6 coarse sands by volume) of specified thickness shall be laid over the base after making it rough and cleaning thoroughly.

The mortar shall be laid for facing one slab at a time.

b. Laying

The slab shall be washed clean before laying. It shall be laid over cement mortar bedding on top, pressed, lapped gently to bring it in level. It shall be then lifted and laid aside. Top surface of the mortar then shall be corrected

by adding fresh mortar at hollows and depressions. The mortar then shall be allowed to harden and cement slurry of honey like consistency @ 4.4 kg of cement per Sqm shall be spread over the mortar. The edges of the slabs shall be buttered with white cement with or without pigment grout to match the shade of the slabs. The slabs shall then be gently placed in position and tapped with wooden mallets till it is properly bedded in level. The joints shall be as fine as possible. Surplus cement on the surface of the slab shall be removed. The slabs in flooring shall continue for not less than 10 mm under the plaster/ skirting. The finished surface shall be true to levels and slopes as instructed by the Employer.

The slabs shall be laid in patterns and size shall not be less than 310mm X310mm. Cut uniform size may be used along periphery as required.

c. Curing

The floor shall be cured for a minimum period of 7 days by wetting.

d. Polishing and Finishing

Unevenness at the meeting edges of slabs shall be removed by fine chiselling. Polishing etc. shall be done in accordance with Clause 4.16.3.1 mentioned above except that cement slurry shall not be applied on the surface before each polishing.

4.16.8 Kota Stone in Risers of Steps, Skirting and Dado

a. Materials

Same as in Clause 4.16.3.1 above.

b. Workmanship

Same as in Clause 4.16.3.1 above.

c. Curing, Polishing and Finishing

Refer Clause 4.16.3.1 above.

4.16.9 Granite Stone Flooring

4.16.9.1 Materials

a. Granite Slabs

The slabs shall be of the kind of granite specified in the item. The marble from which the slabs are made shall be of selected quality, hard, sound, dense, homogenous in texture, free from cracks, decay, weathering and flakes. The sample of granite stone slabs shall be got approved from the Employer.

The slabs shall be machine cut to the requisite dimensions.

b. Pigments

Same as in Clause 4.16.3.1 above.

c. Cement Mortar

Same as in Clause 4.16.2.4 above.\

d. Workmanship

Same as in Clause 4.16.3.1 above.

e. Curing

Same as in Clause 4.16.3.1 above.

4.16.9.2 Polishing and Finishing

Same as in Clause 4.16.3.1 above.

i. Granite Stone in Risers of Steps and Skirting

a. Materials

Same as in Clause 4.16.3.1 above.

b. Workmanship

Same as in Clause 4.16.3.1 above.

c. Curing, Polishing and Finishing

Same as in Clause 4.16.3.1 above.

ii. Acid Resistant Tiles in Floors

a. Material

The tiles shall be vitrified ceramic tiles and shall be homogeneous. They shall have the following properties:

S. No.	Characteristics	Value Required	Norms
1	Water Absorptions	+ 0.5%	ASTM C 373
2	Scratch Resistance	> 6	ASTM C 373
3	Chemical Resistance	Unaffected	ASTM C 650
4	Abrasion Resistance (Hardness)	> 100	ASTM C 501
5	Breaking Strength	1400 kg/sq.cm	ASTM C 648
6	Density	> 2.0 Gm/CC	

b. Workmanship

The base course shall be in accordance with Clause 4.16.3.1 and background surface shall be prepared as per Clause 4.16.3.1 and IS: 4443.

Tiles shall be fixed on the prepared surface over a bitumen priming layer, bitumen mastic layer and resin type chemical resistant mortar. The bitumen shall conform to IS-702 and laying of bitumen mastic shall conform to IS-1196.

Joints shall be allowed to set for 24 hours. The floor shall then be washed as per manufacturer's specifications to totally remove all marks from tile surface.

4.16.10 Epoxy Floor Coating

4.16.10.1 General

Epoxy floor coating shall consist of a solvent based, two pack system with epoxy resins and amine curing agents, chosen to withstand high degrees of chemical and abrasive action.

4.16.10.2 Materials

a. `

The screed shall be a solvent free combination of epoxy resin, modified amine hardeners filled with specially graded and selected chemically inert aggregates of high strength. The system shall include an epoxy resin primer and screed which are both supplied in pre- weighed units ready for on-site mixing and application.

b. Finishing Coat

An epoxy resin sealing coat of specified thickness shall form the topping coat.

a. Workmanship

b. Preparation of Surface

The surface shall be sound, clean and dry In order to achieve maximum adhesion with the primer coating.

a. Laying

The primer shall be applied by brush and shall be allowed to become tacky. The screed shall be prepared as per manufacturers' specification and laid in specified thickness evenly over the base floor by trowel. The finished, cured screed shall have a slightly granular texture of uniform brown.

The epoxy resin topping shall be applied at least 24 hours after the laying of the screed. This topping shall be applied by brush or sprayed to a specified thickness in two coats with 3-5 hours interval between them. Care shall be taken to finish the topping perfectly smooth and devoid of any bubbles and unevenness. The newly laid floor shall be protected from dust or moisture and allowed to be used only after a minimum lapse of 48 hours.

4.17 MONITORING INSTRUMENTS

To ensure the safety of existing Navigational lock and new Navigational lock, monitoring instruments shall be installed for monitoring the safety and stability of the existing and new Navigational lock during the renovation/modernization and operation phase. The proposed monitoring instrument to be installed are following:

- Piezometers – 15 Nos
- Settlement gauges – 09 Nos
- Inclinometers – 09 Nos

These instruments will provide real time monitoring of the structural safety of the existing lock as well as the new lock. During renovation and modernization, if any settlement / inclination of the lock wall is observed, remedial measures to check the structural safety will be taken. During operation of the Navigational lock s, feed of the instruments will be available

in the control room. The location of monitoring instruments is given in Drawing No. ENL 014.

4.18 PAINTING

4.18.1 General

This section of specifications includes all requirements necessary for the white washing, colour washing, distempering, painting, and polishing of all surfaces specified herein or as may be necessary for the completion of the areas intended.

When shop priming, specified under other sections of these specifications is provided, this may serve as the first of the number of coats herein specified.

All materials required for the execution of painting work shall be obtained direct from approved manufacturers and shall be brought to the site in makers drums, kegs etc. with seals unbroken.

If in case of ready mixed paints, thinning, if necessary, the brand of thinner shall be as per recommendations of the manufacturer.

Paint shall be applied by brushing or spraying. The brushing operations are to be adjusted to the spreading capacity advised by the manufacturer. During painting, every time after the paint has been worked out of the brush bristles, the bristles shall be opened up by striking the brush suitably.

Spray machine used may be of high-pressure type or low pressure depending on the nature and location of work. After work, the brushes shall be completely cleaned off paint and shall be hung in a thinner if intended to be used afterwards. The spray guns shall be cleaned thoroughly after

every break in work. The paint containers, when not used shall be kept close and free from air.

After the finishing of work, the adjacent surfaces not intended to be washed/ distempered/painted/polished, shall be thoroughly cleaned of all paint patches and shall be finished in accordance with surface finishing of such surfaces.

Indian Standards

IS 712	Specification for building limes.
IS 55	Specification for Ultramarine blue for paints.
IS 63	Specification for whiting for paint and putty.
IS 427	Distemper (dry), colour as required.
IS 428	Distemper (Oil Bound), colour as required.
IS 5410	Cement paint, colour as required.
IS 384	Brushes, paints and varnishes, flat
IS 486	Brushes, sash, tool, for paints and varnishes.
IS 110	Ready mixed paint, brushing, grey filler enamels for use over primers.
IS 426	Paste filter for colour coats.
IS 345	Wood filler, transparent liquid.
IS 3585	Ready mixed paint, aluminium brushing priming water resistant for wood work

4.18.2 White Washing

White washing in general shall confirm to IS 6278.

4.18.2.1 Workmanship

a. Scaffolding

Wherever scaffolding is necessary, it shall be erected in such a way that as far as possible no part of scaffolding shall rest against the surface to be white/colour washed. For white washing of ceiling, proper stage scaffolding shall be erected.

b. Preparation of Surfaces

The surface shall be thoroughly cleaned of all dirt, dust, mortar dropping and other foreign matter before white wash is to be applied.

Surfaces already white/colour washed shall be broomed down to remove all dust, dirt, loose scales of white wash or other foreign matters.

All damaged portions of the surface plaster shall be removed to full depth of plaster in rectangular patches and plastered again after raking the joints in masonry properly. Such portions shall be wetted and allowed to dry before any operation.

All holes, cracks, patches etc. not exceeding 0.1 sq. m. in area shall be made good with material similar to that of the surface. Surfaces affected by efflorescence, moss, fungi, algae, lichen etc. shall be treated in accordance with IS 2395.

c. Preparation of White Wash

The fat lime confirming to IS 712 shall be slaked at site and shall be mixed and stirred with about 5 litres of water for 1 kg. of unslaked lime to make thin cream. This shall be allowed to stand for a period of 24 hours and then

shall be screened through a clean coarse cloth. 4 kg of gum dissolved in hot water shall be added to each cubic metre of lime cream. Approved quality ultra marine blue conforming to IS 55 @ 3 grams per kg of lime shall also be added to the solution. The whole solution shall be stirred thoroughly before use.

d. Application

White wash shall be applied with 'Moonj' brush to the specified number of coats. The operation for each coat shall consist of stroke of the brush from the top to down wards, another from the down to upwards over the first stroke. Similarly, one stroke horizontally from right and another stroke from the left. Each coat shall be allowed to dry before the next coat is applied.

The white washing on ceiling should be done prior to that on walls.

e. Protective Measures

Surfaces of doors, windows, floors etc. which are not to be white washed shall be protected from being splashed upon. Such surfaces shall be cleaned of white wash splashed if any.

4.18.3 Colour Washing

4.18.3.1 Workmanship

a. Scaffolding

Scaffolding shall be as per Clause 4.17.2.1 above.

b. Preparation of Surface

Refer Clause 4.76.2.1 above.

c. Preparation of Colour Wash

Sufficient quantity of colour wash enough for the complete job shall be prepared in one operation to avoid any difference in colour. The basic white wash solution shall be prepared in accordance with above Clause 4.17.2.1. Mineral colours of approved shade and quality not affected by lime shall be added to the white wash solution in proportions as directed by Employer. Solid lumps etc. in the colour powder shall be ground to fine powder, sieved and mixed evenly and thoroughly to the white wash solution.

d. Application of Colour Wash

Application of colour wash shall be in accordance with above Clause 4.17.2.1.

e. Protective Measure

Same as in Clause 4.17.2.1 above.

4.18.4 Dry Distempering

4.18.4.1 Workmanship

a. Scaffolding

Same as m Clause 4.17.2.1 above.

b. Preparation of Surface

The surface shall be thoroughly brushed free from dust, dirt, grease, mortar droppings, other foreign matter and shall be made smooth by sand papering.

In case of distempering over existing distempered surface, the existing distempering shall be scrapped by steel scrappers leaving a clean surface.

All nails shall be removed. Pitting in plaster shall be made good with plaster of paris mixed with dry distemper of colour to be used. The surface then

shall be rubbed down again with a fine grade sand paper and made smooth.

A coat of distemper shall be applied over the patches. The surface shall be allowed to dry thoroughly before the regular coat of distemper is allowed.

The surface affected by moss, fungus, algae efflorescence shall be treated in accordance with IS 2395.

c. Priming Coat

A priming coat of whiting conforming to IS 63 shall be applied over the prepared surface. The priming coat shall be prepared by mixing 2.5 kg of whiting and one litre of glue solution (prepared by mixing 250 gm. glue conforming to IS 852 with boiling water) together and placing it in a covered vessel with enough water to cover the mixture which shall be left to cool until it becomes a jelly.

The application of priming coat shall be in accordance with above Clause 4.17.2.1.

d. Preparation of Distemper

The dry distemper of approved shade and quality conforming to IS 427 shall be stirred slowly in clean warm water using 0.6 litres of water per kg of distemper. It shall be allowed to settle for at least 30 minutes before applying. The mixture shall be well stirred before and during use to maintain an even consistency.

e. Application of Distemper

After the priming coat has dried for at least 48 hours, the surface shall be lightly sand papered and dusted off avoiding rubbing off of the priming coat

Prepared distemper shall then be applied in minimum two coats with proper distemper brushes in horizontal strokes immediately followed by vertical ones which together shall constitute one coat. The subsequent coats shall be applied only after the previous coat has dried. The finished surface shall be even and uniform without patches, marks, distemper drops etc.

The application of a coat in each room shall be finished in one operation. After each day's work, brushes shall be thoroughly washed in hot water and hung down to dry.

f. Protective Measure

Same as in Clause 4.17.2.1 above.

i. Oil Bound Distempering

a. Workmanship

b. Scaffolding

Same as in Clause 4.17.2.1 above.

c. Preparation of Surface

Preparation of surface shall in general be in accordance with above Clause 4.17.4.1 except that any unevenness shall be made good by applying putty made of plaster of paris mixed with water including filling up the undulation and then sand papering the same after it is dry.

d. Primer Coat

The primer coat shall be alkali resistant primer or distemper primer and shall be of the same manufacture as oil bound distemper.

If the wall surface plaster has not dried completely, alkali resistant primer otherwise distemper primer shall be applied. The mixture of alkali resistant primer shall be prepared as per approved manufacturer's instructions.

The application of primer coat shall be in accordance with Clause 4.17.2.1 above.

e. Preparation of Oil Bound Distemper

The distemper shall conform to IS 428 and shall be diluted with water or any other prescribed thinner recommended by the manufacturer.

f. Application of Distemper

After the primer coat has dried for at least 48 hours, the surface shall be lightly sand papered and dusted off avoiding rubbing off of the primer coat. Minimum two coats of distemper shall be applied with brushes in horizontal strokes followed by immediate vertical strokes which together shall constitute one coat. The subsequent coats shall be applied after atleast 24 hours between consecutive coats to permit proper drying of the preceding coat.

The finished surface shall be even and uniform without patches, brush marks drop etc. Application of a coat in each room shall be finished in one operation. 14 cm. double bristled distemper brushes shall be used. After each days work/brushes shall be thoroughly washed in hot water with soap solution and hung down to dry.

g. Protective Measures

Same as in Clause 4.17.2.1 above.

4.18.5 Waterproof Cement Paint

4.18.5.1 Workmanship

a. Scaffolding

Same as in Clause 4.17.2.1 above.

b. Preparation of Surface

Preparation of surface shall be in accordance with Clause 4.17.2.1. The surface so prepared shall be thoroughly wetted with clean water before the paint is applied.

c. Preparation of Paint

Waterproof cement paint of approved make shall be mixed with- water and stirred to obtain a thick paste which shall then be diluted to brushable consistency. The proportion of mixture shall be as manufacturers recommendation. The paint shall be mixed in such quantity which can be used up within an hour of mixing to avoid setting and thickening of the paint.

d. Application of Paint

The surface shall be treated with minimum two coats of waterproof cement paint. No less than 24 hours shall be allowed between two coats and the subsequent coats shall be applied only after the preceding coat has become hard to resist marking by subsequent brushing.

The finished surface shall be even and uniform in shade without patches brush marks, paint drops etc. Cement paints shall be applied with a brush with relatively short stiff hog of fiber bristles.

e. Curing

Curing shall be started after the paint has hardened. Curing shall be done by sprinkling with water two or three times a day. This shall be done between coats and for at least two days following the final coat.

f. Protective Measure

Same as In Clause in 4.17.2.1 above.

4.18.6 Acrylic Emulsion Painting

4.18.6.1 Workmanship

g. Scaffolding

Same as in Clause 4.17.2.1 above.

h. Preparation of Surface

Same as in above Clause 4.17.4.1 under specification of oil bound distempering

i. Preparation of Mix

Plastic emulsion paint shall conform to IS 5411 (Part-1) and shall be of approved shade. Preparation of mix shall be as per manufacturer's instructions.

j. Application of Paint

The paint mix shall be continuously stirred while applying for maintaining uniform consistency. Number of coats shall be as per item description. The painting shall be laid evenly and smoothly by means of crossing and laying off. The crossing and laying off consists of covering the area with paint, brushing the surface hard at first, then brushing alternately in opposite direction 2/3 times and then finally brushing lightly in a direction at right angles to the same. In this process, no brush marks, no hair marks no

clogging of paint puddles shall be permitted. The full process of crossing and laying off will constitute one coat.

The paint shall be applied by means of brush or roller.

Before starting painting with plastic emulsion paint, the prepared surface shall be treated with two coats of primer consisting of cement, primer, whiting and plastic emulsion paint shall start only after the preceding coat has become sufficiently hard to resist brush marking. Subsequent coats of plastic emulsion paint shall also be started after the preceding coat is dried by evaporation of water content.

The surface on finishing shall present a flat, velvety smooth finish, even and uniform shade without patches, marks, paint drops etc.

k. Precautions

Brushes shall be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the paint from hardening on the brush. Old brushes, if used shall be completely dried of turpentine/oil paints by washing in warm soap water.

- i. No oil base putties shall be used in filling cracks/holes.
- ii. Washing of painted surface shall not be done within 3-4 weeks of application.

l. Protective Measures

Same as in Clause 4.17.2.1 above.

ii. Acrylic Copolymer Aggregate Finish

1. Material

It shall be an acrylic based textured wall coating consisting of quartz and silica aggregate, inorganic pigments and other additives to form a crack free, flexible, tough, waterproof coating.

a. Preparation of Surface

The surface to be coated shall be cleaned and all dirt, dust, grease and loose particles shall be removed. Any old textured surface shall be removed with removing agent as per manufacturer's instructions.

b. Application

Bonding agent and water shall be mixed first. Then the flakes/granules shall be added and mixed thoroughly and kneaded till no lumps are found. The dough shall be left for 20-30 minutes before starting application. The bonding agent, flakes/granules and water shall be mixed in different ratios for different finishes as per manufacturer's specifications.

The first application shall be by steel trowel. It shall be smoothened, if the specified finish requires, by a plastic trowel.

iii. Painting to Woodwork

2. Preparation of Surface

Preparation of surface shall conform to IS 2338 (Part-1) in general. All wood work shall be dry and free from any foreign manor. Nails shall be punched well below the surface. The surface shall be smoothened off with abrasive paper used across the grain prior to painting, with the grain prior to the staining. Any knots, resinous, or bluish sap wood, cutting out of which is not justified shall be covered with red lead conforming to IS 103.

Plywood and block board shall be treated in the same manner as for wood work.

Particle board's surface shall be filled with a thin brushable filler and finished as for solid wood.

c. Priming

Priming shall be in accordance with IS 2338 (Part I and II). Dirt or any other extraneous material on the surface shall be removed and the priming shall be applied by brushing.

Priming shall be done on all exposed and unexposed surfaces. Unless specified otherwise, all joinery work intended to be painted shall receive at least 2 coats of primer.

Type of primer shall be in accordance with Table-1 and Table-2 of IS 2338(Part-II).

d. Stopping and Filling

Stopping and filling shall be done after priming. Stopping shall be made to the consistency of stiff paste and shall be used to fill holes and cracks. Filler shall be used to level up slight irregularities of the surface. Filler shall be applied with a putty knife and subsequently rubbed down to a level surface with abrasive paper.

The filler coat shall be allowed to fully flatten and harden before subsequent coat is applied.

e. Application of Under Coat

Under coat shall be applied after the surface has been primed, stopped and filled, and rubbed down to a smooth surface. Under coat may be brushed

or sprayed. After drying the coat shall be carefully rubbed down and wiped clean before the next coat is applied.

The type of under coat shall be depending upon the finishing and in accordance with Table-1 and Table-2 of IS 2338 (Part 11).

f. Finishing

The finishing paint shall be as specified in the item description and shall be applied either by the brush or by spraying.

Reference shall be made to the Table-1 and Table-2 of IS 2338 (Part-II)

g. Application of Clear Finishes

For the application of clear finishes, the following procedures shall generally be adopted in accordance with IS 2338 (Part-I)

i. Filling

Fillers shall be applied to prevent the excessive penetration of the finish to the surface for obtaining a smooth finish. Fillers shall be conforming to IS 345.

Fillers shall be heavily applied to the wood surface by hand, using hessian or jute rag across the grain. It shall be rubbed when still wet to get better penetration. After 5-10 minutes it shall be wiped off by and across the grain followed by a height wipe with the grain. The filled surface shall be dried preferably overnight and smoothened with abrasive paper.

ii. Staining

a) Spirit Stains

Spirit stains are solutions of spirit soluble dyes in Industrial methylated spirit.

b) Oil Stains

c) Oil stains are solutions of oil soluble dyes in linseed oil, but, usually consist of insoluble, semi-transparent pigments ground in linseed oil and thinned with turpentine or other solvent.

d) Preparation of wood for Staining

Surface intended for staining shall be kept scrupulously clean and free from greasy finger marks. It shall be prepared by careful smoothing with fine abrasive paper used in the direction of the grain.

Small cracks/nail holes shall be stopped with plastic wood/fine plaster of paris. The stopping shall be rubbed down with fine abrasive paper when hard and touched with a thinned knotting before staining. In case of oil staining stopping shall be done after staining using tinted putty or wood filler.

e) Application of Stains

Stains shall be applied by brushing, and wiping or by spraying. The stain shall be so thinned that it can be applied fairly, liberally without over staining and over lapping.

iii. Sealing

A suitable sealer shall be applied on the filled and sanded surface to prevent absorption by the wood of the succeeding coats of finish and to seal stain and filler and thus preclude their bleeding into the finish coat.

Sealer may be sprayed on taking care not to flood the surface and it shall be allowed to dry hard.

When fully dry the surface shall be sanded taking care not to cut through at corners and edges. Dust shall be blown off and surface wiped with a clean rag.

iv. Finishing

The stained surface shall be varnished, wax-polished or trench polished as required after it is dried.

a) Varnishing

Varnishing of wood and wood based material shall be in accordance with IS 2338 (Part-I).

Surfaces to be Varnished shall be prepared to produce a smooth, dry and matt surface and all dust and dirt shall be removed from the surface.

The Varnish shall be applied liberally with a brush and spread evenly over a portion of the surface with short light strokes to avoid frothing. It shall be allowed to flow out while the next section is being laid in. Excess Varnish shall be scraped out of the brush and then the first section be crossed, re-crossed and laid off lightly. The Varnish, once it has begun to set, shall not be retouched. In case of any mistake, the Varnish shall be removed and the work shall be started afresh.

Where two coats of varnish are applied, the first coat shall be a hard drying under coating or flatting varnish which shall be allowed to dry hard and then be flatted down before applying the finishing coat. Sufficient time shall be allowed in between two coats.

When flat varnishing is used for finishing, a preparatory coat of hard drying undercoating of flatting varnish shall first be applied and shall be allowed to harden thoroughly. It shall then be tightly rubbed down before the flat varnish is applied. On larger areas, the flat varnish shall be applied rapidly,

and the edges of each patch applied shall not be allowed to set, but shall be followed up whilst in free working conditions.

b) French Polish

French polish shall conform to IS 348. Suitable pigments shall be added to get the required colour.

The surface to be French polished shall be rubbed down to smoothness with sand paper and shall be well dusted. Pores in the surface shall be filled up with fillers.

A pad of woolen cloth covered by a fine doth shall be used to apply the finish. The pad shall be moistened with polish and rubbed hard on the surface in a series of overlapping circles applying the polish sparingly but uniformly over the entire area to give an even surface. A trace of linseed oil may be used on the face of the pad for the purpose. The surface shall be allowed to dry and the remaining coats applied in the same way. To finish off, the pad shall be covered with a fresh piece of clean fine cloth, slightly dampened with methylated spirit and rubbed lightly and quickly with circular motions. The finished surface shall have a uniform texture and high gloss.

4.18.7 Painting To Steel and Other Metal Surface

4.18.7.1 General

1. Items to be Painted

All structural steel work and metals including handrails, brackets and steel inserts shall be painted except if otherwise specified.

l) Standard

The operations, workmanship, schedules and equipment for painting shall generally comply with the requirements of IS:1477 (Part I & II) “Code of Practice for Painting of Ferrous Metals in Buildings” & IS 2524 except in so far as this Specification modifies it.

m) General Requirements

All surfaces shall be thoroughly cleaned of all foreign matters adhering to the steel surface to Swedish Standard specification Sa 2½ by means of blasting with sand. Use of scraper wire brush and pig hammer is acceptable wherever blasting with sand is not possible due to lack of access.

Air less spray shall be used for painting of all structural steel. Painting by brush shall only be allowed in places where use of air less spray not possible.

The finished coat shall be generally smooth, of a dense and uniform texture and free from sharp protuberances or pinholes. Each coating shall be checked for thickness by “Elcometer”. Areas where the thickness is less than what is specified shall receive additional treatment.

All operations such as handling & transportation etc. shall be carried out in a manner that there is no damage to the coating.

Painting shall generally be done immediately after cleaning. The cleaned surface shall not be allowed to stand overnight before painting. Where galvanised surfaces are to be painted, they shall be cleaned and washed with a solution of copper sulphate before the application of the first coat of primer.

No painting shall commence until the cleaned surfaces have been approved by the Employer.

n) Schedule

- a) One coat of Organic Zinc Rich Primer (thickness, 60 m DFT).
- b) Strip coat on each weld joint and edge of structure by surface tolerant Epoxy – 75 m DFT by Brush – One Coat
- c) Two coats of High Build Abrasive Epoxy (DFT 100 m for each coat)
- d) Total System Thickness = 250 m DFT without Strip Coat
- e) Strip coat and one coat of high build epoxy should be immediately followed by primer. It is not permitted to keep organic Zinc Rich Primer exposed to atmosphere for long time.
- f) Painting system shall be guaranteed for 5 (five) years.

After completion of erection and stanchion grouting, all the painted surface shall be carefully examined for any damage to the painting system and shall be rectified as directed by the Employer.

2. Preparation of Surface

The surface, before painting, shall be cleaned of all rust, scale, dirt and other foreign matter with wire brushes, steel wool, scrappers, sand paper etc. The surface shall then be wiped finally with mineral turpentine, which shall then be removed of grease etc. The surface then shall be allowed to dry.

In case of GI surface, surface so prepared shall be treated with Mordant solution (5 litres for about 100 sqm) by rubbing the solution generously with brush. After about half an hour, the surface if required shall be retouched and washed down thoroughly with clean cold water and allowed to dry.

3. Application of Priming and Paints

Approved quality primer and paint in specified no. of coats shall be applied as per manufacturer's recommendations either by brushing or spraying. Each subsequent coat shall be applied only after the preceding coat is dried.

4.19 SANITARY AND PLUMBING WORKS (BUILDINGS)

4.19.1 General

The work comprises supply, installation, commissioning and testing of sewerage and drainage, sanitary fixtures and fittings within including water supply the building and upto

1.0 m outside the building wall. The work includes supply of all materials as per specifications and drawings, laying, fitting, fixing, installation and commissioning of the same.

All the water supply and sanitary works shall be carried out by the licensed plumbers approved by the Employer and skilled workmen, experienced in the trade.

All works shall be completely concealed either within shafts or chases or in fills and dropped ceilings unless specifically shown in drawings or required otherwise.

All work shall be adequately protected, to the satisfaction of the Employer, so that the whole work is free from damage throughout the period of construction upto the time of handing over.

No work shall be covered without approval of the Employer.

The Contractor shall be responsible for coordinating the work with works of other trades sufficiently ahead of time to avoid unnecessary hold-ups. Hangers, sleeves, recesses, etc. shall be left in time as the work proceeds whether or not these are shown in drawings.

All clamps, screws, brackets, hangers and all miscellaneous steel work needed in the work shall be fully galvanized.

Only specified brand of material will be used subject to the approval of the sample.

The Contractor shall submit as directed by the Employer samples, manufacturer's drawings, equipment characteristics and capability data etc. of all equipment, accessories, devices etc. that he proposes to use in the installation, to the Employer for approval.

The Contractor shall prepare and submit to the Employer for approval before the work is commenced, all drawings.

The work shall commence only after the drawings are approved by the Employer.

Before the work is handed over, the Contractor shall clean all fixtures removing all plaster, stickers, rust stains and other foreign matter of discoloration of fixtures, leaving every part in acceptable condition and ready for use, to the satisfaction of the Employer.

All sanitary ware and fittings shall conform to IS standards. The Contractor shall submit samples of all fittings and fixtures proposed to be used to the Employer for his approval. The approved samples shall remain with the Employer till the completion of the work.

All workmanship shall conform to Indian Standard Codes of Practice. The fixing and finishing shall be neat, true to level and plumb. Manufacturer's instructions shall be followed closely regarding installation and commissioning.

All fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of fittings. Tool marks on exposed fixtures shall not be accepted. Protective paper on fixtures shall be removed with hot water only at the final completion of work.

All the water supply, drainage and sanitary works shall be carried out strictly as per specifications, ISI codes and National Building Code with amendments upto date.

Bye-Laws and Regulations

The installation shall be in conformity with the Bye-laws, Regulations and Standards of the local authorities concerned, in so far as these become applicable to the installation. But if these Specifications and Drawings call for a higher standard of materials and/or workmanship than those required by any of the above regulations and standards, then these specifications and drawings shall take precedence over the said regulations and standards. However, if the drawings and specifications require something, which violates the Bye-laws and Regulations, then the Bye-laws and regulations shall govern the requirement of this installation.

4.19.2 Fees and Permits

The Contractor shall obtain all permits/licenses and pay for any and all fees required for the inspection, approval and commissioning of their installation and shall bear all expenses if any for the same.

4.19.3 Completion Certificate

On completion of the installation for Plumbing, a certificate shall be furnished by the Contractor. This certificate shall be in the prescribed form as required by the local Employer.

The Contractor shall be responsible for getting the entire installation approved by the authorities concerned as required and shall bear expenses if any, in connection with the same.

4.19.4 Maintenance During Defects Liability Period

Contractor shall be required to carry out the maintenance of the Plumbing installation during defect liability period.

The Contractor shall receive calls for any and all problems experienced in the operation of the system under this Contract, attend to these within 10 hours of receiving the complaints and shall take steps to immediately correct any deficiencies that may exist.

All equipment that requires repairing shall be immediately serviced and repaired.

4.19.5 Water Supply

4.19.5.1 G.I. Pipes & Fittings

A) G.I. Pipes

All pipes for water supply inside the building shall be genuine galvanised steel tubes conforming to IS:1239 Part I (heavy grade 'C' class pipe).

The GI pipes shall be of approved make as per the list of approved makes.

B) G.I. Fittings

All fittings shall be malleable cast iron fittings as per IS:1879 (or as revised).

All fittings shall have manufacturer's trademark stamped on it. Fittings in G.I. pipelines shall include elbows, tees, bends, reducers, nipples, union, bushes, G.I. Clamps of approved design, G.I. flanges with 3 mm rubber insertion, nuts, bolts, washers, etc. All fittings shall be tested at manufacturer's works. Contractors may be required to produce certificate to this effect from the manufacture.

c) Laying and Jointing of G.I. Pipes (External)

a) Trenches

The galvanised iron pipes and fittings shall be laid in trenches. The widths and depths of the trenches for different diameters of the pipes shall be as in Table below:

Dia of Pipe	Width of Trench	Depth of Trench
15 mm to 50 mm	30 cm	60 cm

At the joints the trench width shall be widened where necessary. The work of excavation and refilling shall be done true to line and gradient in accordance with general specifications earthwork in trenches.

b) Cutting and Threading

Where the pipes have to be cut or rethreaded, the ends shall be carefully filed out so that no obstruction to bore is offered. The end of the pipes shall then be carefully threaded conforming to the requirements of IS:554-1964

with pipe dies and tapes in such a manner as will not result in slackness of joints when the two pieces screwed together. The screw threads of pipes and fittings shall be protected from damage until they are fitted.

c) Jointing

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 a few turns of spun yarn wrapped around the screwed end of the pipes. The end shall then be screwed in the socket, tee etc. with the pipe wrench. Care shall be taken that all pipes and fittings are properly jointed so as to make

the joints completely water tight and pipes are kept at all times free from dust and dirt during fixing. Burr from the joints shall be removed after screwing. After laying, the ends of the pipes shall be temporarily plugged to prevent access of water, soil or any other foreign matter.

d) Pipe, Coating & Wrapping

All underground pipes shall be protected by pipecoat primer and pipecoat wrapping. The pipe coat primer shall have a density of 0.92 gm/cc and drying time of 24 hours at RH 70% and temp 30 deg. C. Viscosity shall be 1000 – 2000 cps.

The pipe coat shall be a puncture resistant non-woven polyester mat 4 mm thick of high mechanical strength. The mat shall be in 7 layers. The layers shall be so arranged as to also give extra protection to high molecular high density polythene core which is the main permeable agent in the system.

Pipecoat primer shall be applied on the pipe in a uniform coat leaving no drop runs.

The entire surface of pipe shall be primed without any patch left out. Unprimed surfaces shall reprimed immediately. Any uncleaned pipe shall be scraped down to surface of pipe and reprimed pipecoat primer shall essentially be in a layer for quicker drying.

The surface shall be dry at the time of applying pipecoat primer. Freshly primed pipe shall be placed on clean square cut skids and shall not be allowed to come in contact with ground or any foreign matter. It shall remain on skids until lifted or cradled after coating and wrapping operation.

All primed pipes which have excessive coat of dust accumulated over them before primer is dry or where primer has become dead, shall be primed. Drying time shall be minimum 245 hours. The application of pipecoat membrane shall be taken up soon after primer coat has dried up completely and in case within three days after priming. Otherwise fresh coat of primer shall be applied.

Membrane shall be blown under tension by means of a blowtorch. In this process, the inner surface of the membrane, being 10 micron thick polyethylene layer is burnt while at the same time the polymeric mix under it is softened taking care that the centre core is not over heated. This molten polymeric mix is then pressed over pipe surface so that no air is entrapped or voids formed underneath.

Pipecoat primer shall be applied with brushes after cleaning the pipe thoroughly. Pipecoat membrane shall be wrapped as mentioned above.

No wrinkling of the wrapper shall be allowed and all overlaps shall be firmly fused to secure a firm wrapping. Coating shall be absolutely free from pinholes, bubbles and holidays.

4.19.5.2 Testing of Joints

After laying and jointing, the pipes and fittings shall be inspected under working condition of pressure and flow. Any joint found leaking shall be redone and all leaking pipes removed and replaced without extra cost.

The pipes and fittings after they are laid shall be tested to hydraulic pressure of 1.5 times the working pressure. The pipes shall be slowly and carefully charged with water allowing all air to escape and avoiding all shock or water hammer. The draw of traps and stop cocks shall then be closed and specified hydraulic pressure shall be applied gradually. Pressure gauge must be accurate and preferably should have been recalibrated before the test. The test pump having been stopped, the test pressure should be maintained without loss for at least two hours. The pipes and fittings shall be tested in sections as the work of laying proceeds, having the joints exposed for inspection during the testing.

4.19.5.3 Trench Filling

The pipes shall be laid on a layer of 7.5 cm sand and filled upto 15 cm above the pipes. The remaining portion of the trench shall then be filled with excavated earth as specified and directed and the surplus earth shall be disposed-off as directed by the Employer.

4.19.5.4 Laying and Jointing G.I. Pipes (Internal Work)

Cutting, threading and jointing – Ref. Clause 4.18.6.1.

D) Fixing of GI Pipes

All exposed GI pipes shall be fixed by means of standard pattern holder bat clamps, keeping pipes 1.5 cm clear of the wall. If the pipes are fixed in chases they shall be fixed in position by iron hooks.

4.19.6 Soil, Waste, Vent and Rain Water Pipes and Fittings

4.19.6.1 Cast Iron Pipes and Fittings

Cast iron pipes and fittings to IS:3989 shall be used for soil, waste and vent pipes. Pipes and fittings with irregular bore, blow holes and other manufacturing defects shall not be allowed to be used for work.

All fittings shall be of the degree specified or as required at site.

All cast iron soil, waste, vent and rain water pipes used at basement in exposed condition or where specified shall be centrifugally cast spun iron class (LA) pipes conforming to IS 1536. These shall be with spigot and socket ends.

The fittings for centrifugally cast spun iron pipes conform to IS 1538.

E) Holder Bat Clamps

Holder bat clamps shall be of a standard design fabricated from MS galvanised flat 32 x 1.5 mm thick and 12 mm dia. M.S, bar and 6 mm nuts and bolts. Holder bat clamps shall be fixed in cement concrete (1:2:4) blocks 100 x 100 x 100mm.

F) M.S. Stays and Clamps

The clamps shall be made from 2.0 mm thick MS flat of 32 mm width, bent to the required shape and size to fit tightly on the socket, when tightened with screw bolts. It shall be formed of two semi-circular pieces with flanged

ends on both sides with holes to fit in the screws, bolts and nuts, 40 mm long. The stay shall be minimum one metre long of 10 mm dia MS bar. One end of the stay shall be bent for embedding in the wall in cement concrete block of size 20 x 20 x 20 cm in 1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size). The concrete shall be finished to match with the surrounding surface.

G) Floor Traps

Floor taps shall be cast iron deep steal type P or S traps with a minimum seal of 75 mm. they shall be with or without vent. All traps shall be set in cement concrete blocks 1:2:4 mix without additional cost. Traps shall be provided with CP brass screwed down or hinged grating. Traps shall be provided with suitable extension piece where required with CP brass grating to flush with the floor without any extra cost.

H) Paintings

All pipes in ducts and exposed positions shall be painted with two coats of synthetic enamel paint of any colour approve by the Employer over a coat of primer of approved quality.

4.19.6.2 Concrete

All soil ad waste pipes below ground floor fills and in wall chases (but not in open ducts) shall be supported and covered with 75 mm cement concrete 1:2:4 in bed and all around. Encasement of such pipes shall be done after testing of pipes.

4.19.6.3 Cutting and Making Good

All pipes shall be fixed and tested as building work proceeds. Cutting and chasing shall be kept to minimum. No extra shall be allowed for cutting holes, chases etc. in wall and floors.

4.19.6.4 Jointing

a) All joints for CI soil waste and vent pipes conforming to IS:1729/IS:3989 shall be made with maleable pig lead and spun yard. Pig lead shall conform to IS:782 for caulking. Spun yard shall be of hemp and of good quality. It shall be soaked in hot coal-tar or bitumen and cooled before use. The quantity of lead to be filled per joint in various sizes of cast iron drainage pipes shall be as follows:

• 50 mm dia	=	0.75 kg.
• 80 mm dia	=	0.80 kg.
• 100 mm dia	=	0.90 kg.
• 150 mm dia	=	1.60 kg.

b) The joints for all CI centrifugally cast (Spun) iron pipes conforming to IS:1536 and fittings conforming to IS:1538 shall be made with pig lead. The quantity of lead per joint in various sizes of these pipes shall be as follows:

• 80 mm dia	=	1.8 kg.
• 100 mm dia	=	2.2 kg.
• 150 mm dia	=	3.4 kg.
• 200 mm dia	=	5.0 kg.
• 250 mm dia	=	6.1 kg.

4.19.6.5 Testing

All soil, waste and vent pipes shall be tested by filling up the whole or part of stack with water. All openings for connections, etc. shall be suitably plugged.

Contractor shall remove and replace all pipes having holes, cracks, etc. All leaking joints and access doors shall be replaced or remade to the entire

satisfaction of the Employer. Water shall be retained in stack for a maximum period of 2 hours. After all plumbing fixtures are installed, Contractor shall apply the smoke test to the entire stack to the satisfaction of the Employer.

The smoke test shall be carried out as under.

Smoke shall be pumped into the pipes at the lowest end from a smoke machine which consists of a bellow and burner. The material burnt shall be greasy cotton waste which gives out to a clear pungent smoke easily detectable by sight as well as by smell if there is leak at any point of drain.

4.19.7 Sanitary Fixtures and Fittings

4.19.7.1 General

All sanitary fittings are glazed earthen ware shall be 'Hindustan Sanitary Ware/Nycer/Parry' or equivalent of approved make, white in colour and of one piece construction. All metallic fixtures like taps, stop cocks, soap holders etc. shall be of CP brass 'Parco', 'GEM' or approved equivalent make. PVC fixtures shall be of 'Caliplast', 'Brite' or equivalent approved make. All wall fittings shall be fixed with wooden cleats and CP brass screws and washers.

4.19.7.2 Workmanship

All sanitary ware shall be fixed in a neat workmanlike manner, true to the level and plumb. Manufacturer's instructions shall be followed closely regarding installation and commissioning. Cutting or making good of tiles is not permitted anywhere while fixing of fixtures and fittings.

4.19.7.3 Protection of Fixtures

Fixtures shall be protected throughout the progress of the work from damage. Special care shall be taken to prevent damage and scratching of chromium plated fittings. Tool marks on chromium fixtures etc. shall not be accepted.

4.19.7.4 Sanitary-ware

I) Indian Type Water Closet

Orissa Pan W.C. shall be 580 mm long conforming to IS:2556 Part III. The closet shall be fixed in the floor with 150 mm thick sand cushion and shall be connected with 100 mm dia

C.I. or stone ware S or P trap. The closet shall also be fitted with a low level earthen ware cistern conforming to IS 774 of 12½ litres capacity with wiped solder joints, internal overflow arrangement, 40 mm dia C.P. flushing pipe. The cistern shall be fixed on MS or CI Brackets at a minimum height of 610 mm from top of pan. All exposed metallic surfaces shall be painted with two coats of white enamel paint of approved quality over a coat of primer.

Orissa Pan type W.C. of size 580 mm long with concealed 32 mm dia flush valve push button/lever with regulator or 'Nelson', 'Orient' or approved equivalent, CP flush pipe and clamp with rubber joint to W.C. complete including cutting walls and floors and making good the same.

B) Wash Down Type Water Closet

Wash down water closet shall be pattern 1 conforming to IS:2556 Part II. This shall be fixed with plastic seat and cover as per IS:2548 of 'Brite' or approved equivalent make, fixed with CP brass hinges and rubber buffers and an integral 100 mm dia 'S' or 'P' trap with anti-syphonage vent horn.

A low level earthenware cistern conforming to IS:774 of about 10 litres capacity, with 15 mm dia PVC inlet pipe and brass union with wiped solder joint, internal overflow arrangement, 40 mm dia CP brass flushing pipe, CI or MS supporting brackets shall be fixed with the water closet. The closet shall be fixed firmly in the floor with matching cement mortar. All exposed metallic surface shall be painted with two coats of white enamel paint of approved quality over a coat of primer. The cistern shall be fixed at a height not exceeding 300 mm between the top of the pan and the underside of the cistern.

c) Urinals

Half stall type urinal shall be conforming to IS:2556 Part VI. These shall be mounted on walls. The flushing inlet pipe shall be of CP brass 15 mm dia and waste pipe 32 mm dia G.I. 750 mm long, with necessary unions and CP bottle trap.

Rawl plugs with CP brass screws, shall be used for fixing the urinal. Fixing shall ensure that no liquid is left over in the pan after flushing. Unless otherwise indicated height above finished floors shall be 650 mm.

Urinals shall be connected to automatic flushing cistern either individually, or in groups where individually connected to flushing cistern, the cistern capacity shall be 5 litres. For two urinals, one cistern of 10 litres capacity and for three urinals, one cistern of 15 litres capacity shall be provided.

Cistern inlet shall be 15 mm dia PVC pipe with brass union. Outlet pipe from cistern shall be 25 mm CP brass main, with 15mm CP distributor pipe of sufficient lengths to reach each

bowl. Where individual cisterns are provided, the outlet shall be of 15 mm CP brass. All expose metallic surfaces shall be painted with two coats of approved white enamel paint over a coat of primer, cistern interior shall be painted with two coats of anticorrosive paint of approved quality, wherever called for the waste from urinals shall be collected and disposed through concealed pipes and suitable means to clean and maintain the system shall be provided.

D) Wash Basin

Wash basin shall be flat back of 550 mm x 400 mm size with one tap or two tap hole confirming to IS:2556 Part –IV. This shall be fitted on CI or MS brackets conforming to IS:775. Brackets shall be given two coats of white enamel paint or enamel paint or aluminium paint, over a coat of primer.

The wall side shall be fixed well flushed with the plaster of wall and the joint if any, shall be properly stopped with mortar and painted white. Pillar cocks, PVC connecting pipe with brass union, a CP brass bottle trap with union, CP brass chain and rubber PVC stopper, 32 mm dia, GI waste pipe shall also be supplied and fitted with the wash basin, the top of rim of the wash basin shall be fixed at 800 mm above finished floor level unless otherwise specified.

E) Mirrors

The mirror shall be of the best quality of 'Atul'/'Swastic' or equivalent approved make of size 600 mm x 650 mm x 5.5 mm thick. The mirror shall have ½" thick commercial board backing and shall be provided with aluminium beading all around. It shall be fixed to the wall on wooden blocks with CP brass screws and CP washers.

F) Sink

Providing and fixing stainless steel sink of size 485 mm x 385 mm c 190 mm deep or nearest equivalent with R.S. or CI brackets, 40 mm CP waste, CP brass chain and rubber plug, 4 mm CP. Cast brass bottle trap, with pipe to wall and CP wall flange, rubber adapter for waste connection.

G) Towel Rail

Towel rail shall be of aluminium/C.P. brass pipe with suitable brackets. The towel rail shall be 20 mm dia and 1.25 mm thick 600 mm long. It shall be approved by the Employer. It shall be fixed at specified locations shown in the drawing or as directed by the Employer.

H) Liquid Soap Container

The liquid soap container shall be of superior quality chromium plated brass of 'PARCO', GEM make or equivalent as approved by the Employer.

It shall be fixed with CP brass screws on wooden cleat.

I) Showers

The shower head shall be chromium plated brass, 100/150 mm dia with holes of one millimeter diameter each is sufficiently large for all ordinary requirements. It shall be fixed at a height of 2.0 m from floor level or as directed by Employer. It shall conform to IS:2064.

J) Toilet Paper Holder

Toilet paper holders shall be of chromium plated brass as approved by the Employer. It shall be 100 mm long. It shall be fixed on wooden cleats as directed by Employer.

K) Coat and hat Hooks

Coat and hat hooks shall be chromium plated brass of 'Ego' or equivalent as approved by Employer. They shall be fixed on teak wood plate of 75 mm x 75 mm and 12 mm thick. Teak wood plate shall be properly polished. Wooden cleats shall be inserted in wall to fix wooden plates. CP brass screws shall be used.

L) Bib and Stop Cocks

Bid and stop cocks of screw-down type shall conform to IS:781. All taps shall be of heavy grade. The taps shall be chromium plated brass or ordinary brass easy cleaning type as specified.

M) HCI Nahni Trap (Floor Trap)

Nahni trap shall be of heavy cast iron as per IS:3989 with 100 mm inlet and 80/100 mm outlet with CP pressed steel grating. It shall be of self-cleaning design (Grating shall be of either hinged or screwed down type).

It shall be fixed in cement mortar 1:2 and as directed by Employer.

N) Stoneware Gully Trap Chamber

The square mouth gully trap shall be of 100 mm dia, conforming to IS:651 of specified and/or approved quality stoneware, complete with cast iron grating, and shall be got approved by the Employer. The size of CI frame and cover shall be 300 mm x 300 mm. It shall be properly fixed as directed by the Employer.

The size of the chamber shall be 300 x 300 x 675 mm (internal). It shall be constructed of brick masonry walls 115 mm thick in 1:4 cement mortar and M-15 concrete foundations. Inside and outside faces of the masonry walls

shall be plastered with 1:3 cement mortar. The top of the chamber shall be provided with CI cover and frame.

o) Brick Masonry (Manholes/Inspection Chamber & Valve Chamber)

The size of the manholes and valve chambers shall be as specified in the drawings. It shall be constructed of brick masonry walls 230 mm thick in CM 1:4 (1 cement:4 sand) resting on M-15 concrete foundations. The inside and outside faced of the masonry wall shall be plastered with 13 mm thick plaster of cement mortar 1:3 (1 cement : 3 sand).

The top of the chamber shall be provided with reinforced concrete M-20 grade slab as per drawing and directions of the Employer.

MS rungs made out of 16 mm dia MS bars shall be fixed inside the manhole as shown in the drawing after applying two coats of anticorrosive paint.

Valve chambers shall be provided and fixed with a light duty CI cover and frame.

The top of chamber shall be provided with reinforced cement concrete M-15 grade as per drawings and direction of the Employer.

The CI manhole covers and frames shall conform to IS:726. The type, size and grade shall be as per drawing and direction of the Employer.

The frame shall be fixed in position during concreting of top slab, inside faces of frame and cover shall be given two coats of approved anti-corrosive paint.

The specification for brick masonry, plastering, concreting, excavation and back filling, etc. as given under relevant clauses shall be applicable for this work also.

P) Gun Metal Valve

All full way and globe valves shall be heavy gunmetal and tested at 300 psi and shall be approved by the Employer. Valves shall conform to IS:778. Size of valve chamber shall be as per item description, construction of valve chamber shall be carried out as detailed above. Valve chamber shall be provided & fixed with heavy duty CI surface box conforming to IS:3950. The surface box shall be hinged pin open type & shall be fixed in the chamber slab. It shall have a hole for opening.

Q) Marble Partitions

The marble partition shall be 25 mm thick and approved by the Employer. The edges of marble shall be cut by machine to have proper smooth edges. Vertical face shall be fixed in position with cement mortar (1:3) as directed by the Employer for minimum depth of 100 mm in the wall. It shall be polished after fixing. Two horizontal faces shall be supported by MS channels of size 35 mm deep embedded into wall.

4.20 WATER SUPPLY AND DISTRIBUTION SYSTEM

4.20.1 General

This specification covers the installation and commissioning of the complete water supply distribution system with in the lock area including the supply of potable water to ships and buildings and the supply of raw water for landscaping and greenery.

4.20.2 Material

4.20.2.1 Pipe

Piping for supply and distribution lines shall be HDPE pipes conforming to IS: 4984.

4.20.2.2 Fittings and Specials

Fittings and specials shall be suitable for 10 bar pressure rating, unless otherwise specified. Fittings and specials shall conform to Indian standards.

4.20.3 Execution

4.20.3.1 Installation

a) Cutting of Pipe

Cutting of pipe shall be done in a neat and workmanlike manner without damage to the pipe. Unless otherwise recommended by the manufacturer and authorized by the Employer, cutting shall be done with an approved type cutter.

b) Adjacent Facilities

Water Lines

Water lines shall not be laid in the same trench with sewer lines, gas lines, fuel lines, or electric wiring.

c) Joint Deflection

The maximum allowable deflection shall be as per Indian standards. If the alignment requires deflection in excess of the above limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth.

d) Placing and Laying

Underground pipes shall be laid in accordance with IS: 12288:1987. Pipe shall be laid to the grade calculated by the Contractor or as indicated by the Employer. Pipe alignment shall be straight between bends and curves within a tolerance of + 5 mm.

All bends of $11\frac{1}{4}$ degrees and greater shall be made with the proper fittings. Joint deflection shall be limited to the maximum recommended by the manufacturer. Pipe that has the grade or joint disturbed after laying shall be taken up and re-laid. Pipe shall not be laid in water or when trench conditions are unsuitable for the work. Water shall be kept out of the trench until joints are complete. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no trench water, earth, or other substance will enter the pipes or fittings. Pipe ends left for future connections shall be valved, plugged, or capped, and anchored.

e) Service Lines

Service lines shall include the pipeline connecting building piping to water distribution lines to the connections with the building service at a point approximately 1.5 m outside the building where such building service exists. Where building services are not installed, the Contractor shall terminate the service lines approximately 1.5 m from the site of the proposed building at a point designated by the Employer. Such service lines shall be closed with plugs or caps.

4.20.4 Tests and Inspection

The mains shall be slowly filled with water to expel all air from the system and shall be left to stand full of water for a period of not less than 24 hours.

Test pressures shall be applied by means of a manually operated test pump or in the case of long mains by a power-driven test pump, which shall not be left unattended. Adequate precautions shall be taken to ensure that the specified test pressure is not exceeded.

The specified test pressure shall be maintained for a period of 1 hour and if there is any leakage it shall be measured by the quantity of water pumped into the main.

The main shall be deemed to be satisfactory if the loss of water does not exceed 3.5 litres per 100 mm nominal bore, per kilometre, per bar of test pressure per 24 hours.

Any defect or visible individual leak observed during the hydrostatic pressure testing shall be repaired by the Contractor at his own expense in the manner directed by the Employer should losses from the main exceed the specified amount, testing shall be repeated until the main is deemed satisfactory and is accepted by the Employer. All labour, material and equipment for testing shall be deemed to be included in the rates.

These tests shall be conducted on the entire water distribution system by sections of 500 meters as a maximum on the general circuit, and by building, for the distribution from the main network.

All of the installations must undergo the pressure tests.

3. Cleaning and Disinfection

After the water distribution system has been tested, the Contractor shall proceed to clean the system with water, followed by disinfecting of the entire network. This disinfecting shall be carried out according to a method

proposed by the Contractor for approval by the Employer, and according to the provisions indicated above and the current regulation of the Government of India

4.21 SEWERAGE COLLECTION & TRANSFER SYSTEM

4.21.1 General

The intent is to install a sewerage system in the yard area to cater to the collection and transfer of sewage generated from Buildings and sheds.

4.21.2 Scope

The scope covers collection of all sewerage from all buildings/sheds in lock compound to the collection pit/septic tank. The sewerage system within the buildings and to a distance of one meter from the buildings is included in the scope of respective building.

The scope of work shall include pipe and appurtenant structures and building sewers to points of connection with the building drains 1.5 m outside the building to which the sewer system is to be connected and drain all sanitary sewerage to septic tanks and dispose-off the effluent as given in IS:2470 (Part 2). The system includes furnishing and installing sanitary sewers systems and appurtenances complete for this Contract.

Systems of pipes and appurtenances are to be sized by the Contractor according to the standard usage for sanitary sewers. Scope also consists of furnishing transportation, labor, equipment, and materials to construct sewerage system in accordance with their own Design and Drawings. All products and execution shall be subject to prior approval by the Employer.

The Contractor shall have a copy of the manufacturer's instructions available at the construction site at all times and shall follow these instructions unless directed otherwise by the Employer.

4.21.3 Material

4.21.3.1 Pipe

Sewer pipe and fittings shall be concrete NP3 grade conforming to IS: 458 Codes. All reinforced concrete pipes shall be class NP3 conforming to IS: 458. RCC pipe of class NP4 type shall be used below road. Before being laid, the pipe and fittings shall be carefully inspected for defects, those not meeting the foregoing specifications shall be rejected.

4.21.3.2 Manholes

The manholes shall be made of reinforced cement concrete of grade M25.

PVC encapsulated foot rests shall be built into the wall of the tank at 300 mm intervals below each of the manholes, they shall be set staggered in two vertical runs at 200 mm centres horizontally the top footrest shall be 450 mm below the manhole cover and the lowest not more than 300 mm above the floor of the tank.

It must be possible to install the pipe in the wall of the manhole without touching the walls perpendicular to that wall.

Manholes types and construction shall be submitted for the approval of the Employer.

The covers shall be equal to heavy roadway type made of ductile iron, with frame of cast iron Ft. 20 for closed manholes.

4.21.3.3 Septic Tank

A septic tank is a combined sedimentation and digestion tank where the sewage is held for one to two days. This shall be provided at suitable location. During this period the suspended solids settle down to the bottom. This is followed by anaerobic digestion of settled solids (sludge) and liquid, resulting in reasonable reduction in the volume of sludge, reduction in biodegradable organic matter and release of gases like carbon-dioxide, methane and hydrogen sulphide. The effluent although clarified to a large extent, still contain appreciable amount of dissolved and suspended putrescible organic solids and pathogens.

f) Design

Septic tank shall be water tight, single storeyed, underground, rectangular in shape, single or double tank having roof. In case of double tank, the first compartment is usually twice the size of the second. The liquid depth is 1 – 2 m and the length to breadth ratio i.e., 2.3 to 1. The sizes of the septic tank shall be based on IS: 2470 (Part I).

g) Construction Details

The inlet and outlet should be located at different levels to avoid disturbance due to the force of water entering or leaving the tank. Every Septic tank should be provided with ventilation pipes, top being covered by mosquito proof wire mesh. The height of the pipe should extend at least 2 m above the top of the highest building within a radius of 20 m.

Septic tanks, constructed in concrete cast in-situ shall be provided with watertight covers of adequate strength. Access manholes of adequate size

shall also be provided for purpose of inspection and desludging of tanks. The floor of the tank should be sloped towards the sludge outlet.

h) Sludge Withdrawn and Disposal

Portable pumps may be used for desludging. Mechanical vacuum tankers may preferably be used to empty the septic tanks. Yearly desludging of septic tank is desirable while desludging a depth of 2.5 cm of well-digested sludge is left at the bottom of the tank for further anaerobic action.

i) Secondary Treatment and Disposal of Effluent

The septic tank effluent contains sizable portion of dissolved organic content and pathogenic organisms and hence need to be treated before its final, safe disposal. Depending on the position of the sub-soil water level, soil and subsoil conditions, size of the installation, resource available etc. The extent and type of secondary treatment facility may vary from the most conventional land disposal methods like soak pits or dispersion trenches to additional secondary biological treatment system.

4.21.4 Execution

4.21.4.1 Installation of Pipe, Fittings and Appurtenances

Excavation, trenching, installation, compacting soil and finishing operations for all pipe and soil materials shall conform to the Indian standards. Carefully examine each pipe prior to placing. Promptly set aside all defective pipe and all damaged pipe. Clearly identify all defects. Do not install defective pipe or damaged pipe. Provide all required equipment for lowering pipe safely into the trenches.

4.21.4.2 Pipe Joints

All pipe joints shall be watertight and of such design as to remain sealed after possible settlement. The length of pipe shall be pressure tested as per Indian Standard.

4.21.4.3 Repair and Retesting

Sections of pipe not meeting the pressure test requirements shall have individual joints tested and sealed.

4.22 WASTE COLLECTION SYSTEM

The specifications for earth filling shall be followed as provided in section 4.8. The sub grade shall be prepared by compacting top 2 m soil in layers of 225 mm with road roller; in which the top layer of the ground is then compacted with stone aggregate of specified sizes in uniform thickness by a vibratory roller to proper grade and camber. Waste generated at the terminal shall be segregated by providing different colour bins at location of waste collection centre for recyclable and non- recyclable waste. Recyclable waste shall be sold to authorized vendors and non- recyclable waste shall be disposed of regularly through authorized agency in area responsible for waste collection and management. Oil waste generated from incoming barges & vessels and equipment/machinery at the terminal shall be stored and disposed off two authorized recyclers.

4.23 MASONRY BOUNDARY WALL

4.23.1 General

This section of the specifications includes the requirements for furnishing and installing of masonry boundary wall and barbed wire fencing Y shape

on top of the wall and appurtenances as required providing a complete security system.

4.23.2 Materials

Refer specifications under 'Materials'.

4.23.3 Workmanship

The purpose of fencing is to provide a solid uninterrupted stone masonry boundary wall around the lock area, and keeping only openings being the road.

Stone boundary wall shall be erected and installed by professional organization who are regularly engaged in this business, employing skill labour in this type of work to provide a complete security fencing system.

Refer to specifications under Plain and Reinforced Concrete for the different concretes and reinforcing steel for the construction of the boundary wall. Refer to specifications under Stone Masonry Work for the construction of the boundary wall. Refer to specifications under Structural Steel Work for the construction of the fence and appurtenances as required.

4.23.4 Construction

The Contractor shall submit for approval shop drawings of fencing, and appurtenances and shall not proceed with abreaction and installation thereof prior to approval by the Employer. The location and alignment of the boundary wall shall be planned by the Contractor with the approval of the Employer. The wall shall be able to withstand the collision of vehicle with a speed of 10 km/hr.

The masonry boundary wall shall have stone masonry foundation with cement mortar 1:4 (1 cement: 4 coarse sand) on lean mix concrete 1:3:6 (1 cement: 3 coarse sands: 6 aggregates) base. Minimum height of the wall shall be 2.4 m. Reinforced Concrete (Grade M-25) coping breams shall be constructed on top of stone masonry wall. Barbed wire fencing Y shape on top of the wall with minimum height of 1.0 m shall be provided. Expansion joints shall be provided at 30 m centre to centre.

Barbered wire shall be fastened to the Y angles with wire ties at adequate spacing. Painting to the masonry boundary wall and structural steel shall be as per specifications under painting.

4.23.5 Clean Up & Repair

Upon completion of the masonry boundary wall, the Contractor shall clean all soiled places and repair the damages if any to the satisfaction of the Employer.

4.24 LOCK APPURTENANCES

4.24.1 General

This specification includes requirements for furnishing, constructing and placing all lock appurtenances complete in all respects including but not limited to the following:

- Fenders
- Bollards
- Ladders
- Mooring rings
- Rubbing strip
- Edge angles

- Handrails
- Expansion joints
- Contraction joints
- Drain pipes

4.24.2 Fenders

For the lock structure, suitable type fenders of Trelleborg/ Bridgestone/ Hi-Tech elastomers make or any other equivalent fenders shall be used.

The supplier of the fenders should be actively involved in erection of fenders.

4.24.2.1 Materials

j) Rubber

The material used for the fender shall be natural or synthetic rubber of high quality having sufficient resilience, anti-aging, weather-resistant and wear-resistant properties to meet all normal service conditions. The material shall be homogeneous without any defects, impurities, pores, cracks etc. and generally have the following properties:

Property	Test STD & Condition		Criterion	Equivalent International STD		
				ASTM	BS ISO	DIN
Tensile Strength	JIS K6251 NO. 3 DUMBBELL	BEFORE AGING	16 MPA MIN. MORE THAN 80% TO ORIGINAL	D412	BS ISO 37 BS 903 A3*1	DIN 53504
Elongation		AFTER AGEING 70 DEG X 96 HRS	360% MIN. MORE THAN 80% TO ORIGINAL			
Hardness	JIS K6253 DUROMET	BEFORE AGING	82 MAX. LESS THAN	D2240	BS ISO 48 BS 903	DIN 53505

	ER A	AFTER AGEING 70 DEG X 96 HRS	+8 TO ORIGINAL		A26*1	
Ageing	JIS K6257	70 DEG X 96 HRS		D573	BS 188 BS 903 A19*1	ISO DIN 53508
Compression Test	JIS K6262	70 X 24 HRS	30% MAX	D395	BS 815-1 903 A6*1	ISO DIN 53517
Tear Resistance	JIS K6252	CRESCENT TYPE	70N/MM MIN	D624	BS 34-1 903 A3*1	ISO DIN 53507
Abrasive Wear	JIS K6264	AKRON METHOD	1.5CC MAX	D5963-04	BS 4649 BS 903 A9	ISO DIN 53516
Bond Strength	JIS K6256-2	90 DEGREE	7N/MM MIN.	D429	BS 903 A21.1	
Sea Water Resistance	JIS K6258	3% NACL SOLUTION 23 DEG X 24 HRS	VOLUME CHANGE +10%/-5% MAX. HARDNESS CHANGE +/- 10 MAX	D471	BS 1817 BS 903 A16*1	ISO
Ozone Resistance	JIS K6259	50PPHM 20% ELON. 40 DEG X 72 HRS	NO CRACK	D1149	BS 1431-1 903 A43*1	ISO DIN 53509
Density	JIS K6268		1.1 g/cc to 1.30 g/cc	D1817	BS 2781 BS 903 A1*1	ISO

k) Accessories

The materials for fender accessories shall generally conform to the following requirements:

- i. Protector (Frontal) Panels Frame shall be made of rolled steel to ASTM A441 or equivalent
- ii. Bolts, nuts and washers used for fixing the Protector Panel Frame to the

Fender Body shall be of stainless steel to AISI 304 or equivalent

- iii. Shackles and turnbuckles where required shall be galvanized carbon steel to ASTM A575 Gr. 1025 or equivalent
- iv. The chain and its components shall be sized to withstand the maximum loads with a minimum factor of safety of three on breaking strength, but with a stock size of not less than 30 mm. Suspension chains shall have provisions for field adjustment. All chains and padeyes for attaching chains shall be hot dip galvanized carbon steel to ASTM A 575 Gr. 1025 or equivalent subject to approval of the Employer
- v. U-anchor where required shall be of stainless steel to AISI 304 or equivalent
- vi. The material for resin anchor sleeve shall be made of synthetic resin and proved satisfactory to the following requirements

Physical Properties:

Tensile Strength (23oC) - Min 300 kg.sq. cm ASTM 638 Water
absorption (weight change)- Max 3%

Chemical resistance to 10% NaCl - Max 1% (weight change)

Elongation (23oC) - 20% ASTM 638

The anchor bolt shall be made of stainless steel to AISI 304

Frontal pads shall be provided with low function UHMP protective pads

l) Dispatch of Fenders

Fenders shall not be dispatched from manufacturer's works to the Site without the written consent of the Employer.

4.24.2.2 Performance Verifications

All testing shall define fender performance under linearly-decreasing or sinusoidal- decreasing deflection velocities to simulate actual, vessel-berthing conditions.

Rated Performance Data (RPD), manufacturer's published performance curves and/or tables, shall be based on:

- a) Initial berthing velocity of 0.25 m/s and decreasing to no more than 0.005 m/s at test end
- b) Testing of fully broken-in fenders;
- c) Testing of fenders stabilized at $23^{\circ}\text{C} \pm 5^{\circ}\text{C}$
- d) Testing of fenders at zero-degree angle of approach
- e) Berthing frequency of not less than one hour

Catalogues shall also include nominal performance tolerances as well as data and methodology to adjust performance curves and/or tables for application parameters different from RPD conditions. Adjustment factors shall be provided for initial velocities, temperatures and contact angles.

Adjustment factors for velocity and temperature shall be provided for every catalogue rubber compound or other energy-absorbing material offered by each manufacturer.

4.24.2.3 Fender Testing

Performance testing to establish design data may use either of two methods as mentioned in PIANC Guidelines for the Design of Fenders Systems—2002

- The traditional and widely used Constant Velocity (CV) Method and
- Decreasing Velocity (DV) Method

4.24.2.4 Test Apparatus

The test apparatus shall be equipped with a calibrated load measuring device such as load cell(s) or pressure transducer and linear transducer(s) for measuring displacement capable of providing continuous monitoring of fender performance.

The test apparatus shall be capable of recording and storing load-cell and transducer data at intervals of 0.01H-0.05 H, where H is a fender's nominal height, and storing manually- entered inputs. Also, information related to serial nos., date, time at start, test ambient temperature etc. shall be furnished.

For fender tests, all equipment used to measure and record force and deflection shall be calibrated, and certified accurate to within ± 1 (one) percent in accordance with ISO or equivalent JIS or ASTM requirements. Calibration shall be performed within one year of the use of the equipment, or less, if the normal calibration interval is shorter than one year. Calibration of Test Apparatus shall be checked annually by a qualified third-party organization, using instrumentation, which is traceable to a certified, national standard.

4.24.2.5 Test Protocol

The performance test shall deflect specimens according to either of the two methods, Method CV or Method DV. Clear and unambiguous calculations must be provided for any adjustments made to the test results.

4.24.2.6 Supporting Protocols

Supporting Protocols shall cover temperature stabilization, Velocity Factor (VF) and Temperature Factor (TF) as mentioned in PIANC Guidelines for the Design of Fenders Systems – 2002.

4.24.2.7 Verification/Quality Assurance Testing

m) Energy/Reaction Compliance Testing

Samples for verification testing shall be actual fender elements fabricated for the project following the PIANC Guidelines for the Design of Fenders System – 2002.

A minimum of ten percent of the fender order shall be tested for compliance with energy/ reaction requirements.

n) Break in Deflection

Break-in deflection of actual elements should be at least manufacturer rated deflection. At least one cycle should be performed.

o) Other Testing

Effect of contact angle and durability tests should be carried out as per PIANC Guidelines for the Design of Fenders Systems – 2002 recommendations.

4.24.2.8 Dimensions

Fenders shall meet manufacturer's specified dimensional tolerance.

4.24.2.9 Steel frame, Frontal Frame, Hardware, Chains and Related Accessories

All steel hardware for securing of fenders shall be stainless steel grade AISI 304 or equivalent.

All hardware shall be of sufficient capacity to safely resist all normally anticipated loading conditions. Chain anchor assemblies shall be designed to resist the maximum loads with a minimum factor safety on breaking strength and concrete pillion of four.

4.24.3 Bollards

4.24.3.1 General

Cast Steel bollards to be installed on the lock as required for the spectrum of vessels to be berthed at lock and they should not be protruding out. The bollards have to withstand sudden jerking effect from ropes connected to vessels and to resist rubbing effect of ropes on its sides. For the proposed lock minimum 30 T capacity bollards shall be provided.

Lock should have bollards at both corners. The Contractor shall provide bollards of suitable type at all locations of lock.

Painting and numbering of the bollards shall be done.

4.24.3.2 Standards and Codes

The following latest editions of standards and codes or approved equivalent international codes shall be followed for the manufacturing and testing of cast steel bollards.

IS 1030 - Specifications for carbon steel casting for general engineering purposes
IS 1387 - General requirements for supply of metallurgical materials

IS 3664 - Code of practice for ultrasonic Pulse Echo Testing by contact and Immersion methods

IS 1599 - Method for bend test for steel products other than sheet, strip, wire and tube. IS 1608 - Method of tensile testing of steel products

4.24.3.3 Classification

The casting shall conform to IS 1030. The mechanical properties of it shall be:

Tensile strength : 540 MPa (min.)

Elongation : 15% (Gauge length 4JA)

Yield strength : 50% of min.

Tensile strength Angle of bend : 60% (min.)

Chemical composition: The limit for sulphur and phosphorous in the steel when analysed shall be as follows:

Sulphur: 0.05% max.

Phosphorous : 0.5% max.

4.24.3.4 Specifications for Casting

4.24.3.5 Method of Casting

The steel for the casting can be made from open hearth, electric, duplex, acid Bessemer, basic oxygen (L.D) or a combination of these processes.

Castings manufactured from steel made by Bessemer processes will not be accepted. The steel shall conform in quality, strength, hardness etc. to IS 1030.

The casting shall be made under strictly controlled condition to ensure chemical composition, soundness, uniformity, correct grain size to develop shock resistance properties and to avoid any blow-holes.

4.24.3.6 Moulding and Moulding Tolerances

The casting shall be accurately moulded in accordance with the drawing.

The dimensional tolerance that can be allowed for all important dimensions shall be ± 1.6 mm. The variation in thickness of casting shall in no instance be more than 1.6 mm.

The castings shall be sound, clean and free from sand. They shall be free from distortion, blowholes, twists and other injurious defects. They shall be properly flattened and dressed.

4.24.3.7 Heat Treatment

All casting shall be supplied in the heat-treated condition which shall be carried out at suitable temperature to give the mechanical properties as specified. The casting shall thoroughly be annealed to refine the crystalline structure throughout the casting by heating to a uniform temperature not less than the normalizing temperature and allowing to cool slowly from maximum temperature in a uniform manner or alternatively normalizing by heating in a similar manner and allowing it to cool in air away from draughts.

In no case it shall be allowed to conduct heat treatment process for more than two times on the same casting.

The Contractor shall furnish to the Employer, the method of heat treatment and all relevant records.

4.24.3.8 Marking Procedure

Each casting shall be legibly marked with

- Number or identification mark by which it can be traced to the melt from which it was made, and
- The manufacturer's initial and trade mark
- The capacity of the bollard

4.24.3.9 Defects and rectification

If the casting is found defective during the course of any subsequent preparation or machining, it shall be rejected even if it has been found satisfactory during earlier testing, if any.

No casting shall be repaired or welded without the prior permission of the Employer or his representative. When repairs that might have been so sanctioned are completed, the concerned casting shall be again presented for inspection. When welding is carried out, the welding technique and the preparation of the casting for repairs shall be in accordance with IS 5530.

4.24.3.10 Inspection

The Employer shall have free access to the works of the manufacturer at all reasonable times during the manufacture of the castings. He shall be at liberty to inspect the manufacture at all stages and to reject any casting or material that is unsound and does not otherwise conform to the terms of this specification.

4.24.3.11 Testing

- a) Test Sample

All test samples shall be cast in the presence of the Employer or his representatives and shall be tested in his presence.

The test samples shall be cast separately from the casting. The test sampling shall be cast from moulds of the same material, which is used for casting and shall be poured at the same time and from the same melt as the casting they represent. The samples shall be treated along with the casting they represent.

The test samples shall be provided to the extent of 2% of the number of castings from each melt but in no case less than two samples per melt. When a casting is made from more than one melt, at least four tensile tests and four bend tests shall be made from samples situated as far apart as possible in the casting. Some of the test samples shall be taken as near the top and others from as near the bottom of the casting as is practicable.

The test samples shall be stamped in presence of the Employer so as to identify the casting to which they relate.

b) Type of Test

i. Tensile Test

The tensile test shall be carried out in accordance with IS 1608. The minimum tensile strength and elongation shall be as given earlier in this specification.

ii. Bend Test

The bend test shall be carried out in accordance with IS 1599. This test piece shall be capable of being bent without fracture to the angle specified earlier in this specification. It should be bent round a former having a radius of 25 mm.

iii. Non-destructive Tests

The following non-destructive tests at Cross-sections decided by the Employer shall be carried out to ensure that the castings are in every aspect sound, free from cracks, hot tears, shrinkage cavities and other defects.

- a) Ultrasonic flaw detector test as per IS 3664 for checking the thickness of the castings and to detect the defects in the casting
- b) Magnetic particle test
- c) Ringing test

The Employer shall indicate the location to be examined on the casting and the stage of manufacture at which such examinations are to be made.

The technique, inspection and interpretation of results shall be laid down and agreed between the Employer and the Contractor before the manufacture is commenced.

iv. Test by chemical analysis

Chemical analysis test shall be conducted to ascertain the percentages of sulphur and phosphorous content in the material of which the casting is going to be made. The Contractor shall supply a certificate of chemical analysis of such cast when required to do so by the Employer.

The Employer shall have the option to take the test sample and subject it to complete analysis by a metallurgist appointed by the Employer at the cost of the Contractor.

v. Testing facilities

The Contractor shall supply the casting required for testing free of charge and shall at his own cost furnish and prepare the necessary test pieces and

supply labour and appliances for conducting all tests at his own premises in accordance with this specification.

If such facilities are not available at the place of manufacture for conducting the prescribed tests, the Contractor shall bear the cost of transportation for the test pieces or casting and for carrying out the tests at a place approved by the Employer.

vi. Test Certificate & Acceptance Criteria

The Contractor shall supply a test certificate giving the results of all tests mentioned in this specification, batch-wise, stating that the material complies with requirements as specified by the Employer.

vii. Re-test

If any of the test piece fails to pass any of the mechanical tests specified under tensile test and bend test, two further samples which represent that particular casting or castings shall be selected and tested in the same manner. The Contractor shall have the option, if he so desires, to re-heat-treat (not more than twice) the casting before the two further samples is accepted. Should either of these tests fails, the casting represented shall be liable for rejection.

4.24.3.12 *Bolts, Nuts and Washers*

All anchor bolts, nuts and washers shall be of stainless-steel conforming to AISI 304 or equivalent.

4.24.3.13 *Fixing Details*

The Contractor shall submit the detailed fixing arrangements of the bollard to the lock with full details of bolt etc. to the Employer for his approval.

The Contractor shall submit the following documents and certificates at suitable time for the approval of Employer.

- Drawing showing the complete details of cast steel bollard.
- Drawing showing the fixing arrangements of bollard in the lock.
- All relevant test certificates.

4.24.4 Ladders

Ladders shall be provided on the lock face either in grooves without protruding outside the lock face or providing fender bars on either side of the ladder if it is protruding outside the lock face. Design & location of these shall be planned in such a way that shall not interfere with the ship's mooring operations.

The ladders and connecting hardware shall be made of steel grade St 37-2, DIN 17100 or equivalent and approved by the Employer.

4.24.5 Rubbing Strip

Wooden / Stainless steel rubbing strip complete in all respects shall be provided as instructed by the Employer at relevant locations of the lock suitably. If wooden rubbing strips are provided, painting of the same shall be done.

4.24.6 Edge Angles

Galvanised iron edge angles shall be provided at the edges of the lock and painting of the same shall be done.

4.24.7 Drain Holes

Deleted.

4.24.8 Mooring Rings

Mooring rings at suitable locations on lock face shall be made from 20 mm dia stainless steel to AISI 304 or equivalent with an outer diameter of 150 mm. Suitable eyebolts of stainless steel to AISI 304 or equivalent shall be used with the mooring rings for fixing to the lock face.

4.24.9 Expansion Joints

Expansion Joints at suitable interval shall be provided to the satisfaction of the Employer.

4.24.10 Contraction Joints

Contraction Joints as a structural discontinuity shall be provided as per structural design to the satisfaction of the Employer. PVC water bars shall be used in contraction joints to safeguard them from water leakages.

4.25 SIGNS AND SIGNAL SYSTEM

4.25.1 General

This specification covers the installation and commissioning of the complete signal system to navigate the ships properly from the Navigational lock . Establishment of signal system shall follow the relevant Indian and international codes for inland waterways such as European Code for Signs and Signals on Inland Waterways.

4.25.2 Materials

Refer section specification of materials

4.25.3 Visibility and Minimum Dimension

In order to ensure the first-degree visibility, in daytime the sign shall be visible with an angle of more than 1' (angular minute) and with sufficient contrast in relation to the environment. Detailed form and colour of the sign

(second- and third-degree visibility) can only be distinguished with a larger angle of sight or with a reduction in the distance L to the object being observed.

When there are simple drawings (dot, line, arrow) on the signs, a 15 per cent visibility reduction must be taken into account, while with complex drawings it shall be 30 per cent.

The minimal angle of distinction in daytime for simple shapes (cylinder, cone, sphere, etc.) is between 3 and 5 angular minutes, and for complex shapes (numbers, letters, etc.) between 5 and 8 angular minutes. For the boatmaster to be able to recognize the daymark (without any optical aids) at appropriate distances and visibility

4.25.4 Variable Message Signs to Regulate Traffic

When variable message signs are used to regulate traffic, attention shall be paid to the following:

- I.If variable message signs regulating traffic show images of signs, the images must be depicted using a mechanical display system. applicable with regard to colour selection and dimensions as per the relevant codes
- II.By night, mechanical display systems shall be externally lighted.
- III.The use of auto-illumination display systems should be avoided for the signs in Inverse representation (e.g., inversion of black and white surfaces for prohibitory signs) shall not be allowed;
- IV.A remote-controlled auto-illumination matrix display may constitute a reasonable alternative in order to indicate frequently changing information, such as water levels and the height of navigable passages through bridges. Technically, it is possible to display images using light emitting diodes, liquid crystals and light guides;

V.By day, there must be sufficient luminosity to ensure the sign can be read; by night, luminosity must be reduced in order to prevent any dazzling and to ensure that the sign can be identified. The image must thus be regulated according to light measurements in the surroundings.

5. SPECIFICATIONS - ELECTRICAL

5.1 ELECTRICAL EQUIPMENT

5.1.1 HT SWITCHGEAR

5.1.1.1 General

This specification covers the requirements of 11kV Switchgear complete with all accessories. Continuous current rating of the Switchgear shall be based on the name plate rating of the connected equipment with 20% margin, rounded off to the next higher standard rating. 11kV Switchgear shall be rated for short circuit withstand capacity of 26.3kA for 3 seconds.

Busbars, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The inside cubicle temperature shall be considered as design ambient temperature for maximum continuous operation rating of the equipment. For breaker control, 110 V DC supply shall be considered.

Each breaker module shall be provided with multifunction numerical relay for protection. Switchgear shall be provided with separate earthing trucks for cable earthing and bus earthing.

5.1.1.2 Switchgear Construction

Switchgear shall be indoor, single front, single tier, metal-clad, floor mounted, fully draw- out with VCB breaker. Design and construction shall be such as to allow extension at either end. Switchgear cubicle shall be so sized as to permit closing of the front access door when the breaker is pulled out to Test position. The working zone shall be restricted within 750 mm to 1800 mm as from floor level.

Circuit breakers, instrument transformers, bus-bars, cable compartment, auxiliary control devices etc., shall be housed in separate compartments within the cubicle. The design shall be such that failure of one equipment shall not affect the adjacent units. The circuit breaker and bus voltage transformers shall be mounted on withdrawable trucks. In case breaker truck rolls out on telescopic rails suitable trolley shall be provided. All relays, meters, switches and lamps shall be flush mounted on the respective cubicle door or on a control cabinet built on the front of the cubicle.

The trucks shall have distinct 'Service', 'Test' and 'Isolated' positions. The switchgear assembly shall be designed to achieve IP54 degree of protection, with the truck in any position 'Service', 'Test' and 'Isolated' and all doors and covers closed. Relaying and Metering compartment shall also have degree of protection IP54.

Enclosure shall be constructed with rolled steel sections / sheets of not less than 2mm. The switchgear shall be cooled by natural airflow. Forced cooling shall not be accepted. The Breaker and the auxiliary compartments provided on the front side shall have strong hinged doors. Breaker compartment doors shall have locked facility.

5.1.1.3 Bus and Bus Taps

Main buses and connections shall be of high conductivity aluminium, sized for specified current ratings with maximum temperature limited to 90°C. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm². The busbars shall be designed for a short circuit rating of 26.3kA for 3 sec. All bus connections shall be silver plated. Adequate contact pressure shall be ensured by means of two bolts connection with

plain and spring washers and lock nuts. Bimetallic connectors shall be furnished for connections between dissimilar metals. Busbar insulators shall be epoxy cast resin type designed to withstand stresses due to maximum short circuit current.

Busbars and connection shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating sleeves for busbars and cast-resin shrouds for joints shall be provided. Cross section of the main horizontal busbar shall be uniform throughout the switchboard and continuous in one transport unit. All buses and connection shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion.

Busbars shall be colour coded for easy identification and so located that the sequence R-Y-B shall be from left to right, top to bottom or front to rear, when viewed from front of the switchgear assembly. The busbar chamber shall be provided with inter panel barrier with epoxy case seal-off bushings which the buses shall pass through so as to prevent fire from one panel to another.

5.1.1.4 Circuit Breaker

Circuit breaker shall be triple pole, single throw Sulphur Hexafluoride (SF₆) or Vacuum Circuit breaker. It shall be restrike free, trip free type. Breakers shall be suitable for switching transformers at any load. Rated operating duty shall be O-3min-CO-3min-CO. Short circuit withstand/interrupting capacity shall be 26.3kA. Circuit breaker shall have communication facility for communicating with the PLC/Control desk.

Circuit breakers shall be draw-out type, having SERVICE, TEST and DISCONNECTED positions with mechanical positive indication for each position. Operating mechanism shall be stored energy type. Circuit breakers of identical rating shall be physically and electrically interchangeable.

Each breaker feeder shall be provided with the following:

- An anti-pumping relay.
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator (to show whether the breaker / contactor is 'ON' or 'OFF' in the service, test and disconnected positions)
- Closing coil (100% continuous rated)
- Shunt trip (100% continuous rated)
- Manual trip push button
- Operation counter,
- Locking facility to prevent breaker/contactor from being closed when it is open.
- Pressure relief device
- Safety shutters for power contacts
- Inter-pole insulators
- SF6 gas pressure low alarm/trip relay (In case of SF6 type Switchgear)
- Auxiliary Signaling contacts

For motor wound mechanism, spring charging shall take place automatically after each breaker closing operation. One open-close-open operation of the circuit breaker shall be possible after failure of power

supply to the motor. SF₆ breakers shall be provided with SF₆ density / pressure switch with separate trip, alarm and blocking contacts.

Robust fail-safe mechanical and electrical interlocks shall be provided to prevent the following situations:

- Move the breaker unit from the service or disconnected position while the unit is closed.
- Move the breaker from the disconnected position to the service position while the earthing switch is closed.
- Close the earthing switch when the breaker unit is in service position or between the service and disconnected position.
- The operation of the circuit breaker while the truck is not properly installed in the service, test or disconnected position.

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The shunt trip coil shall operate satisfactorily at all values of control supply voltage between 70 and 110 percent of the rated voltage. For breakers spring charging motor shall be provided with overcurrent protection. Motor windings shall be provided with class B insulation or better.

Circuit breaker shall not produce any harmful over-voltage during switching off induction motors. Surge protective devices to limit over voltage shall be included in the scope of supply for all motor feeders.

5.1.1.5 Current Transformer (CT)

CTs shall be mounted on the switchgear stationary parts. CT secondary current shall be 1A. For metering separate core shall be provided. Core

balance CT shall be provided for all the outgoing feeders. Accuracy class of the current transformer shall be: -

- a) Class PS/ 5P20 for differential relaying and REF protection (Based on type of relay)
- b) Class 5P20 for other relaying
- c) Class 0.5 and ISF < 5 for metering
- d) Class 0.2S for Energy Accounting & Audit meters

For metering separate core shall be provided. Core balance CT and associated relay combination shall be such as to ensure a pick-up sensitivity of 10 A primary ground fault current for all the outgoing feeders. Facilities for easy shorting and grounding the terminals shall be provided at the terminal block. All terminal blocks shall be of stud type with marking strip.

5.1.1.6 Voltage Transformer

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 0.5. Voltage Transformer mounted on breaker carriage is not acceptable. Rated secondary voltage shall be 110V. Accuracy class for metering core shall be 0.5, protection core shall be 3P and 0.2 for energy accounting & audit meters. High voltage windings of voltage transformer shall be protected by current limiting fuses. Fuse failure relay shall be provided on the secondary side of all voltage transformers to monitor failure of fuses.

The following over voltage factor shall be considered for PT.

- 120% for continuous duty.
- 150% for 30 sec (for 415V solidly grounded system)

High voltage windings of voltage transformer shall be protected by current limiting fuses. The voltage transformer and fuses shall be completely disconnected and visibly grounded in fully draw-out position.

Low voltage MCB's, sized to prevent overload, shall be installed in all ungrounded secondary leads. MCB's shall be suitably provided with auxiliary contacts. MCB's auxiliary contacts connected suitably through relay shall be provided on the secondary side of all voltage transformers to monitor failure or trip of MCB's. The relay shall initiate alarm and block the tripping etc. which shall operate in case of VT MCB trip or failure.

5.1.1.7 Relays

Numerical multifunction relays shall be provided for all feeders. Numerical relay shall have trip circuit supervision. All protective relays shall be of draw-out type, suitable for flush mounting and fitted with dust tight covers. All relays shall have built-in testing facilities. Small auxiliary relays may be of non-draw-out type and mounted within the cubicle. Relays shall have lock-out facility with manual reset. Each feeder shall be complete with necessary auxiliary relays, timers, etc., to meet the circuit requirement. Under voltage relays shall be provided in the bus PT circuit.

Relays shall be rated for operation on 110V VT secondary voltage and 1A CT secondary current. The switchgear shall be provided with DC fail relay and DC fail indication lamp for each DC control supply incomer. DC isolation switch for each feeder shall be provided with backup HRC fuse. Breaker auxiliary contacts used for interlocking purposes shall be multiplied using electrically latched relay.

Incomers and Outgoing transformer feeders shall have the following minimum protection relays.

- Numerical protection relay having Instantaneous over current protection (50) on all the three phases, IDMT Over current protection (51) on all the three phases, Instantaneous earth fault protection (50N)
- Instantaneous Ground fault protection through CBCT (50G)
- Backup earth fault protection connected to Transformer neutral CT (51N)
- Latched Lock out relay (86).
- Trip circuit supervision relay (95)
- DC Fail relay (80F)
- REF protection relay (For Transformers 2MVA & above)

Self-reset auxiliary relays with hand reset flag indicator shall be provided for contact multiplication (52X) of the following:

- Transformer winding temperature indicator alarm and trip contacts.
- Transformer pressure relief trip contacts.

Motor feeders shall have Numerical motor protection relay having as a minimum following protection.

- Instantaneous earth fault protection through CBCT (50 N).
- Latched Lock out relay (86).
- Under voltage protection
- Trip circuit supervision relay

5.1.1.8 Control Switches

Circuit breaker control switches shall be 3-position spring return to 'neutral' from both close and trip positions. They shall have 'Pistol Grip' handle.

The contacts shall be of silver plated, air brake type. The continuous current and breaking capacity of the contacts shall be adequate for the duty involved.

5.1.1.9 Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application. Bulbs and lamp covers shall be easily replaceable from the front of the cubicles. Low Voltage Glow Prevention (LVGP) feature shall be provided for indicating lamps. The colour of indication lamps shall be as follows:

- GREEN : Breaker Open
- RED : Breaker Closed
- AMBER : Auto trip & all Alarm conditions
- BLUE : Spring Charged
- WHITE : For all healthy conditions (e.g., Trip coil healthy & Control supply healthy).

For each breaker feeder, Panel indication lamps shall be provided as follows:

- Breaker Open
- Breaker Closed
- Auto trip
- Motor Spring Charged
- Trip coil healthy
- Control supply healthy

- Breaker in service position
- Breaker in Test position
- Lockout relay healthy
- SF6 Gas Pressure Low (Alarm) (In case of SF6 type Switchgear)
- SF6 Gas Pressure Low (Trip) (In case of SF6 type Switchgear)
- Any other indication, as required

For incomer and Bus, indicating lamps for R, Y, B phase shall be provided.

5.1.1.10 Meters

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level. All digital meters shall be with RS485 communication port.

For incomers following Meters and transducers shall be provided:

- Ammeter
- Voltmeter
- Current transducer on three phases
- Voltage transducer on three phases
- Multifunction meter with digital display and communication port for kW, kVAR, kWh and power factor measurement.

For outgoing transformer feeders following Meters and transducers shall be provided:

- Ammeter
- Current transducer on one phase

- Multifunction meter with digital display and communication port for kW, kVAR, kWh measurement.
- For outgoing motor feeders following Meters and transducers shall be provided:
 - Ammeter on one phase
 - Current transducer on one phase
 - Hour run meter

All the transducers shall have dual output of 4-20 mA range. For motor feeders, it shall be 4-20-24 mA to measure starting current also.

5.1.1.11 Secondary Wiring

The Switchgear shall be fully wired at the factory to ensure proper functioning of control, protection, transfer and inter locking schemes. Fuse and links shall be provided to permit individual circuit isolation from bus wires without disturbing other circuits. All spare contacts of relays, switches and other devices shall be wired up to terminal blocks. Wiring shall be done with flexible, 1100V grade, PVC insulated switchboard wires with stranded copper conductors of 2.5mm² for current circuits and 1.5 mm² for voltage circuits. Each wire shall be identified, at both ends, with permanent markers bearing wire numbers as per Contractor's wiring Diagrams. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals. All external cable terminations shall be accessible while the breaker is in service position.

5.1.1.12 Terminal Blocks

Terminal blocks shall be 1100V grade box-clamp type with marking strips. CT shorting links, drop link type terminals shall be provided for CT

secondary leads. Not more than two wires shall be connected to any terminal. Spare terminals equal in number to 20% active terminals shall be furnished. Terminal blocks shall be located to allow easy access. Wiring shall be so arranged that individual wires of an external cable can be connected to consecutive terminals.

5.1.1.13 Cable Termination

Switchgear shall be designed for cable entry from the bottom. Sufficient space shall be provided for ease of termination and connection. All provision and accessories shall be furnished for termination and connection of cables, including removable gland plates, cables supports and crimp type tinned copper lugs, brass compression glands with tapered washer and terminal blocks.

5.1.1.14 Name Plates

Name plates of approved design shall be furnished at each cubicle and at each instruments & device mounted on or inside the cubicle. The material shall be lamicaid or approved equal, 3 mm thick with white letter on black back ground. The material shall be held by self-tapping screws. Nameplate size shall be minimum 20 X 75 mm for instrument device and 40 X 150 mm for panels. Caution notice on suitable metal plate shall be affixed at the back of each vertical panel.

5.1.1.15 Space Heaters and Plug Sockets

Each cubicle shall be provided with thermostat-controlled space heaters and cubicle lamp with door switch suitable for operation from 240 V, single phase AC supply and 5A, 3 pin plug socket. The space heater shall be located at the bottom of each switchgear compartment. Cubicle heater,

Motor heater, Plug/socket circuits shall have individual MCB units. In addition, motor feeder cubicle shall be wired-up for feeding the motor space heater through suitable rated breaker auxiliary NC Contact and/or contactor.

5.1.1.16 Testing and Inspection

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.1.1.17 Spares

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

5.1.2 TRANSFORMERS

This specification covers the requirements of 11/0.433 KV distribution dry type transformers complete with all accessories. The Cast resin dry type transformers shall be capable of operating continuously at its rated output without exceeding the temperature limits specified.

The transformers shall be suitable for connection to the system having short circuit level and short circuit duration as specified. The transformers shall be capable of withstanding without injury, the thermal & magnetic stresses caused by faults on any of the winding/through faults. Calculation shall be submitted along with the offer to prove that thermal as well as mechanical

withstand capacity of the transformer is as per Indian Standards in the event of short circuit to the specified duration. Transformers shall be designed to withstand the thermal and dynamic stresses due to short circuit at the terminals for 5 seconds duration with respect to fault level specified.

The impedance of the transformer shall not be less than as stated in Indian Standard at a reference temperature of 75°C.

The transformers shall be capable of delivering the rated output at any particular tap without exceeding the specified temperature limits under the following operating conditions.

- Voltage variation of $\pm 10\%$ of rated voltage of that particular tap.
- Frequency variation of $+3\%$ to -5% of rated frequency.
- Combined voltage and frequency variation of 10% (absolute sum).

The transformers shall be free from annoying hum and vibration when it is in operation, even at 110% rated voltage. The noise level at rated voltage and frequency shall be as per NEMA-TR1 standard.

The transformers shall be suitable for over-fluxing (due to combined effect of voltage & frequency) up to 10% on any tapping without injurious heating at full load condition. The maximum flux density in any part of core and yoke under such condition shall not exceed 1.9 Tesla.

Generally, the Transformer shall have total efficiency not less than 98% at full load condition. Transformer shall be fitted with diagram and rating plates. The diagram plate shall show the winding connections and tapings in tabulated form.

Salient parameters of the transformers are as follows:

- Nominal system voltage (HV / LV): 11/0.433K V
- Vector group : Dyn11
- Temp rise in winding by resistance method: 60°C over 45°C ambient
- Parallel operation of transformer : Yes, only momentary
- Short circuit withstand duration : 2 seconds
- 11kV System fault level : 26.3kA for 3 sec
- 415V System fault level : 50kA for 1 sec

5.1.2.1 Windings

Transformers shall be connected as specified in design requirements. Winding shall comprise of high conductivity copper conductors completely impregnated and cast under vacuum in epoxy resin, fully insulated (with glass fibre reinforced epoxy insulation of very good electrical and mechanical quality), and shall be suitable for the highest system voltage. Winding shall be concentrically wound on the core, and shall be braced to withstand shocks, which may occur through rough handling during transport, switching and other transient condition during service, and also to reduce to a minimum the damage arising from stresses due to an internal fault. All windings shall be subjected to vacuum drying.

5.1.2.2 Core

Cores shall be built from best quality, low loss, cold-rolled, grain oriented electrical steel laminations conforming to relevant Indian Standard. All core sheets shall be to reduce the core loss to a minimum. The flux density in core shall not exceed 1.6 Tesla under over voltage conditions and to this effect calculations shall be submitted. Maximum current density shall not exceed 2.5A per sq.mm. All joints shall be interleaved and the core shall be

securely clamped so as to ensure that the noise level and the vibration are maintained at a minimum. All clamps shall be adequately insulated. The complete core shall be coated with special resin as a protection against corrosion.

5.1.2.3 Temperature Indicators

For measuring hot spot temperature in the winding, 150 mm dia dial type winding temperature indicator (WTI) with adjustable potential free alarm and trip contacts, maximum reading pointer and resetting device shall be provided. Temperature sensing element shall be complete with image coil, bushing CT etc. Accuracy class of WTI shall be $\pm 2^{\circ}\text{C}$ or better.

5.1.2.4 Bushings

All bushings shall be homogenous, non-porous porcelain type, uniformly glazed and free from blisters, burns and other defects complete with suitable terminal connectors of adequate capacity. Bushings located inside cable boxes / busduct flanges can be epoxy- molded types. Bushing CTs shall be provided as per system requirement. Secondary leads of CTs shall be wired upto-marshalling box. The arrangement shall be such that the CT can be removed from the transformer without removing the tank cover. Current transformers shall be cast resin type with Class E or better insulation.

5.1.2.5 Terminal Arrangement

Type of terminal connection shall be by Cables on both HV & LV side. The cable box shall be suitable for the working pressure of cable with which it is associated and shall have adequate clearances for the specified voltage and cable termination kits. For cable termination, terminals of transformer

shall be brought out through side wall mounted bushings to a detachable cable box with disconnect link. The cable box shall be self- supporting, weather-proof, air-filled type complete with all hardware such as undrilled gland plates, etc.

The design of the box shall be such as to preclude the access of water to the box. An adequate space shall be provided within the box so that the cable cores may be formed into the lugs without undue bending or stress on the lugs, and adequate clearance shall be preserved between live metal and frame such that the electrical pressure tests specified in Indian Standard are satisfied. Flexible links shall be provided between transformer terminals and cable lugs. Cable box shall have IP 55 degree of protection.

5.1.2.6 *Marshalling Box*

Marshalling box shall be sheet steel enclosed with IP 55 degree of protection alarm & trip contacts of all the fittings & accessories and secondary leads of CTs shall be wired up to marshalling box. Cable gland plate shall be of removable type. The marshalling box shall have isolated switch & MCB for incoming power supply. Cubicle illumination lamp with door switch and space heater with thermostat and ON/OFF switch shall be provided. The marshalling box shall have 10% additional set of control terminals.

5.1.2.7 *Grounding*

Two grounding pads, located on the opposite sides shall be provided for connection of station ground mat / overall earthing for each transformer. Grounding pads shall have clean buffed surface with tapped holes. M10 GI bolts, nuts and spring washers. Two ground terminals each shall be

provided on marshalling box & cable box. For neutral connection, two ground copper conductors of specified size shall be provided, supported on pin insulators (provided on tank) from neutral bushing to the bottom of the tank for connection to station ground.

5.1.2.8 Off Circuit Tap Changer

Off Circuit tap changers shall be provided on HV winding with $\pm 10\%$ range of taps in steps of 2.5%. The tap changing shall be affected by an external 3 phase gang operated tap change switch. The operating handle shall be padlocked at any position. The mechanism shall be provided with a mechanical tap position indicator, mechanical stop to prevent over cranking of mechanism etc. A warning plate indicating 'For de-energised operation only' shall be fitted.

5.1.2.9 Wiring and Terminal Blocks

All control cabinets, marshalling boxes, etc. shall be fully wired at the factory to ensure proper functioning of the control, protection and interlock schemes. All spare contacts of switches, relays and other devices shall be wired upto the terminal block.

Wiring shall be done with flexible 1100V grade HR PVC cables with stranded copper conductor of minimum size 2.5 sq.mm. Wiring shall be identified at both ends with ferrules bearing wire numbers as per approved drawings. Wire termination shall be made with crimping type connectors with insulating sleeves. Wires shall not be spliced between terminals.

Terminal blocks shall be of 1100 V grade suitable for terminating required cable size. Terminals for CT secondary shall have provision for shorting.

Not more than two wires shall be connected to any terminal. 20% spare terminals shall be provided. All devices and terminal blocks within the panel shall have identification numbers as per schematic diagram.

5.1.2.10 Nameplate

Each transformer shall be provided with a nameplate of weather-resistance material fitted in a visible position showing all the 'information and additional information' as per IS: 1117.

5.1.2.11 Fittings & Accessories

Each transformer shall be supplied with the following as a minimum:

- Two nos. Stainless steel Rating & Diagram (Hindi & English), terminal marking and danger plates.
- 3 earth terminals per transformer, each suitable for earth conductors of size 2 numbers 75x10mm GI strip for earthing of the body of the transformer and its enclosure.
- Lifting lugs for complete transformer and Core-coil assembly
- 6 numbers PT100 RTDs with Winding temperature indicator (WTI) display
- 4 nos. Jacking Pads
- 4 nos. Bi-directional Rollers / flanged wheels with stopper arrangement to lock transformer in required position
- 4 nos. cover lifting eyes
- Marshalling box
- Cable box
- 1 no. off circuit tap changer
- 3 nos. HV Bushings with terminal connectors
- 3 nos. LV Bushings with terminal connectors

- 1 no. LV Neutral Bushings with terminal connectors
- Platform mounting channel
- 1 set LV Neutral Bushing CTs
- 2 nos. Inspection covers
- 2 nos. support for HV cable box
- 1 Lot Interconnecting cables

5.1.2.12 Testing and Inspection

Transformer and all its fittings should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Transformer and all its fittings shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.1.2.13 Spares

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

5.2 LT SWITCHGEAR

This specification covers the requirements of 415 V Power Control Centre, Motor Control Centre, Main Lighting Distribution Boards, AC Distribution Boards, Lighting / Welding Distribution Boards, Starters, Local Push button stations etc. complete with all accessories. The switchgear and its components shall be designed for design ambient temperature of 45°C. Switchgear shall be designed for natural air cooling. No forced cooling is acceptable.

Auto/Manual/Planned Changeover scheme with synchronizing feature for various incomers and bus couplers shall be provided in Power Control Centre (PCC) / Motor Control Centre (MCC) for interlocking of Incomer breaker with upstream breaker. Incomer, bus-coupler & Outgoing breakers shall also be controlled from PLC (only provision to be provided since there is no PLC envisaged at this stage) in addition to Local operation from the panel.

- Short circuit withstands rating of the switchgear shall be as given in the attached SLD.
- 415V normal system shall be solidly grounded. 110V DC system shall be ungrounded.

Busbar, breaker and other components shall be designed for continuous operation at rated current considering temperature inside the cubicle. The continuous current rating of the bus bars, incomers, bus couplers of the MCC shall be the maximum load on the bus due to all the running auxiliaries during any operating condition plus 20% margin rounded off to the next higher standard rating. Maximum current density for Aluminium busbars shall be considered as 1.0 Amps/mm² and for copper busbars as 1.25 Amps/mm².

Close & Open control of all the motors in PCC/MCC shall be provided in PLC (provision only at this stage) in addition to Local Push Button Station (in the field) and from the panel. Local operation of circuit breakers shall be possible in "Test" position. Remote indications / alarms shall be provided in the PLC (provision only at this stage). The control / interlock schemes for various types of feeders shall commensurate with their application.

PCC & MCC shall be of draw out type for all the modules including breaker modules/ Starter module/SFU module. Distribution boards shall be of fixed type. All PCC/MCC/DB shall be single front type. 220V control supply shall be derived from 415/220V control supply transformer located in respective module. 240V AC space heater supply provision shall be provided for motors rated above 30 kW. For breaker operated feeders, control supply voltage shall be 110V DC.

At least 20% of feeder modules covering the range of motors used subject to minimum of one module in each bus section shall be provided as spare. Spare modules shall be completely wired up.

All motors shall have direct on-line starter. 90kW and above capacity motors shall be fed from ACBs. Less than 90kW capacity motors shall be fed by MCCBs and contactors. However, the duty of the drive/application, i.e., high impact loading, etc. to be considered as criteria for selecting ACB operated motors even for rating < 90kW. Wherever applicable, priority shall be given to the use of Motor Protection Circuit Breaker (MPCB) with Contactor.

Operating height of the handles/switches shall be limited to a maximum of 1800 mm and a minimum of 300 mm.

For PCC changeover shall be provided. If there is an under voltage (dipped to 30-40% voltage) on any one of the buses, sensed through under voltage relays, the respective incomer breaker shall trip automatically and the bus coupler shall close, if the voltage is available on the other bus section, thereby establishing voltage at 415V motor terminals before motor reaches

standstill condition. The auto changeover shall be blocked if any of the following condition exists:

- Any of the involved breaker is in the test or withdrawn position.
- Source voltage is not available.
- Source breaker is tripped due to bus fault.

No release is acceptable for Breaker feeders. Only CT operated relays shall be provided for protection. MCCB, Contactor and overload relay shall meet type-2 co-ordination as per applicable standard.

5.2.1 DESIGN AND CONSTRUCTION

5.2.1.1 PCC / MCC

415 V panels shall be of metal enclosed, indoor, floor-mounted, free-standing type. Switchboard frames and load bearing members shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. Doors and covers shall also be of CRCA sheet steel of thickness not less than 1.6 mm. Thickness of gland plates shall not be less than 3.0 mm for sheet steel & 4.0mm for non-magnetic material. All switchboards shall be of dust-proof and vermin-proof construction and shall be provided with IP54 degree of protection. Outdoor switchgear enclosures should have minimum IP55 degree of protection for covered area and IP65 for uncovered area.

All switchboards shall be of uniform height not exceeding 2450 mm. Switchboards shall be easily extendable on both sides by the addition of vertical sections after removing the end covers. Module size of switchboards shall not be less than 200mm. Cable entry for PCCs/MCCs/DBs shall be from bottom.

Switchboards shall be divided into distinct vertical sections (panels), each comprising of the following compartments:

- Main busbar compartment:
- Switchgear / feeder compartment
- Cable alley
- Auxiliary busbar compartment
- Control compartment for relays for ACB feeder

The feeder compartment shall be sheet steel enclosed on all sides with the withdrawable units in position or removed. The front of the compartment shall be provided with the hinged single leaf door with captive screws for positive closure. All circuit-breaker panels shall be of single-front type. All single-front switchboards shall be provided with single- leaf, hinged or bolted covers at the rear. The bolts shall be of captive type. The covers shall be provided with “DANGER” labels.

All 415 V circuit-breaker modules and MCC modules shall be of fully draw-out type having distinct ‘Service’ and ‘Test’ positions. The equipment pertaining to a draw-out type module shall be mounted on a fully withdrawable chassis, which can be drawn out without having to unscrew any wire or cable connection. Suitable arrangement with cradle / rollers and guides shall be provided for smooth movement of the chassis.

5.2.2 Main Lighting Distribution Board (MLDB) / AC Distribution Board (ACDB)

MLDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. MLDBs shall be provided with separate chambers for (i) bus bars (ii) outgoing

feeders (iii) incoming feeders (iv) cabling chamber. MLDBs shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation.

ACDB shall be totally enclosed, sheet steel, indoor, dust tight, vermin proof and floor mounting type. The sheet metal thickness shall be 2mm. ACDB shall be provided with separate chambers for (i) bus bars (ii) outgoing feeders (iii) incoming feeders (iv) Dry type transformer (v) cabling chamber. ACDB shall have degree of protection of IP-54 for indoor and IP-55 for outdoor installation. ACDB shall be provided with 415/415V, 3 phase dry type transformer of suitable capacity to obtain 3 phases, 4 wire system and to limit the fault level to 3KA. The capacity of the transformer shall be decided such that there is at least 20% margin over the total lighting load.

MLDB & ACDB shall be provided with one TPN MCCB for incomer feeder and required number of 3phase outgoing feeders with TPN MCB's and two Nos. Spare feeders. CT operated ammeters and Voltmeter and indicating lamps shall be provided for incomers.

5.2.3 Lighting Distribution Boards (LDB)/ Control Distribution Board (CDB)

Distribution boards shall be metal enclosed, fixed type, single front, and compartmentalized construction. The Distribution board frame shall be fabricated using CRCA sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by CRCA sheet steel of thickness not less than 1.6 mm. Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin-proof with a degree of protection of IP54 for indoor and IP55 for outdoor installation. The handle of incoming switch shall be mounted on the door of the board, with padlocking facility in both 'ON' and 'OFF' positions. Cable entry facilities shall be provided with

removable gland plates of suitable thickness. All incoming and outgoing cables shall be terminated on suitable terminal blocks.

For lighting circuits, Lighting Distribution Boards (LDBs) shall be provided and for welding receptacle circuits, separate Power Distribution Boards (PDBs) shall be provided.

5.2.4 Air Circuit Breakers

Air Circuit breakers shall be (three pole for motor feeders and TPN for other feeders), air brake, horizontal draw-out type, and shall have fault making and breaking capacities as specified. These shall be microprocessor based with RS 485 communication facility. There shall be “SERVICE”, “TEST” and “ISOLATED” positions for the breakers. In “Test” position, circuit breaker shall be capable of being tested for operation without energizing the power circuits i.e. power contacts shall be disconnected, while the control circuits shall remain undisturbed. Locking facilities shall be provided so as to prevent movement of the circuit breaker from the “SERVICE”, “TEST” or “ISOLATED” position. It shall be possible to close the door in “Test” position.

Each breaker feeder shall be provided with the following as a minimum:

- Electrical anti-pumping feature
- Motor charged spring operating mechanism.
- Manual spring charging
- Mechanical indication of spring charge
- Mechanical position indicator
- Closing coil
- Shunt trip coil

- Manual trip push button
- Operation counter
- Phase barriers
- Shutter assembly
- Door interlock kit

The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 80 and 110 percent of the rated voltage. The closing coil & shunt trip coil shall be rated for 100% continuous duty. One Open-Close-Open operation of the circuit breaker shall be possible after failure of power supply to motor. For breakers spring charging motor shall be provided with over current protection. Motor windings shall be provided with class B insulation or better. The shunt trip coil shall operate satisfactorily, all the values of control supply voltage between 70 and 110 percent of the rated voltage.

Circuit breaker of the same type and ampere rating shall be wired alike and shall be mechanically interchangeable.

All Air Circuit Breakers shall be provided with the following interlocks:

- Movement of a circuit breaker between “SERVICE” and “TEST” position shall not be possible unless it is in open position.
- Closing of a circuit breaker shall not be possible unless it is in “SERVICE” position, “TEST” position or in “ISOLATED” position.
- Once the closing springs are discharged, after one closing operation of circuit breaker, it shall automatically initiate recharging of the spring.

Telescopic trolley or suitable arrangement shall be provided for maintenance of circuit- breaker module in a cubicle. The trolley shall be such that the topmost breaker module can be withdrawn on the trolley and

can be lowered for maintenance purpose. ACBs shall have CT operated relays for over current and earth fault protection.

Following shall be provided for each breaker feeders

- Electrical anti pumping feature (94)
- Hand reset High speed lockout relay (86)
- Trip circuit supervision relay (95)
- Aux relay for breaker contact multiplication (52X)
- Aux relays as required for contact multiplication
- Indicating lamps for ON, OFF, Auto trip, spring charged, Trip circuit healthy, DC supplyfail etc.
- Breaker control switch
- Local / Remote / Test selector switch
- Test Terminal blocks

ACB incoming feeders for PCC from transformers shall be provided with the following as a minimum.

- TPN Air Circuit Breaker
- Current transformers for metering & protection
- Digital Ammeter & Ammeter transducer
- Fuse/MCBs for control circuits
- Voltage transformers, Digital voltmeter & voltage transducer
- Under voltage relay with timer
- Microprocessor based multi-function meter with communication facility
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

ACB Bus coupler for PCC from transformers shall be provided with the following as a minimum:

- TPN air circuit breaker
- Current transformer for protection & metering
- Fuse/MCBs for control circuits
- Numerical three phase overcurrent (instantaneous & IDMT) and earth fault relay

Unidirectional motor feeders rated less than 10 kW shall be provided with the following as a minimum:

- Triple pole motor protection circuit breaker (MPCB)
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Interposing relays

Unidirectional motor feeders rated 10kW and up to 30kW shall be provided with the following as a minimum:

- Triple pole MPCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Push buttons.
- Indicating lamps LED cluster type
- MCB for control circuit
- Current transformer for metering
- Digital Ammeter

- Interposing relays

Unidirectional motor feeders rated above 30kW and less than 125kW shall be provided with the following as a minimum:

- Triple pole MCCB
- Triple pole contactor
- Auxiliary contactors
- LOCAL/REMOTE selector switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons
- Indicating lamps LED cluster type
- Numerical Motor protection relay
- MCB for 240V AC space heater circuit
- MCB for control circuit
- Current transformer for metering
- Current transducer
- Digital Ammeter
- Interposing relays

Unidirectional motor feeders rated 125 kW and above shall be provided with the following as a minimum:

- Triple pole Air Circuit Breaker
- Current Transformer for metering & Protection
- Numerical Motor protection relay
- Fuse/MCBs for control circuit
- Indicating lamps LED cluster type
- MCB for 240V AC space heater circuit

- MCB for control circuit
- Current transducer
- Digital Ammeter
- Interposing relay

Bi-directional Motor feeders shall be provided with the following as a minimum: (Not applicable for Integral Actuators)

- Triple pole MCCB
- Triple pole mechanically interlocked, open / close contactors
- Auxiliary contactors
- Local/Remote/Test switch
- Bimetallic thermal overload relay with single phasing preventer
- Push buttons.
- Indicating lamps LED cluster type
- MCB for space heater circuit
- MCB for control circuit
- Interposing relays

5.2.4.1 Moulded Case Circuit Breaker (MCCB)

MCCB shall in general conform to IS: 13947 Part-2. MCCBs shall be provided with thermo- magnetic type release for over current and short circuit protection. These shall be microprocessor based with RS 485 communication facility. The setting of the thermal release shall be adjustable from 75% to 100% of the rated current. The MCCB shall have breaking capacity not less than 50kA. MCCBs used for incomers and Bus coupler shall be equipped with stored energy mechanism for electrical

closing and tripping. All other MCCBs shall be manually operated. The operating handle should give a clear trip indication.

5.2.4.2 Control and Selector Switches

Control and selector switches shall be of rotary type, with escutcheon plates clearly marked to show the function and positions. Circuit breaker control switches shall have three positions and shall be spring return to "NEUTRAL" from "CLOSE" and "TRIP" positions and shall have pistol grip handles. Circuit breaker selector switches shall have three stay put positions marked 'Test', 'Local' and 'Remote', respectively. They shall have black spade handles. Selector switches for starter modules shall have 'Test', 'Local', 'Remote' positions as specified.

5.2.4.3 Contactors

Motor starter contactors shall be air brake, electromagnetic type rated for uninterrupted duty. Contactors shall be double-break, non-gravity type and their main contacts shall be silver faced. Direct-on-line contactors shall be of utilization category AC3. Reversing starters shall comprise of Forward and Reverse contactors mechanically and electrically interlocked with each other. These contactors shall be of utilization category AC4. The contactor shall operate satisfactorily from 85% to 110% of the rated voltage. The contactor shall not drop out at 70% of the rated voltage but shall definitely drop out at 20% of the rated voltage.

5.2.4.4 Instrument Transformers

The CTs shall be mounted on the switchgear stationary parts. For metering separate core shall be provided. The CTs shall be of cast resin, bar primary type and of Class E or better insulation. CT secondary current shall be 1A.

Accuracy class of Current Transformer shall be Class 5P20 for relaying and Class 0.5 and ISF < 5 for metering. CTs for current rating less than 50A shall be 'Wound primary' type and above 50A shall be 'Bar primary' type.

Voltage Transformer shall be cast-resin, draw-out type and shall have an accuracy class of 1.0. The bus VTs shall be housed in a separate compartment. All VTs shall have readily accessible fuse and MCBs on primary and secondary sides respectively.

5.2.4.5 Indicating Instruments

All Indicating meters shall be digital type, 96 x 96 mm size, suitable for flush mounting with constant accuracy for the entire range of respective parameters with an inbuilt provision for calibration verification. The instruments shall have an accuracy class of 1.0. All such meters shall be fed through suitable Current transformers for motors rated 10kW & above. All Multifunction meters shall have digital display and communication port with true RMS measurement facility with minimum 1% accuracy level.

5.2.4.6 Push Buttons

Push-buttons shall be of spring return, push-to-actuate type. Where specified push buttons shall be stay put type. Their contacts shall be rated to make, continuously carry and break 10A at 500 V AC. All push-buttons shall have two normally open and two normally closed contact, unless specified otherwise. The contact faces shall be of silver alloy. All push-buttons shall be provided with integral escutcheon plates marked with its function. All emergency push-buttons shall be stay put/latching type. To detach, master key provision shall be provided.

The colour of the button shall be as follows:

- Green for motor START, breaker CLOSE, valve / damper OPEN /CLOSE commands.
- Red for motor TRIP, breaker OPEN.
- Black for all annunciator functions, overloads reset and miscellaneous commands.

5.2.4.7 Indicating Lamps

Indicating lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. All indicating lamps shall be rated for continuous operation at 85% to 110% of their rated voltage. Low Voltage Glow Prevention (LVGP) feature shall be provided for indication lamps. Lamps shall have translucent lamp-covers of the following colours, as warranted by the application:

- Red for motor ON, breaker CLOSE.
- Green for motor OFF, breaker OPEN.
- Blue for Service
- White for Test, Spring Charged, Spring Discharged, Lockout Relay Healthy
- Amber for auto trip

5.2.4.8 Control Supply and Space Heater Supply

The breaker operated PCC/MCC shall receive two nos. 110V DC feeder for the control supply and distribute to each panel. Auto changeover arrangement shall be envisaged between two supplies. Each panel shall receive control supply through bus wires and shall be tapped off through switch & fuse provided in the respective panel. It shall be possible to isolate any panel without disturbing the power supply to other panels. Each

sub circuit shall have separate fuse. An under-voltage relay to monitor control supply shall be provided. A contact of the relay shall be wired to the terminal for external use. 'Control Supply Failed' indication shall be provided.

Each starter module of MCC shall derive 220V AC control supply through control supply transformer. The control transformers shall be of insulation class 'B' or better. The sizing of control transformers shall be carried out by the contractor considering the actual load of power contactors, auxiliary contactors, indicating lamps and other equipment including remote auxiliary relays and lamps in the circuit.

For space heater circuits of motor rated more than 30kW and also for panel space heater, 240V AC supply shall be provided by tapping from the incomer before the main isolating switch/breaker. Necessary switch and MCB to isolate and distribute the supply to each panel shall be provided. For motor feeders, circuit for motor space heater shall be wired through NC contact of breaker/contactors and MCB.

Each panel of PCC/MCC/DB shall be equipped with the following as required:

- Thermostatically controlled space heater(s)
- Illumination lamp with door switch
- 5A 3pin socket with MCB protection

5.2.4.9 Wiring

All switchboards shall be supplied completely wired internally upto the terminals, ready to receive external cables. All internal wiring shall be

carried out with 1100 V grade, HR PVC/ XLPE insulated single core, copper conductor of minimum 2.5 sq.mm for CT circuits and 1.5 sq.mm for other circuits. All internal wiring terminations shall be made with solder less crimping type tinned copper lugs. Insulation sleeves shall be provided over the exposed parts of lugs. Engraved core identification plastic ferrules marked to correspond with panel wiring diagrams shall be fitted at both ends of each wire. Number 6 and 9 shall not be used for wire identification.

Control terminal blocks shall be of 1100 Volts grade, rated for 10 Amps and in one piece moulding. It shall be complete with insulating barriers, clip-on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. Terminal blocks for CT & VT secondary leads shall be provided with test links & isolating facilities. CT secondary leads shall be provided with short circuiting & earthing facilities. In all the panels at least 20% spare terminals for external connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks.

5.2.4.10 Power Cable Termination

Cable termination compartment and arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC / XLPE insulated, armoured and FRLS PVC sheathed cables. All power cable terminals shall be of stud type and the power cable lugs shall be of tinned copper solderless crimping ring type conforming to IS:8309. All lugs shall be insulated / sleeved.

5.2.4.11 Nameplates and Labels

PCCs, MCCs, Distribution Boards, local push-button stations and local motor starters shall be provided with prominent, engraved identification plates. The module identification plate shall clearly give the feeder number and feeder designation. For single front switchboards, similar panel and board identification labels shall be provided at the rear also. All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Suitable stenciled paint mark shall be provided inside the panel/module for identification of all equipment, in addition to the plastic sticker labels, if provided. These labels shall be positioned so as to be clearly visible and shall have the device number, as mentioned in the module wiring drawings. Caution name plate “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation is possible only at remote end.

5.2.4.12 Busbars and Insulators

Each PCC/MCC & DB shall be provided with three phase and neutral busbars. DC distribution boards shall have two busbars. All busbars and jumper connections shall be of high conductivity aluminium alloy for PCC/MCC and Copper for DB of adequate size. The cross-section of the busbars shall be uniform throughout the length of switchboard. Interleaving of PCC busbar arrangement shall be envisaged. All busbars shall be adequately supported by non-hygroscopic, non-combustible, track-resistant and high strength sheet moulded compound or equivalent type polyester fiber glass moulded insulators. All busbar joints shall be provided with high tensile steel bolts, Belleville/ spring washers and nuts. All copper to

aluminium joints shall be provided with suitable bi-metallic washers. All busbars shall have HRPVC sleeves and colour coded.

Contact surfaces at all joints shall be silver plated or properly cleaned and anti-oxide grease applied to ensure an efficient and trouble-free connection. Suitable bimetallic connectors shall be used for dissimilar metal connections.

The continuous rating of the main busbars shall be same as that of the incomer breaker, and busbar shall carry this continuous current without exceeding the temperature of 90°C. For silver plated joints, temperature shall not exceed 105°C. All horizontal and vertical busbar joints shall be covered by insulating shrouds.

5.2.4.13 Earthing

A copper/ Aluminium earthing bus of adequate size shall be provided at the bottom and shall extend throughout the length of switchgear. It shall be bolted to the framework of each panel and each breaker earthing contact bar. The earth bus shall be sized to withstand specified short circuit current. The truck and breaker frame shall get earthed while the truck is being inserted in the panel and positive earthing of the truck and breaker frame shall be maintained in all positions i.e., 'Service', 'Test' and 'Isolated' as well as throughout the intermediate travel.

All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus. All hinged doors shall be earthed through flexible earthing braid. VT and CT secondary neutral point earthing shall be at one place only on the terminal block. All metallic cases of relays, instruments

and other panel mounted equipment shall be effectively bonded to the earth bus by independent stranded copper wires of size not less than 2.5 sq.mm.

5.2.4.14 Local Push Button Stations

The local push buttons stations shall be with FRP enclosure, suitable for outdoor mounting on wall or steel structures. The local push button stations shall be dust and vermin proof and shall have a degree of protection of IP55 as per IS: 13947 Part-1. Local push button stations shall comprise Start/Stop push buttons as per drive control philosophy. Emergency stop Push-buttons shall be stay put/Latching type, requiring master key for de-latching.

5.2.4.15 Testing and Inspection

Switchgear and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Switchgear and its components shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.2.4.16 Spares

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

5.2.5 110V DC SYSTEM

This specification covers the requirements of 110V DC Batteries, Chargers and DC Distribution Board. The function of the 110V DC Power Supply

System is to provide the normal source of power to the 110V DC loads, such as Control Supply to Switchgears / Panels.

The duty cycle imposed on the battery shall include the following:

- Continuous loads (indicating lights, continuously energized coils, Control Panels, Relays)
- Momentary loads (switchgear operation (Trip coil/Closing coil), which exist for a period of less than 1 min period)

110 VDC Power Supply System shall be operated as an ungrounded system; that is, the negative terminal or ground reference terminal is not connected to the station ground grid. A DC ground monitoring system on the DC systems shall be provided and any DC ground fault shall be alarmed.

Batteries shall be sized in accordance with IEEE-485. The battery shall be sized with a 10% design margin and an ageing factor of 1.25. 110V DC Power Supply System shall consist of 1x100% 110V batteries, 1x100% 110V battery charger cum DC Distribution Board. End Cell Voltage of Lead Acid Plate battery shall be considered as 1.85 V / Cell and for Nickel cadmium battery as 1.14V / Cell. During Normal operating condition, batteries shall be supplied from one (1) 100 percent battery charger. The chargers are supplied power from PCC/ MCC. The battery charger shall supply power to 110V DC loads and, at the same time, shall continuously float charge fully charged batteries. Both the chargers shall have dedicated incoming AC supply from MCC/PCC. During Emergency operation the battery shall supply the DC load when there is a loss of all auxiliary AC power supplies and/or a loss of power from the battery chargers. Batteries

shall normally be permanently connected to the load in parallel with a charger and shall supply the load during emergency condition when AC supply is lost.

The Charger shall be float cum boost type suitable for float charging both the batteries and supply load simultaneously. Chargers shall boost charge fully discharged batteries in 12 hours. Design margin of minimum 20% shall be considered in charger sizing for either mode of operation. Charger protections such as DC-O/V & U/V, AC U/V, E/F, S/C protection etc. shall be considered.

5.2.5.1 Construction of Battery

Lead Acid (Valve regulated) sealed maintenance free Plate type batteries shall be float charged at 2.15 to 2.20 Volts per cell and chargers shall also be capable of boost charging the associated DC battery up to 2.7 Volts per cell at the desired rate. Batteries shall be rated for 10-hour discharge rate (C10) as per manufacturer data. Containers shall be made of suitable glass fibre reinforced plastics or Polypropylene. Containers shall be robust, heat resistant, leak proof, non-absorbent, acid/alkaline resistant, non-bulging type and free from flaws such as wrinkles, cracks, blisters, pin holes etc.

Batteries shall have thick plates designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion. The positive and negative terminals shall be clearly marked. Each cell shall be separately supported on porcelain insulators fixed on to the racks with

adequate clearance between adjacent cells. Breathers/Vent plugs etc. shall be provided for each cell. It shall be anti-splash type and having more than one exit hole to allow the gases to escape freely but prevent the acid spray from the battery. Lead coated copper inter-cell connectors shall be used for connecting up adjacent cells and rows. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. All the terminals and cells, interconnections shall be fully insulated or have insulation shrouds/covers.

End take off connections from positive and negative poles of batteries shall be made by single core cables having stranded copper conductors and PVC/XLPE insulation. Necessary supports and lugs for termination of these cables on batteries shall also be supplied. All connectors and lugs shall be capable of continuously carrying the 60-minute discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared. Anti-corrosive gel shall be applied at the Battery terminals.

Wooden racks shall be provided for batteries for multi-tier installation. These racks shall be made of good quality first class seasoned teak wood. They shall be free standing type mounted on porcelain insulators. Numbering tags, resistant to acid for each cell shall be attached on to the necessary racks. The bottom tier of the stand shall not be less than 150 mm above the floor.

Following accessories shall be provided with batteries.

- Syringe type Hydrometer : 2 Nos per Battery

- Thermometer with specific gravity correction scale: 2 Nos per Battery
 - Cell testing voltmeter 3-0-3 volts : 2 Nos per Battery
 - Acid resistant funnel: 2 Nos per Battery
 - Acid resistant jug. : 2 Nos per Battery
 - Rubber apron and gloves : 2 sets per Battery
 - Spanners : 2 sets per Battery
 - Wall mounted teak wood rack for above items : 2 Nos per Battery
- Following maintenance spares shall be provided as a minimum:

- Inter cell connectors: 10 Nos.
- Inter row connectors : 2 Nos.
- Battery stand insulators : 2 Nos
- Cell insulators : 2 Nos
- Nuts, bolts & washers : 10 pieces each
- Vent plugs : 10 Nos.
- Spare dry cell : 4 Nos.

Fuse box for each battery shall be provided in the battery room and shall comprise the following:

- DP Fuse Switch unit
- HRC Fuses with striker pin & aux contact for remote alarm
- FRP enclosure.

Discharge resistor made of punched stainless-steel grid enclosed in sheet steel enclosure shall be provided for discharge testing of Battery.

5.2.5.2 Construction of Battery Charger cum DCDB

During float charging, charger shall feed the respective DC Distribution board and as well as float charge its own batteries and maintain a DC voltage that shall pass the minimum current through the cells to keep them

charged without overcharging. In case of mains failure to charger or charger failure, battery shall supply the full load. While boost charging of respective battery, DCDB shall be isolated from the Charger and shall be fed from another Charger. Each Battery charger should meet the Trickle requirement of both banks (under emergency) and boost requirement of each bank.

During boost charging, battery charger shall operate on constant current mode (when automatic regulator is in service). It shall be possible to adjust the boost charging current continuously over a range of 50 to 100 % of the rated output current for boost charging mode. During boost charging, the Boost charger shall recharge the completely discharged battery to full capacity in 12 hours.

When on automatic control mode during float charging, the charger output voltage shall remain within $\pm 1\%$ of the set value for AC input voltage variation of $\pm 10\%$, frequency variation of $\pm 3\%$, a combined voltage and frequency (absolute sum) variation of 10 % and a continuous DC load variation from zero to full load. Uniform and step-less adjustments of voltage setting (in both manual and automatic modes) shall be provided on the front of the charger panel covering the entire float charging output range specified. Battery chargers shall have a selector switch for selecting the battery charging mode i.e., whether float or boost charging.

All Battery chargers shall be provided with facilities such as automatic voltage regulator (AVR) for both automatic and manual control of output voltage and current. The chargers shall be self-regulating, natural air cooled, static type provided with suitable double wound transformer, full wave thyristor type rectifiers, filter circuits, DC & AC Switchgear. Chargers

shall be metal enclosed, fixed type, suitable for indoor mounting on floor. Panel frame shall be fabricated using cold rolled sheet steel of thickness not less than 2.0 mm. The frames shall be enclosed by cold rolled sheet steel of thickness not less than 2.0 mm. Suitable synthetic rubber gaskets shall be provided to achieve a degree of protection of IP54.

Rectifier transformer shall be continuously rated, dry type, class F insulation, epoxy resin impregnated, Air Natural (AN) cooling and with adequate number of taps. The rating of rectifier transformers shall correspond to the rating of the associated rectifier assembly.

All the Charger panels shall be provided with an illuminating CFL lamp, a 5 Amp socket and space heaters with thermostat. Toggle switches and MCB's shall be provided separately for each of the above fittings. Space heaters "ON" indication to be provided. Two separate grounding pads shall be provided.

Locking facilities shall be for locking float / boost selector switch in the float position only.

Digital type Window annunciator shall be provided for alarm annunciation with acknowledge, test & reset push buttons and a buzzer for the following conditions:

- SCR fuse fail
- Battery / DC system under voltage
- DC system over voltage
- DC over load
- Output fuse blown

- AC supply fail
- AC under voltage
- Battery earth fault
- Filter fuse failure
- Battery on Float / Boost
- Charger fail/Battery on discharge
- Any other annunciation, as required

Remote alarm contacts for hooking up to PLC shall be provided. For each charger, current & voltage transducer shall be provided for remote monitoring of DC voltage and Current at PLC.

Protection features, indications, meters and alarms shall be provided for each charger. Protection features shall include the following as minimum.

- Overload Protection
- Phase failure protection
- Voltage unbalance protection
- Fuse failure protections for SCR and filter circuit

Suitable potential free contacts for remote indication of above abnormal conditions shall be provided. However, the requirements / design shall be firmed up during the detailed engineering stage.

5.2.5.3 Testing and Inspection

Battery & Charger and all its components should have been type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Battery & Charger shall be subjected to routine tests as per applicable Indian Standard. In addition, any special test required shall also be performed. Test reports shall be submitted for approval.

5.2.5.4 Spares

Suitable number of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

5.2.6 Power and Control Cables

Power cables shall be sized to satisfy the following Criteria:

- Short circuit withstand capacity for applicable fault current and duration.
- Full load current carrying capacity under installation conditions considering Site ambient temperature & site installation (Grouping) conditions based on Manufacturer's recommendation.
- Permissible voltage drops limits under steady state/transient state as applicable.

Power cables shall withstand fault current of the circuit for the duration not less than the maximum time taken by the primary protective system to isolate the fault. Cables shall be sized for the following short circuit rating.

- Outgoing cables from 11kV Switchboards: 26.3 kA for 0.16 sec.
- Incoming cables to 415V PCC (Breaker operated): 50 kA for 1 sec.
- Incoming cables to 415V MCC (Breaker operated): 50 kA for 0.5 sec.
- Incoming cables to 415V MCC/DB (MCB protected): Fuse cut-off current for 10m.sec
- Cables from 415 V MCC to Motors: 50 kA for 0.16 sec ACB operated
- Feeders from MCC/DB (MCB protected): Fuse cut-off current for 10msec

To maintain voltage at motor terminals / equipment end within desirable limit, it is proposed to limit the voltage drop in the cables within the following limits:

- Steady state Voltage drop (Continuous running condition): 2.5%
- Transient state voltage drops (During Motor Starting) : 10 %

All cables shall be suitable for laying on racks, in ducts, trenches with chances of flooding by water and shall also be suitable for directly buried installation. All the cables shall be flame retardant low smoke (FRLS) type designed to withstand mechanical, electrical and thermal stresses developed under steady state and transient operating conditions.

The minimum size of LV power cable shall be of 2.5 Sq.mm for Copper. Power cables shall have copper conductor for sizes up to 10 sq.mm. For higher sizes, aluminium conductor shall be provided. The minimum size of control cable shall be of 1.5 Sq.mm copper. For CT/VT circuits, minimum 2.5 sq.mm copper cable shall be provided. Conductor of Copper cables shall have plain annealed copper. All the conductors shall be multi-stranded.

Power cables shall be XLPE insulated. Control cables shall be PVC insulated. PVC insulation shall be suitable for continuous conductor temperature of 70°C and short circuit conductor temperature of 160°C. XLPE insulation shall be suitable for continuous conductor temperature of 90°C and short circuit conductor temperature of 250°C.

The cable cores shall be laid up with fillers between the cores wherever necessary. All the cables shall have distinct extruded PVC inner sheath. For single core armoured cables, armouring shall be of aluminium wire. For multicore armoured cables, armouring shall be of galvanised steel strip/wire

as per applicable IS. Outer sheath shall be of PVC black in colour having following FRLS properties.

- Oxygen index of not less than 29.
- Acid gas emission of max. 20%
- Smoke density of not more than 60%

The cables shall meet flammability test as per IEEE – 383. All the cables shall be protected against rodent and termite attack. Necessary chemicals shall be added in to the PVC compound of the outer sheath.

5.2.6.1 Construction

A) HT cables

Cables shall be XLPE insulated, screened, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-II. 11kV cables shall be suitable for unearthed system. The conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied along with the XLPE insulation in a single operation of triple extrusion process. The metallic screen of each core shall consist of copper tape with minimum overlap of 20% copper screen which shall be capable of carrying the system earth fault current for 2 seconds. Outer sheath shall be FRLS PVC.

B) LV Power cables

LV Power cables shall be of 1.1 kV grade, XLPE insulated, PVC inner sheathed (extruded), armoured, FRLS PVC outer sheathed, stranded aluminium conductor conforming to IS: 7098 Part-I.

C) Control cables

Control cables shall be of 1.1 kV grade, multicore, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed stranded copper conductor conforming to IS:1554 Part-I. Up to 5 cores it shall be colour coded and above 5 cores shall be numbered.

D) Trailing cables (if applicable)

Trailing cables / Flexible cables shall be rubber insulated with copper conductor as per applicable standards. The minimum size of LV power cable shall be 4 Sq.mm for Copper.

5.2.6.2 Cable identification system

In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed over outer sheath.

- Cable size and voltage grade.
- Word 'FRLS' at every 5 metre.
- Sequential marking of length of the cable in meters at every one metre.

The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

5.2.6.3 Cable Drums

Cables shall be supplied in wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with waterproof layer. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps, secured by 'U' nails so as to eliminate ingress of water during transportation, storage and erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418.

5.2.6.4 Testing and Inspection

Cables offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished.

Routine tests, Acceptance tests and all special tests for FRLS properties shall be carried out for all the cables as per applicable standards. The sample shall be drawn at the rate of one per type and size for every lot offered for inspection.

5.2.6.5 Special Tests

The following tests as applicable to FRLS sheathed cables shall be conducted as type tests on each size of each lot.

- Oxygen index test
- Temperature index test
- Acid gas generation during fire
- Smoke generation test under fire
- Swedish chimney test for class F3 as per SS: 424-14-75
- Under fire conditions for bunched cables as per IEEE std. 383 / 74

5.2.6.6 Spares

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

5.2.7 Lighting System

This specification covers the requirements of Illumination system. The lighting system includes

- 100% Normal AC lighting
- Emergency lighting shall consist of aesthetically designed rechargeable

5-Watt LED lantern with dimming and SOS feature in selected areas of the plant during plant emergency conditions.

Normal AC Lighting shall be energised from 3-phase, 4-wire, 415 V main lighting distribution board. These MLDBs shall feed Lighting Distribution Boards (LDB) for each individual area. Dry type lighting transformers of voltage ratio 1:1 shall be provided for reducing fault level in MLDB. The single-phase voltage level considered for lighting system & fixtures shall be optimally arrived to achieve energy efficiency without sacrifice in the illumination level. Lighting transformer tap range & tap step to be designed accordingly.

Emergency lighting shall be provided in specific areas such as Control rooms, areas near local panels, staircases and other strategic areas during AC supply failure. Emergency lighting shall normally be “off,” and upon loss of normal AC supply, emergency lights shall be turned “on” in auto mode. Emergency lighting units with integral batteries shall be used. Emergency lighting unit shall provide light for one hour when the normal power source is lost. Each emergency light unit shall be provided with battery, battery charger and one number 5-watt LED lamps. Exit light fixtures shall be LED and provided in all the building at exit doors.

LED lamps shall be used as light sources in the lighting system.

Fixtures considered shall be energy efficient type with low loss & low harmonics (less than 10%) and with higher lumen / watt.

Emergency lighting luminaries shall be supplied to ensure a safe exit in case of power failure. Emergency light shall be with dimming and SOS feature. Each shall be connected to the 240 V supply system and shall

automatically switch to the battery in case of power supply failure. The battery shall be able to supply power to the lamps for a minimum of 1.0 hour.

Enclosure of all fittings shall be of weather & dust-proof construction and consist of cast aluminium body able to withstand direct hosting.

AC lighting fixtures and accessories shall be suitable for operation on 240 V AC, 50 Hz supply with supply voltage variation of $\pm 10\%$, frequency variation of $+3\%$ to -5% and combined voltage and frequency variation of absolute sum of 10% .

Lighting level design shall include a Maintenance factor as follows to account for lamp lumen depreciation, luminaries surface dirt and room surface dirt, etc.

- Air-conditioned areas : 0.8
- Non-Air-conditioned areas : 0.7
- Dust prone outdoor Areas : 0.6

All receptacles shall be of high-quality Polyamide P-6 body (shock proof, rust free, corrosion free, acid and chemical resistant, fire retardant, having high impact, made of halogen and silica free recyclable material) & terminals with Solid high-quality turned contacts made of copper alloy (Brass). All steel components (screws, springs etc) shall be Zinc plated & blue-chromed or nickel plated. For each contact double screws shall be available to give better cable strain relief. It shall be heavy duty type, IP67 suitable for fixing on wall/column and complete with individual switch.

In general, the receptacles to be installed shall be of the following type:

Power Socket - 15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building & Local Control rooms etc.

Welding Socket - 63A, 415V, 3 Ph, 4 Wire, 5 pin interlocked plug and switch with earthing contact to be used in transfer towers and along the Conveyor length. Other requirements shall be same as type RA. Welding sockets shall not be connected to lighting distribution board and shall get supply from feeders in the MCC/ACDB/PDB. For long conveyor feeders shall be provided from MCC/ACDB/PDB at head end (for 50% load) and from tail end (for 50% load) at interval of 100M.

Suitable number of 63 ampere, 3 phase, 415-volt AC welding receptacles shall be provided. Welding receptacles shall be placed near all major equipment and minimum 2 numbers on each floor in all the buildings.

15A, 240V, Single phase convenience receptacle with switch shall be provided in all the rooms. The convenience outlets shall be spaced to provide access to any point with a 15-meter extension cord. Receptacles shall be served from an earth leakage circuit breaker (ELCB).

Welding sockets shall be fed from ACDB / PDB. Number of receptacles per circuit shall not be more than 2. Each welding receptacle unit shall have dedicated MCB installed adjacent to the receptacle with IP55 type enclosure.

The light fixtures shall be circuited so that adjacent fixtures are connected to alternate phases of a 3-phase circuit. Auto-timed switching may be

considered with manual bypass mode for indoor lighting system. The lighting for enclosed areas within the buildings shall be manually switched 'on' and 'off' at local light switches near personnel entrance doors. Wall mounted switches shall be provided at the entrance to battery room and equipment/office rooms.

Electric power to light fixtures located outdoors shall be switched with photoelectric controllers and timers. Outdoor lighting shall have auto/manual mode of operation. Provision shall be made to bypass the photoelectric controller and timer.

Switches shall be sized maximum of 80 percent of the light switch ampere rating with enclosures suitable for the location in which they are installed.

Load on each lighting circuit and single-phase receptacle circuit shall be limited to 2000 W.

For areas illuminated by more than one circuit, the adjacent circuit shall be fed from different phase. Load balance on all the 3 phases to be envisaged for lighting as well as 1- ph power distribution circuit.

Wiring for indoor lighting installation shall be carried with PVC insulated wire with following sizes laid in conduit.

- Lighting Panel to lighting Fixtures: 2.5 sq.mm copper
- Switch box to lighting Fixtures : 2.5 sq.mm copper
- Lighting Panel to Sockets : 4 sq.mm copper

For Area lighting, PVC insulated, PVC inner sheathed, armoured, FRLS PVC outer sheathed Aluminium conductor cables shall be provided. Wiring for lighting circuits of Normal AC system and DC system shall run in

separate conduits. Wiring for Lighting fixtures and receptacle units shall be fed from different circuits and shall run in separate conduits. Two different phase circuits shall not be laid in the same conduit.

All conduits shall be surface mounted in general. In Control room conduit shall be concealed type. Conduit fill criteria shall be 40%. Conduits should have the minimum number of bends in their run with pull boxes at suitable locations. Conduits shall be sloped & drained to avoid water accumulation & draining into the equipment at its end. Conduits shall be galvanized steel except in corrosive areas, where it shall be epoxy painted.

5.2.7.1 Receptacles

Power Socket - 15A, 230V, 2 pole, 3 pin type with third pin grounded, metal clad with gasket having 19 mm conduit entry and a metallic screwed cover tied to it with a metallic chain and suitable for indoor & outdoor installation in Control room building Local Control rooms etc.

Welding Socket - 63A, 415V, 3 Ph, 4 Wire, 5 pin interlocked plug and switch with earthing contact to be used in Control room building & Local Control rooms. Other requirements shall be same as type RA. Welding sockets shall not be connected to lighting distribution board and shall get supply from feeders in the MCC/ACDB/PDB.

All receptacles shall be provided with matching plug-tops. All hardware shall be of Stainless-steel type only including the mesh of well glass luminaries, nut, bolts, washers, etc.

5.2.7.2 Street Light Poles (For Boundary Wall)

Hot dipped galvanized poles with integrated in-built control box and lighting brackets are a preferred option to ensure long life of poles and to delay effect of corrosion. But in keeping view of energy efficiency the street and area lighting should be designed to keep lux level at lower limit specified in the standards. LED Streetlight system wattage 30W IP66 Multiple LED with Lens optics and Pressure die-cast aluminium housing for effective thermal management. Total system Lumen of 30W LED should be Lumen Efficacy >95 Lm/W, Power factor >0.95, CRI >70. Complete with Mounting Brackets & accessories as required with connections. It consists of GI pipe bkt of 3.5-meter length, 1 meter Tilted at 45 degree & 2.5 mtr straight with 3 nos of suitable size Clamp having MS plate 300 mm x 300 mm x 6 mm thick welded with bottom of pole and suitable hole with rectangle shape wiring of pole with 3 x 1.5 sq mm copper conductor FR wires, Bracket should be Painted

from bottom and rest of pole with 2 coats of aluminium paint of superior quality of approved brand etc as required for boundary wall

5.2.8 High Mast Lighting System

5.2.8.1 General

High Mast at the proposed locations in the plant area shall have adequate height to achieve the required illumination. Top level of high-mast foundations shall be as per the approval from the Employer's Engineer. All High Mast of similar height shall be identical in construction to allow possible future relocation of High Masts within the area. A High Mast

Switchboard is required to be installed at the base of each High Mast. The High Masts are expected to be fabricated out of steel.

The High Mast shall be designed for the number of light fittings determined by the Lighting Design based on the average 30 lux (with minimum 20 lux) of illumination plus two additional fittings to allow for possible future modifications/expansion. The High Mast shall be designed for the worst sail area resulting from the most adverse configuration. The High Mast shall be designed to withstand loads from fabrication, handling, erection, and for the dynamic loading outlined below.

5.2.8.2 Design Criteria

The lighting design shall be in accordance with IS:3646. The selection of lamps and luminaire types shall be based on high efficiency, good glare control and illuminance level required. Luminaires, mast and brackets shall be selected to suit the harsh environmental conditions specified. Luminaires shall have high power factor (0.85 or higher) control gear. Any apparatus, appliance or material or services which may be necessary to make the system complete and perfect in all respects even if not particularly specified shall be furnished, without any additional expense to the Employer. Details not usually shown or specified, but necessary for the proper installation and operation of the work shall be included.

5.2.8.3 Fittings

Lighting fittings selected shall be High Pressure Sodium type. Lighting fittings shall be full cut off type to prevent stray light above 90 deg. Light fixtures shall be provided with Power factor correction capacitor to achieve high power factor.

5.2.8.4 *Light Switching Philosophy*

Each High Mast shall be controlled from Main Lighting distribution board (MLDB). When there will be main power failure the high mast will automatically operate on DG supply.

5.2.8.5 *Location of High Masts*

Contractor shall provide the High Mast at the suitable location with sufficient height and number, final details as per the detailed design shall be submitted to the Employer for approval.

5.2.8.6 *Detailed Lighting Plan*

Detailed lighting distribution plans of the entire area along with Lux level plot plan shall be provided for approval of the Employer by the successful contractor.

5.2.8.7 *High Mast Head Frames*

Each High Mast shall be fitted with a head frame, which shall be capable of being lowered and raised by means of a winch or other similar mechanical mechanism. The winch shall be able to be operated by use of a power tool. Each High Mast shall be provided with internal power tool complete with drive motor and drive assembly of suitable rating. The power for the drive motor of power tool shall be from the respective high mast switchboard. The head frame shall be of durable steel construction fitted with light and gear fixings and junction box. It shall be in single piece for maximum strength. The head frame shall also act as an electrical conduit with cable holes protected by grommets. The head frame shall incorporate arrangements to prevent damage to the galvanizing of the High Mast.

5.2.8.8 Mechanical Arrangement – Lowering and Raising Headframe (Ring) System

For installation and maintenance purpose, it is required that the headframe (ring) be able to be raised or lowered using a winch or approved lowering device to the base of the High Mast. The steel wire rope supporting the headframe shall be kept in balance and horizontal at all times. A device, suitably protected from corrosion, shall be incorporated to ensure that the tension rope cannot accidentally or manually be released without a service tool.

5.2.8.9 Top Pulley Assembly – Lowering and Raising Headframe (Ring) System

The pulleys for the lowering and raising of the headframe system shall be of non-corrodible material and shall run on self-lubricating bearings with stainless steel axles. They shall be of sufficient diameter so as to enable multicore flexible cables to be used. Arrangements shall be provided to ensure that the electric cables and steel wire ropes are separated before passing over their respective pulleys and close-fitting guides shall protect the pulleys to prevent ropes and cables leaving the pulley grooves. It is intended that there will be 2 cables from the High Mast Distribution Board at the base of the High Mast to the junction box on the headframe. Individual cables will then run from the junction box to each light fitting. This cabling arrangement will need to be considered in the design.

The pulleys shall be housed in a chassis integral with a sleeve which slips over the top of the High Mast and is secured axially and in azimuth. Guides and stops shall be provided for locking the headframe and an anchor point

shall be securely welded to the assembly to receive the safety maintenance equipment. The complete chassis assembly shall be hotdip galvanized after fabrication. The pulley assembly shall consist of safety brakes capable of immediate stopping of the raising and lowering device even in the extreme case of hoisting cables breaking.

The pulley assembly shall be protected by a galvanized steel/aluminium or other approved weatherproof cover.

5.2.8.10 Winches – Lowering and Raising Headframe System

Winches shall be completely self-sustaining without the need for brakes, springs or clutches which require adjustment and shall be designed to be installed or removed through the door opening. Termination of the winch ropes shall not involve distortion or twisting of the rope structure. A minimum of four turns of the rope shall remain on the drum when the lantern carriage is fully lowered. Winch drums shall be grooved to ensure a tidy rope lay. A test certificate issued by an independent test house shall be supplied with each winch. The capacity and operating speed of the winch shall be clearly marked on each winch on an indelible label together with the Specification of the recommended lubricant. Each winch shall be supplied with a fitted canvas cover.

5.2.8.11 Lightning Protection and Earthing System of High Mast

Each high mast shall be provided with lightning protection and earthing system which shall be installed and tested as per BS:6651, BS:7430 and TR7, ILE, UK, and IS:2309, IS: 3043 & IEEE:80-2000.

5.2.8.12 Openings

Any openings in High Mast for feeding of cables/stainless steel rope in and out of the High Mast require coverings/capping so as to prevent the intrusion of rain water into the High Mast.

5.2.8.13 Dynamic Loading

All High Masts shall be designed for maximum reaction arising from basic wind speed of 180 km/hr and factors K1, K2, K3 as per IS:875 (Part III) for design wind speed. The minimum design life shall be 30 years. High Masts shall be designed in accordance with relevant Indian earthquake standard. The design shall be such that wind excited oscillations are damped as much as possible and an adequate allowance shall be made for the stress due to these oscillations. The method of damping shall be stated. Full calculations of the forces involved shall be submitted for approval. The analysis shall show the resultant loadings, deflection and stresses in all three principal axes at a minimum of 500 mm increments over the total length of the High Mast. In addition, High Mast structures shall have adequate strength to resist fabrication, handling and erection loads without becoming overstressed or deflecting excessively.

5.2.8.14 High Mast Construction

All steel used in the construction of the High Mast, including welding shall comply with relevant Indian or British standards for Structural Steelwork. High Mast shall be constructed from mild steel plates, of grade and thickness as determined in the design. The minimum steel plate thickness shall be 6 mm. An appropriate corrosion allowance shall be used in the design. High mast shall be cut and folded to form a polygonal/circular

section. Adjoining sections of the High Mast shall be joined by taper slip fit jointing. No sitewelded joints will be permitted.

All High Masts shall have a close-fitting weatherproof door at the base with hinges and a heavy-duty lock. The lighting distribution board shall be placed inside the High Mast base at this location. The size of the door is expected to be approximately 1.00 m x 0.50 m in size but may vary according to each design. The bottom of the door shall be located at a height of 0.50 m from the underside of the base plate of the High Mast. The door opening shall be reinforced where required to prevent buckling. The reinforcement being designed to suit the width of the door opening under the designing loading specified. Ten (10) sets of keys shall be provided for each type of lock.

The baseplate shall be free from laminations and the welded connection to the High Mast shall fully develop the strength of the section. In addition, supplementary gussets shall be provided between bolt holes. On the completion of fabrication, all High Masts and headframes shall be hot dipped galvanized both internally and externally to a minimum thickness of 100 microns.

5.2.8.15 Foundations

The design and layout of each type of High Mast shall be furnished. The design shall be based on the foundations not resting on bedrock & shall be carried to a depth of at least

2.0 m below final grade. Settlement shall not exceed 25 mm, unless specified otherwise and the structural arrangement and design shall be

such as to withstand such settlements. The top level of the concrete pedestal shall be as per the approval of the Employer's Engineer. The footings for the High Mast including holding down anchor bolts with nuts and washers shall be supplied and installed under this contract.

5.2.8.16 Wire Ropes

Wire rope system shall be suitable for maintaining the lighting fixtures/control gear from the ground level in spite of crash barriers around the mast. Wire ropes shall be flexible stainless-steel type. Thimbles and terminals shall be of compatible material. Ropes with hemp cores will not be permitted. In the event of failure of one rope the other rope shall hold the lantern carriage.

5.2.8.17 Materials

All materials shall comply with relevant Indian or British Standards. All steel conduits, metal work, angle iron brackets, suspension rods etc. shall be hot dipped galvanized to a minimum thickness of 100 microns. Where galvanizing has been damaged this shall be repaired with an approved two pack zinc rich epoxy finish.

5.2.8.18 Luminaires

Luminaires shall be standard industrial type suitable for high pressure sodium vapour SON- T lamps of 2x400 W/1x1000 W/1x400 W and shall have not less than 55000 lumens per 400 W lamp. Lighting fixture shall be waterproof, dust proof and suitable for highly corrosive atmosphere. It shall be manufactured with die-cast aluminium, MBV treated reflector, electronically brightened and anodized, IP 54 degree of protection and conform to relevant IS specifications. The lamp shall be easily replaced from

rear without disturbing the aiming position. It shall be provided with stainless steel toggles, heat resistant & toughened glass cover. Hardware used to install the fittings, control gearboxes and for other purposes shall be of stainless steel. The luminaires shall be tested as per Indian Standard and shall be suitable for installation on high mast.

5.2.8.19 Aviation Light

LED type aviation light shall be provided at each mast.

5.2.8.20 Power Tools

This is a geared motor with suitable torque limiter, industrial duty type. The motor is mounted on MS hot-dip galvanized plate inside the mast with a possibility of adjusting its position. However, the adjustment shall be so arranged that it cannot be altered easily during normal use of tool at site.

5.2.8.21 High Mast Switch Boards (HMSB)

These boards shall be free standing pad mounted type. The boards shall be designed for the number of circuits as required. The boards shall include miniature circuit breakers/ELCB, Contactor, ON-OFF Control Switch and all other required accessories as required. The cubicle shall be designed for mounting over RCC pad of 300 mm thickness minimum and shall be capable of withstanding the vibrations normally experienced due to vehicular traffic. The top cover of the enclosure shall have slope to prevent accumulation of rainwater. A gland plate shall be provided at the bottom of the switchboard. An incandescent lamp shall be provided inside the switchboard, with door switches on both doors, so as to switch 'ON' when the door is open.

The circuit wiring shall be as required. System control panel shall be fabricated out of CRCA sheets – 2 mm thick for structural components and 1.6 mm thick for covers and doors & hot dip galvanized after fabrication. HMSB shall be fabricated out of stainless steel of grade 316 to prevent corrosion. HMSB shall be sized to allow for heat generated and design includes for dissipation of heat and shall be IP 65 degree of protection plus canopy, whereas system control panel shall have minimum IP54 degree of protection. Each board/panel shall be provided with hinged door with gaskets.

230V AC auxiliary and control supply aluminium bus bars shall be provided through control transformer of adequate capacity in HMSB. The Board/Panel shall have earth bus bar running through the whole length of the board. All equipment mounted in the board shall be directly connected to this earth bus.

5.2.8.22 Wiring

Wiring shall be complete in all respects so as to ensure proper functioning of control, protection and interlocking schemes. Control wiring shall be PVC insulated stranded, copper conductor of 2.5 sq.mm cross section. Each control wire shall be identified at both ends with wire designations in accordance with the relevant Indian Standards. All wire terminals shall be with compression or clamp type connectors. Wires shall not be spliced or tapped between terminal points. Designation ferrules shall be interlocking type with designation engraved with indelible ink. Not more than two wires shall be connected to one terminal. Power and control wires shall be neatly bunched, separately and adequately supported so as to prevent sagging

and strain on termination. Terminal blocks for power and control wiring shall be provided with adequate clearances.

5.2.8.23 Component Specification of HMSB

A) Contactors

Contactors for AC shall be 3 pole air-break electromagnetic type suitable for making and breaking locked rotor current of the motor which is equal to around six (6) times the full load current. Contactor shall have minimum 2 Nos. auxiliary contacts. Minimum rating of power contactor shall be 16 Amps. Contactors shall be suitable for uninterrupted duty as per IS 2959 and utilization category shall be AC3 as per IS:4064. The contact material of the contactors shall have anti-weld properties. Insulation class of the operating coils shall be class E or better. Operating coils of AC contactors shall be suitable for 240 V $\pm 10\%$, 50 $\pm 3\%$ Hz, AC supply. The contactors in general shall not drop out at voltage on and above 65% rated control supply voltage.

B) Auxiliary Contactors

The auxiliary contactors and no volt relay will be provided as per circuit requirement. The contact rating shall be 10 Amp for AC. The auxiliary contactors shall have at least 8 contacts in contact combinations as per the requirement.

c) Control Terminal Blocks

Control terminal blocks shall be of 650 volts grade, rated for 10 amps and in one piece moulding. It shall be complete with insulation barriers, clip on type terminals and identification strips. Marking on terminal strip shall correspond to the terminal numbering on wiring diagrams. At least 20%

spare terminals for connections shall be provided and these spare terminals shall be uniformly distributed on all terminal blocks. All terminal blocks shall be suitable for terminating on each side, two (2) Nos. of 2.5 mm² size stranded copper conductors. All terminals shall be numbered for identification and grouped according to the function. Engraved white-in-black labels shall be provided on the terminal blocks. Wherever duplication of a terminal block is necessary it shall be achieved by solid bonding links. Self-aligning, spring loaded, silver plated, sliding contacts for proven design shall be provided as control terminals for withdrawable / draw out modules. Detachable plug and socket type control terminals shall also be acceptable.

D) Indicating Lamps

The indicating lamps shall be panel mounting large industrial cluster LED type and shall be interchangeable. Indicating lamps shall be with translucent lamp covers. The lamp covers shall be mounted flush on the front panel door and shall be replaceable from the front of the cubicle.

5.2.8.24 Installation of Light Fittings

Mounting height of centre-line of the various lighting equipment from FFL/Working platforms or finished grade level shall be as noted below unless otherwise specified in corresponding lighting layout drawings:

- Lighting panels/control gear boxes : 1500 mm
- Switch boxes: 1500 mm
- Receptacle boxes (Indoor) : 500 mm
- Receptacle boxes (Outdoor) : 1000 mm
- JB on poles/Masts : 750 mm

Lighting fixtures to be mounted on ceiling/platforms having considerable vibrations which can cause damage to the fixtures shall be suitably supported with rubber pads to limit vibrations in the fixtures. Where conduit wiring is adopted, an earth continuity conductor of 12 SWG galvanized steel wire shall be provided for earthing the lighting fixtures, switch boxes, etc. The earthing conductors shall be run along the entire length of the conduits and shall be securely connected and terminated at the junction boxes/control gear boxes/lighting panels. The earth connection shall be properly secured with bolts, nuts and washers. For outdoor lighting installations, an earth continuity conductor of at least 25 x 3 mm galvanized steel flat shall be used for earthing the lighting masts/poles.

While designing the lighting circuit, the cables shall be sized such that the farthest loop from the supply receives no less than 95% of its nominal voltage, in addition it must be assumed that all the light fittings are energized while this design calculation is made. LED lights should be chosen & located carefully where they illuminate rotating shafts, so as to avoid stroboscopic effect. Fittings made from Aluminium and its alloys should be avoided because the oxide that invariably forms after a time is considered as a potential source of sparks caused by mechanical impact. All fittings shall be installed at a safe height for maintenance & effective illumination. All lighting controls shall be from a non-hazardous area, using double pole, switches, the supply neutral should be switchable along with the phase.

5.2.8.25 Testing and Inspection

Equipment of Illumination system should be type tested and proven type. Type test certificates shall be furnished for Purchaser's review. Equipment shall be subjected to routine tests as per applicable Indian Standard. Test reports shall be submitted for approval.

5.2.8.26 Spares

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

5.2.9 Cable Trays and Accessories

This specification covers the requirements of cable trays, support structures, cable laying, termination, earthing and lightning protection system.

While finalizing Cable routing layouts, consideration shall be given to the requirements of Safety, Reliability and Convenience of cable laying and termination. Where duplicate drives/auxiliaries are provided for reliability, cable routing shall be segregated to the extent practically possible.

In cable trenches, distance between bottom most tier and bottom of trench shall be 150 mm and clearance from top most tray to top of trench cover shall be 400 mm. Distance between two tiers shall be minimum 250 mm. PCC flooring of built-up trenches shall be sloped in longitudinal and also in transverse direction for effective drainage system. Cables should not be laid directly in the trench floor. Cable trenches should be provided with strong

& effective covers with water & fire proof sealing arrangement at trench entry & exit points.

Other than cable vault & cable trenches, Cable trays shall be laid in vertical formation to avoid dust accumulation. In cable spreader room a clear access passage of at-least 800mm wide shall be provided along the cable ways. Wherever passage is through cable routes, a clear height of not less than 2.0 M shall be provided.

Cables of different voltages shall be laid in separate racks. Minimum distance of 250 mm shall be maintained along the routes between various types of cables. In case of horizontal formation, the highest voltage cables shall be laid in the top most position in the tray stack followed by other grades as follows in the descending order.

- 11 kV Power cables (Top Tier)
- 1.1kV Power cables (Below HT Tier)
- Electrical Control Cables (Below LT Tier)
- Instrumentation/Signal cables (Bottom most tier)

On cable trays all the multicore power cables can be laid in touching formation. Single core cables shall be laid in trefoil formation with the spacing equal to twice the diameter of the cable. Control cables shall be laid in not more than two layers. Power & Control cables shall be laid on ladder type trays. Instrumentation & Signal cables shall be laid on perforated type trays. Cable trays shall be supported at an interval of 1500 mm approximately. Vertical runs shall be supported at an interval of 1000 mm approximately. Cable tray support system shall be site fabricated, welded and painted steel supports. Cable tray support system shall consist

of ISMC channel as vertical support & ISA as horizontal arm. Horizontal arm is welded to the vertical support MS channel.

Cables shall be terminated using double compression cable glands suitable for the voltage grade of cables. Cable glands shall be heavy duty brass. Cable lugs for power and control cables shall be tinned copper solderless crimping type conforming to IS 8309. 11 kV cable terminations shall preferably be of heat shrinkable type kits.

Fire barriers/ Fire stops shall be provided for all fire rated wall and floor penetrations and for all direct cable entries into electrical Switchgear / Panels from Cable Vault. Fire barriers/ Fire stops shall provide a fire endurance rating of at least 2 hours. The fire sealing material shall be non-hygroscopic, mechanically steady, non-toxic and physically & chemically stable under fire conditions.

Fire barriers/ Fire stops shall be either of the following methods:

- a) Panel sealing method comprising Encasing Panels, Cavity fill material & Sealant
- b) Mortar Sealing method comprising Mixing Mortar curing with water

5.2.9.1 Design and Construction of Cable Trays

Cable trays shall be ladder/perforated type as specified prefabricated made out of Fibre Reinforced Plastics (FRP) complete with matching fittings (like elbows, bends, reducers, tees, crosses, etc.), accessories (like side coupler plates, Tray cover etc.) and hardware (like bolts, nuts, washers, GI strap, hook etc.) as required. The size of the trays shall be selected on the basis of maximum 50% fill criteria. Cable trays shall be standard width of 150mm, 300mm, 450mm & 600mm. Thickness of side coupler plates shall

be minimum 2.5mm and of tray covers shall be minimum 1.6mm. Cable Trough shall be required for branching out few cables from main cable route. These shall also be fabricated of FRP of minimum thickness 3mm. Troughs shall be of standard width of 50mm & 75mm and 25mm height.

5.2.9.2 Design and Construction of Conduits/Pipes, Fittings & Accessories

Conduits/pipes offered shall be complete with fittings and accessories (like tees, elbows, bends, check nuts, bushings, reducers, enlargers, coupling caps, nipples etc.). The size of the conduit/pipe shall be selected on the basis of maximum 40% fill criteria. Hume pipes shall be of reinforced concrete conforming to class NP3 for road crossings as per IS: 458. GI pipes shall be of medium duty as per IS: 1239.

Rigid steel conduits conforming to IS: 9537 Part-I & II shall be suitable for heavy mechanical stresses, threaded on both sides and threaded length shall be protected by zinc rich paint. Conduits shall be smooth from inside and outside. Fittings and accessories shall also be hot dip galvanized.

Flexible conduits where required, near equipment terminations, shall be made with bright, cold rolled, annealed and electro-galvanized mild steel strips. Flexible conduits shall be supplied with suitable end coupler nipple and check nut. In corrosive areas, epoxy coated conduits shall be provided.

5.2.9.3 Cabling Installation

The work shall be carried out in the best workman like manner in conformity with relevant specifications / code of practices of the Bureau of Indian Standards. In addition, work shall also conform to the requirements of latest editions / amendments of the following:

- Indian Electricity Act and rules framed thereunder
- Fire Insurance Regulations
- Regulations laid by the office of the Chief Electrical Inspector to Government
- Any other regulations laid down by the local authorities

Support system shall be so designed that it is able to withstand weight of the cable trays, Weight of the cables, concentrated load of 75 Kg between every support span without any permanent deflection. Factors of safety of at-least 1.5 shall be considered. Cable tray mounting structure shall be welded/bolted to the plate inserts or to steel structure and the type of welding shall be of fillet type of at least 6mm size.

All cable way sections shall have identification, designations as per cable way layout drawings and painted/stencilled at each end of cable way and where there is a branch connection to another cable way. Minimum height of letter shall be not less than 75mm. For long lengths of trays, the identification shall be painted at every 10 meters. Risers shall additionally be painted/stencilled with identification numbers at every floor. Tray covers shall be provided for overhead cable trays on top most tier. The cable risers or vertical raceways shall also be covered by cable tray covers up to 1.5 metres from respective floor for mechanical protection. The sheet cover shall be of removable type.

5.2.9.4 Testing and Inspection

Equipment offered shall be of type tested and proven type. Type test certificates for test conducted earlier on similar rating shall be furnished.

Routine tests shall be carried out for all the equipment as per applicable standards.

5.2.9.5 Spares

Suitable quantity of commissioning and successful running for 2 years spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

5.2.10 415 V SILENT DIESEL GENERATOR SET

The output from the unit shall be 400 KVA (at alternator output), 415 volts, 3 ph, 50 Hz, 0.8 power factor. It shall cater to 100% indoor lighting, Operation of Mitre & Radial Gates and 20% High Mast Load.

DG set shall be required to operate as standby unit under the following environmental conditions:

- Ambient temperature : 45°C
- Relative humidity : Above 90%
- Altitude : Sea-level

5.2.10.1 Diesel Engine

The engine shall comply with the requirements of relevant BS 649/BS 5514. Engine shall be designed for maximum reliability ensuring uninterrupted operations. Engine shall be capable of delivering 10% overload for a period of one hour in any consecutive twelve (12) hour period. The values of rating, rotative speed and brake mean effective pressure (BMEP) for a specific engine design will not be accepted unless they are published as catalogue data.

Engine shall be heavy duty, industrial type four stroke delivering matching BHP at 1500 rpm, turbo charged radiator coded suitable for standby duty. Engine and auxiliary system shall be designed for safe start, stop and running on high-speed diesel (HSD). Engine performance shall confirm to ISO:3046/BS:5574.

Engine Governor shall be electronic.

The set shall be capable of accepting at least 60% of rated load in a single step from an initial start-up condition.

Filters of the replacement element type shall be provided on the engine for fuel oil, lubrication oil and air intake.

Engine Starting shall be 24 V DC battery system designed so that at least two separate attempts can be made, to prevent complete loss of starting capacity in one attempted engine start. Sizing of starting system should be in accordance with the engine manufacturer's recommendations, but in no case should the storage capacity be less than 30 seconds of cranking. An automatic static battery charger which possesses characteristics of "Zero-float" and positive charging shall be used. An engine-driven battery-charging generator is not acceptable. Batteries shall be maintained in a warm (20°F to 110°F) atmosphere to assist in quick starting. The battery system shall be of lead acid automotive type.

Flywheel Guards shall be provided as required.

An engine control unit free from vibrations comprising of the following devices with sensors (mounted at engine) shall be provided as minimum:

- Water temperature gauges for jacket water temperature

- Water pressure gauge
- Tachometer for engine speed
- Lubricating oil, pressure and temperature gauges
- Automatic shutdown and indication for low lubricating oil pressure, over crank, low coolant level, high cooling water temperature and engine over speed.

5.2.11 Engine Auxiliaries

5.2.11.1 Cooling System

Cooling system shall be radiator type. Anti-freeze liquids and corrosion inhibitor as recommended by engine manufacturer shall be used to obviate the danger of damage occurring from the use of incompatible or improper liquids or inhibitors.

5.2.11.2 Intake and Exhaust System

- A) A residential type exhaust silencer of suitable size for exhaust run shall be provided complete with all support frames etc. to reduce engine exhaust noise. It should be kept as straight as possible.
- B) Dry type air-inlet filter, exhaust manifold, mufflers shall be used. Type of filter selected shall be to fit the environmental conditions at the site.
- C) Combustion air shall be taken directly from outside.
- D) The air-intake and exhaust shall be so located as to preclude the contamination of fresh air with exhaust gases.
- E) To dispose of the radiant heat given off by the exhaust pipe, sheet metal ductwork shall be supplied with 50 mm of space between the ductwork and the exhaust pipe.

5.2.11.3 Fuel Oil System

- A) The fuel-injection system shall be complete with PT fuel pump, injectors, fuel filters and self-contained piping.
- B) The system shall generally comprise of

- Day tank capacity for 10 hours running at 75% load.
- Pumps required for conveying fuel from day tank to engine. Critical pumps should be provided in sets (1 working + 1 standby)
- The day tank shall also act as a relief and by-pass tank for fuel oil that is circulated to the injectors whereupon any excess fuel is by-passed back to the day tank.

5.2.11.4 Fuel Filtering System

The primary filtering system shall be located at day tank inlet. In addition, the engine shall have secondary filtering system. Both filters shall be capable of absorbing water.

5.2.11.5 Lubricating Oil System

The pressure lubrication system shall be used. The filter shall be of simplex type with paper element. The full flow lubricating oil filter can be mounted on the lubricating pump or remote mounted with flexible lines.

5.2.11.6 Piping and other Associated Connections

All piping, flexible connections, flange valves, seals, fittings etc. shall be supplied by the Contractor for all the associated auxiliaries of equipment.

5.2.11.7 Alternator

Alternator shall be air cooled, brushless, 3 phase, fan ventilated, synchronous type fitted with heavy-duty, long-life ball or roller bearing with forced lubrication or lubricant packed for approximately 4000 hours of running without attention. The alternator shall be manufactured in

accordance with BS 2613 IEE-341 or as per relevant BIS, ISO, DIN, NEMA, standard. The unit shall be horizontally mounted.

Enclosure shall possess minimum IP23 degree of protection.

Insulation throughout shall be class H; temperature rise by resistance. All windings shall be impregnated to allow operation in climatic conditions specified in this volume.

The Alternator shall be provided with following minimum accessories:

- Resistance temperature detectors
- Bearing temperature detectors
- Space heaters.

The basic ratings of the Alternator shall be as follows:

- a) Rated voltage : 415 Volts
- b) Speed: 1500 rpm
- c) Rated power output : As specified (Continuous rating)
- d) Frequency : 50 Hz
- e) Number of phases : Three
- f) Power factor : 0.8
- g) Type : Brushless, synchronous, self-excited self-regulated
- h) Neutral earthing : Solid grounding
- i) Voltage regulation : +1% of rated voltage from no load to full load at any

Power factor between 0.8 lagging and unity

- j) Type of cooling : Self cooled fan ventilated

5.2.11.8 Metering and AMF Control Panel

This is intended for operation of DG set in auto mode. The panel shall be sheet steel construction and arranged for free standing, floor mounting and bottom entry with front and rear access. The interior wiring of the cubicle shall be looped and clipped and all wire ends are to be clearly identified. Any printed circuit boards shall be tropicalized.

Following metering and protection devices as a minimum requirement shall be included in each panel:

A) Metering Instruments (Digital)

- Voltmeter
- Ammeter
- Frequency meter
- KW meter
- Battery voltmeter
- Power factor meter
- Hours run indicator
- KWH meter
- KVAR meter
- Excitation current ammeter
- Excitation voltmeter
- Engine Speed Indicator

B) Push Buttons

- Engine start PB
- Engine Stop PB
- Lamp Test PB
- Reset PB

- Emergency Trip PB
- c) Indication Lamps (Cluster LED type)
 - DG set on
 - Load on DG set
 - Set running
 - Mains available
 - Mains failure
 - Start failure
 - Generator over current
 - Generator high voltage
 - Generator low voltage
 - Earth fault
 - High engine speed
 - Low engine speed
 - Low fuel level
 - High fuel level
 - Charge failure
 - Generator winding temperature high
 - High bearing temp
 - Low lubricating oil pressure
 - High lubricating oil temperature
 - Engine jacket water temperature high
 - Engine jacket water pressure low
 - Reverse power
 - Low fuel oil pressure
 - Rotor diode failure

D) Protective Relays

- IDMT relay (Over current and earth fault)
- Over voltage relay
- Under voltage relay
- Reverse power relay
- Field failure relay
- Differential relay
- Phase failure relay

E) Multi-function Meter with Transducer

- Voltage – Ph-to-Ph & Ph-to-N
- Current – line to neutral
- Power – kW, kVAH, kVAR (Avg. & Ph. wise)
- Energy – kWH, kVAH, kVARH
- Power Factor – Average & Ph. wise.
- System frequency
- Import & export kWH & kVARH.
- RS 485 MOD BUS

5.2.12 415V Capacitor Bank with Automatic Power Factor (PF) Correction**Control Panels**

415V Automatic Power Factor Control Panels shall comprise of 415V circuit breaker, sets of Fuse & Contactors for each capacitor bank, PF Meter, Automatic PF Correction Relay, Capacitor Banks (Heavy Duty, Star connection) with series reactors, discharge resistance, residual voltage transformer & neutral displacement protection relay of suitable rating as indicated in the attached Single Line Diagram. Rating shown in the SLDs are indicative. Contractor shall perform their own calculations to verify the

size and submit the same to Employer for verification. Number of steps shall be based on 5kVAR power step minimum. The capacitor banks ratings shall be finally selected to provide a power factor of 0.95 lag on the bus. Zero step shall also be provided. Capacitor bank shall be double layer construction (film + paper + foil) gas impregnated type.

5.2.13 Telephone System (EPABX)

5.2.13.1 General

The design shall be in accordance with the basic requirements described in the Tender Document and the best current engineering practice, together with the following general design requirements:

- The essence of design shall be safety, simplicity and reliability in order to give long continuous service with high economy and low maintenance cost.
- All equipment shall be designed to minimize the risk of fire and any damage which may be caused in the event of fire.
- Care shall be taken so that materials and equipment are the standard Catalogued products of manufacturers regularly engaged in the manufacturer of such products and shall be of the latest standard designs that conform to the specification requirements. Design shall also be based on similar type of equipment supplied from one manufacturer, utilizing interchangeable parts, wherever practicable.
- The design shall comply with relevant codes and regulations listed.
- All apparatus, equipment and works shall be so designed that they provide satisfactory service and without any harmful effects for prolonged and continuous periods in the worst climatic conditions.
- The reference design ambient temperature for all electrical equipment shall be taken as 45OC and appropriate derating factors should be considered for equipment as applicable.

- Suitable derating shall be applied based on published data against the most severe conditions encountered in the site, by reducing the permissible temperature rise above the ambient level.
- Tentative number and location of the Telephone system is shall be decided during detailed engineering in consultation with the Employer.

5.2.13.2 Main EPABX

The proposed EPABX shall be 100% Non-Blocking, Electronic, ISDN native. The topology shall be totally distributed so as to support and configure the Remote Units flexibly as per the changing and evolving requirements on Optical Fibre as well as copper cable.

The system shall be based on High Speed, i3 CPU and with at least 2 GB RAM. It shall be equipped with Duplication of complete Control section (viz. CPU, Signalling circuits, Tone generators, Memory, Hard Disk – 1TB, RS232 ports, DTMF resources, conference circuits and other essential circuits) and common Power Supply & Ringer section in 100% Hot Standby mode. The system shall enable automatic changeover in case of failure in any of these without disrupting the existing calls in progress. The Operating system software shall be Unix based.

The system shall have RISC processor, RAM capacity of the system explicitly mentioned. It shall also specify the different control system elements duplicated in the offered system.

EPABX system shall be equipped with Ethernet port (30/100 Base T) and shall have provision to connect a TCP/IP LAN for management and metering application, which shall facilitate system management from any LAN node without using modems.

It shall be equipped with storage devices to save the data, as well as software necessary for its operation. For security reasons, these devices shall be of Flash ROM type, easy to duplicate and shall not cause any disturbance to the system. The Contractor shall specify whether information concerning variable data (forwarding, screenings) is automatically saved in real time, so that if the system goes down and comes up for any reason it doesn't lose data integrity.

5.2.13.3 Trunk Interfaces

The EPABX shall have all the following types of Interfaces:

- Analogue Interface to PSTN lines
- Interface to Leased Lines
- Paging System Interface
- Interface to VSAT Equipment
- BR and PR interface to Public ISDN Network
- Digital Interface for DID
- IP FOR VoIP & Data transfer

5.2.13.4 Extensions

A) Analogue Extensions

The system shall be compatible with both Pulse & Tone Dialling Instruments. Contractor shall clearly specify the DTMF receivers available on the system whether they are centralized or distributed, if they are centralized. Contractor to mention number of such receivers on each board. The number of DTMF Receivers shall be 50% of the ultimate capacity to handle peak traffic conditions. The Contractor shall specify the number of such boards equipped in the system offered.

B) Digital Extensions

The Digital phones shall have an Alphabetic Keyboard with "Dial by Name" facility from the central database of the PABX system and a user-friendly operation of the PBX internal services and of the services provided by the ISDN trunk. These terminals, as well as lower- range terminals shall be equipped with keys, which can be directly programmed by the user. The keys enable the user to change several functions (for example: call forwarding code + external number, etc.)- An option shall allow the number of keys on certain terminals to be extended. It is desired that all programming information on digital sets to be centralized and saved in the PBX to enable simple replacement.

The Contractor shall offer his range of digital terminals giving detailed specifications of their features:

- voice sets
- voice and data sets for ISDN & VoIP.

For each type of terminal, the Contractor shall specify the following characteristics:

- type of terminal,
- remote power supply or not,
- maximum distance of connection on 0.5mm cable (min. 1000meters)
- number of pairs necessary for the distribution,
- capacity of data transmission,
- interface for ISDN & VoIP,

The features, which have to be systematically accepted by digital terminals, are:

- connection of VDU terminals

- additional ISDN services
- IP services

The Digital telephone sets with Display panels and Dynamic Soft keys as a part of this display panel shall be quoted. These shall be equipped with Text Messaging facility. The digital telephones shall have keys along with LCD display with associated icons / LEDs.

5.2.13.5 Attendant Console (Operator)

The operator console shall have the following features:

A) General

The attendant shall provide call presentation, chaining process, call-back shall be entirely managed by the PBX. However, it shall be possible to put certain calls on individual hold on keys that have been reserved to that effect. The capacity of the various queues shall have to be unlimited. The information displayed on the terminal shall have to be explicit enough to facilitate unambiguous call handling and shall give maximum details about the communication (normal call, urgent call, queue status, name of the internal called-party, status of the telephone set etc.).

B) Supervision of the Installation's Stations

An add on unit with attendant console shall be provided to enable single touch dialling and to supervise the status of certain extensions and trunks. A minimum of 48 terminals shall be supervised.

c) Manual or Automatic Answer

The operator shall be able to modify the call answer mode from his/her attendant console. In "automatic answer", calls must be presented and connected without any intervention from the operator.

D) Calling Internal or External Correspondents by Name

To facilitate the operation of attendant consoles, operators shall be able, whatever their communication position (direct call, transfer), to call internal and external circuits according to surname, first name or initials. To assist searches, the system shall be equipped with a spelling and phonetic approximation utility program. User-friendliness being a requirement, the user shall access the service via an alphanumeric keyboard, either integrated or external to the attendant console. The Contractor shall describe in detail the access modes and the number of subscribers serviced.

E) Text Messaging

The system's telephone application shall enable the operator on transfer call status to send a text message to a selected internal subscriber. The operator shall have the choice between sending the message immediately onto the display panel of the subscriber if his/her line is engaged, or sending it to a text mailbox linked to the terminal, whether the latter is free or busy. This service shall only be provided if the internal subscriber's terminal is compatible with the service (digital terminals with text messaging feature). To facilitate the operation of this service, the operator shall have the choice between several types of messages:

- Pre-programmed messages to answer most common cases (example call back the switchboard, a visitor is waiting for you in reception etc.).
- pre-programmed messages to be completed (example: call back number XYZ).
- free messages to be composed entirely by the operator.

The Contractor shall describe clearly all the characteristics of the service and the size of messages, which can be sent in the various communication positions.

F) Hands-free and Amplifier

The operator can freely modify the operating mode of the attendant console and answer calls either in hands-free with the amplifier or with the telephone handset or headphones. When using the latter, the user can operate the amplifier with volume adjust.

G) Ringing levels

The operator shall be able to modify the melody and the ringing volume of the attendant console.

H) DTMF Frequency Transmission

The operator shall have the possibility to use servers controlled by Q23 coded frequencies.

I) Withdrawal of an Attendant Console

There must be a simple procedure to withdraw an attendant console from the group and switch it into a "night service" position. The status of his/her terminal should be clearly indicated to the operator. Calls shall be forwarded to a particular station or a group distributed within the premises.

J) Automatic Transfer of Calls to Attendant Consoles

Then the attendant consoles that are present do not answer calls, the system should, after a time delay, automatically switch to "night service" mode. Calls must be routed towards dedicated stations; the status of the

installation shall be clearly indicated to the operators and a simple procedure should enable return to normal situation.

κ) Routing Calls to Individual Operator

Incoming calls on Specific trunks shall be possible to route to a particular operator or extension.

λ) Additional Services

Attendant consoles enable the user to manage some operation parameters of the system, in particular the following points:

- Create, change or delete a subscriber's attributes,
- Manage service classes (automatic dialing and call transfer etc.)
- Manage the external abbreviated dialing.

All of these operations shall have to be protected by a password programmable by the head administrator.

5.2.14 Telephone Features

5.2.14.1 General

Following features shall be available without restriction to all the subscribers or freely programmable:

- Routing of an external bundle on a group or individual user,
- Calling an attendant console,
- External call barring,
- Local calls,
- Simultaneous 6 party Conference
- Consult a pending call,
- Broker's call
- Recording and transmission of external numbers
- Transit function,

- Bundles of external lines,
- Call pick-up,
- Call pick-up: group,
- Put on hold,
- Abbreviated external numbers - Minimum 200 numbers,
- Directory database in the system - minimum 1000 numbers,
- Call parking,
- Direct Outgoing Dialling (DOD),
- Direct Outgoing Dialling per cost center,
- Direct seizure of external line,
- Dedicated incoming station,
- Dedicated outgoing station,
- Station with direct routing to another station, to an abbreviated number, to an attendant console,
- Station with delayed routing,
- Protection against intrusion,
- Automatic call-back to a busy or free station
- Appointment call-back,
- Storing last dialed number,
- Last number redial,
- Call forwarding - no answer, busy, no answer/busy, fixed
- External call forwarding
- Remote call forwarding
- Night answering service,
- Call diversion on ringing,
- Moving service - without any intervention by the maintenance people,

subscriber must be able to move to a new location and by dialing codes at the new locations, he should retain his existing number.

- Padlock with password protection
- Substitution -to temporarily avail all the features of the subscriber extensions at another extension.
- PIN dialing - Each extension should have a PIN dialing, through which one could make calls from a different extension and the metering must be made to the subscriber's extension.
- Call ID on Analogue Extension

5.2.14.2 Push Button Telephones

A) Features

- Feather touch push buttons for quick and sure dialing.
- Memory storage, upto 22 digits for purposes of redialing.
- Facility for redialing the last number called by pressing the repeat push button just once.
- Ringing facility with adjustable volume.
- Digital pulses during dialing to be muted to eliminate harsh sounds.
- Compatible with P&T network.
- Built in automatic gain control.

B) Specifications

1. System voltage : 48V DC + 10 %
2. Pulse Rate : 10PPS
3. Break make rates : 66:33/60:40
4. Inter-digit pauses : 800m secs. (minimum)
5. Loop resistance from the exchange : 1 Kohms (maximum)

The push button telephones must confirm to CCITT standards.

The telephone offered shall be approved by the TRO for interface with P&T network. A copy of the certificate shall be enclosed.

c) Following Additional Features shall be built-in the System:

Multi Line Digital Stations

This function shall enable a user to simultaneously establish, from a station answering only one number, several outgoing or incoming communications. Only one communication is active at a given time, the other engaged communications being on hold; the user shall be clearly informed of the status of the pending communications.

Each key on the station can be allocated to a different call number, hence allowing differentiation of the calls. Contractor to mention how many multiline numbers can be programmed on one digital set.

Multiple Keys and Number Stations

Combining the two previous functions, each directory number can have several keys. The Contractor shall specify the number of manageable keys per station, a minimum of 6 keys which can be allocated to the multiple key / multiple number function would be desirable.

Executive/Secretary sets

- Call Filtering - Certain calls on the Executive set should be programmed to reach directly, whereas all other calls shall be routed to the secretary.
- Real time diversion without picking-up the call, Work Groups Status to be supervised (Visual and audible) on a digital set by associating a key to an extension and monitor for the following status:
 - free station

- busy station
- station receiving a call (ringing)

Hunt Groups of stations - sequential / cyclical / parallel Utilization of ISDN

Additional Services

The Contractor shall submit the list of ISDN additional services to be used on proprietary stations. The main requirements are as follows:

- Identification of an ISDN Caller

Some external subscribers must be identifiable by their name or the name of their company upon display of the calls on the attendant console or on proprietary stations. The caller's name shall be maintained after pick-up and shall reappear during all communication modes (back-and-forth, conference, and transfer).

List of unanswered calls upto 8 calls Automatic forwarding to Night-mode

Night-mode shall be automatically activated by the clock system and it is required to have night service based on the time of the day.

Additional Features

Following features shall be available with the EPABX system in addition to the above. Music-on-hold

The system shall be equipped with in-built music-on-hold device that shall have a capacity of 10-15 seconds and shall have good acoustic quality.

Automatic Attendant

The proposed telecommunications system shall be equipped with 4 port P.C. "automatic attendant" feature allowing, the reception of external calls

and offering to direct them interactively to a pre-defined service or subscriber. The interactive dialogue shall be based on DTMF. Errors (incorrect codes) shall be handled by an information message and return to the current message. If no Q23 code is received, the call shall automatically flow over to a dedicated number, after a pre-set delay.

Computer Telephone Integration

CT1 shall support for following computer environment- Digital, IBM, Microsoft, etc.

The physical interfaces supported shall be on V.24, RS232, SO, TCP/IP. Both first party and third-party CTI solutions shall be supported.

IP Components

The EPABX shall have in-built interface for IP functionalities. The Contractor shall enclose the detailed implementation schematic for VoIP and shall quote price for 10 VoIP users. It shall support the following:

- Connection of a server via LAN-LAN router and LAN-WAN (ISDN)
- Voice over IP and Frame Relay.

5.2.14.3 System Administration - Management terminal

The proposed system should:

- offer GUI based windows software with user-friendly access to the various proposed services,
- be protected by an overall access code and offer several secondary access levels,
- enable overall management of the system,
- provide menus in English, without obligation to answer questions with hexadecimal characters or mnemonics. A Windows-compatible

application would be desirable.

5.2.14.4 Main distribution frame

The main distribution frame for Field side and Exchange side shall be housed in a metal cabinet and shall be equipped with Krone modules for 8 Pair terminations. An Intermediate Distribution Frame shall also be provided for 8 Pairs with Over-voltage and over-current protection for all the Trunk lines. The interconnection between MDF and IDF shall be done using Jumper Wire. The Contractor shall do all termination of cables and jumpering at the MDF.

5.2.14.5 Power Supply

A) FCBC

The Float cum Boost Charger shall be sized to supply power to the PBX for the required capacity and it shall simultaneously allow re-loading of the battery within 10 hours maximum. FCBC shall also be provided for the Remote units also.

B) Battery

Sealed Maintenance Free Lead Acid battery shall ensure automatic standby for the PBX in case of failure of the electric power supply or the rectifier. A minimum back-up of 6 hours is required.

5.2.15 List of Approved Makes

S. No.	Equipment / Component	Preferred Makes
1	HT Switchgear	Adlec (Schneider) / SPC Electrotech (L&T) / RISHA (L&T) / NITYA (Siemens)
2	LT Switchgear/Control desk	Adlec (Schneider) / RISHA (L&T, ABB) / SPC Electrotech (L&T) / Vidhyut Control (L&T) / NITYA (Siemens)
3	Distribution Boards	SPC Electrotech (L&T) / NITYA (Siemens) / RISHA (L&T, ABB) / Adlec

		(Schneider)
4	Distribution Transformer	Areva / Emco / Crompton / BHEL / Voltamp / Bharat Bijlee / PETE Hammond
5	HT Power cables	Havells / Ravin / Gemscab / Gloster / Paramount
6	LT Power cables	Havells / Ravin / Gemscab / Gloster / Grandlay / Paramount
7	Control Cables, Wires & Flexible cables	Havells / Gemscab / Ravin / Gloster / Grandlay / Paramount
8	Copper Wires PVC FRLS	Skytone / Echo Cables / National / Finolex / Polycab
9	Cable Glands/Lugs	Jainsons / Dowells / Gripwell / SMF
10	Cable Trays (FRP)	Ercon / Indiana / Sumip Composites / Sintex
11	Capacitor Panel with Banks and other related accessories	L&T / Epcos / Schneider / ABB / Asian / Madhav/ Havells
12	Battery	Exide / Amco / Amara Raja / Chloride / HBL
13	Battery Charger with DCDB	Chhabi Electricals / Caldyne / Mastek / DB Electronics / HBL
14	Diesel Generator Set	Powerica / Jakson / Sudhir/ Greaves
15	Alternator	Crompton Greaves / Kirloskar / Stanford
16	Lighting fixture with street light poles	Bajaj / Philips / GE Lighting / Havells / Pharox / Surya
17	High Mast	Bajaj / CGL / Philips / Surya
18	Aviation Light	Avaid's Technovators Pvt. Ltd.
19	Plate-Switches & Sockets, Boxes	MK / Crabtree (Havells) / Anchor / ROMA
20	GI Conduit with accessories	BEC / AKG / SENCO / Jindal
21	VCB	Siemens / L&T / ABB / Schneider
22	ACB	Siemens / L&T / ABB / Schneider
23	MCCB	Siemens / L&T / ABB / Schneider
24	MCB / ELCB / RCB / MPCB	Siemens / L & T / MDS / Schneider / Havells
25	Fuse/Link	Siemens / L&T / Alstom / Schneider / C&S / Areva
26	Switch Fuse Units	Siemens / L&T
27	Contactors	Siemens / L&T / ABB / Schneider

28	Indicating Lamps / Push buttons	Siemens / Schneider / Teknic / Kaycee / L&T / Essen / Vaishnav / BCH / C&S
29	Push button stations	Siemens / Schneider / Teknic / Rishabh / L&T / BCH / Control Group
30	Meters (digital) MFM	Schneider (Conzerv) / L&T / Secure
31	Voltmeter / Ammeter / PF Meter / Frequency Meter/ KWH Meter	AEI / IMP / MECO / INDCOIL / Enercon / L&T / Rishabh / Siemens / Industrial Meters
32	Selector Switch	L&T / Siemens / Schneider / Kaycee / Salzer / C&S / Vaishnav
33	Auxiliary Contactors/ Relays	L&T / Siemens / BCH
34	Overload Relays (Hand Reset Type)	L&T / Siemens / BCH / Telemachanique
35	Protective / Auxiliary Relays	Areva / Schneider / Siemens / EasunReyroll / ABB / Telemachanique / L&T
36	Time Delay Relays	BCH / Siemens / L&T / English Electric
37	Power Contactor with 2NO+2NC	L&T / Siemens / Telemachanique
38	Timer	Siemens / L&T / BCH / Schneider
39	Terminal Blocks	Elmex / Connect Well
40	Current Transformer/ Potential Transformer	AE / Kappa / L&T / Siemens / Pragati
41	Plugs & Sockets	Hensel/Menneks
42	PVC Conduit and accessories	BEC / Polypack / Precision /AKG
43	Cable Termination Kits & Straight Through Joints	Raychem / M-Seal (3M)
44	Motors	BHEL / Kirloskar / Crompton / Siemens / Havells
45	Chemical Earthing	Ampere Protection / JK Earthing / JMV/OBO
46	Exhaust Fan	Bajaj/Orpat/Havells
47	Air Conditioners	O'General / Samsung / Blue Star / LG / Hitachi
48	EPABX	Panasonic / Coral

5.3 CONTROLS AND AUTOMATION WORKS

5.3.1 System Description

A Central Control System is proposed as shown in the **Drawing ENL012, Control Architecture** to ensure safe and reliable operation of Lock Gates and other facilities. At the highest level - the Management Network shall include network servers, PC work-stations, printers, communication and data interfaces, software(s) etc., to provide planning, inventory management, data acquisition/communications and other management functions.

The Control Network shall be used for providing automation functions, Opening & Closing of Mitre and Radial Gates, Submersible Pump motors, Capstan Motor for Caisson gate & third-party instruments/software etc. monitoring and supervisory functions from Control Room.

At the lowest level of automation System, the individual drive motor controllers for lock gates with their associated control devices (limit switches, sensors, local control devices, local control panel and other sub-systems (as per the details given in this specification and Control Architecture) shall be controlled in groups or individually by the PLCs.

The core of the system shall consist of Server station, Operating cum programming station (all the computers shall be latest version of the Industrial PCs as on the date of bidding) with printer and along with centralized real –time redundant PLC system (One online and the other in hot standby excluding I/O modules), sharing a RAID 6 (redundant array of independent disk) data storage system and a data network, with shared

high-capacity data backup and off-site data archiving as per attached Control Architecture.

The control system would incorporate all safety interlocks to ensure complete safety to operating personnel and to avoid any damage to equipment due to mal-functioning.

The control system shall generally be based on the following principles:

- i) To start equipment in either of the two modes i.e., 'Local' or 'Remote'.
- ii) To trip off minimum equipment in the desired sequence during abnormal operating conditions, leaving all the other equipment running, which may safely be permitted to continue the operations.
- iii) To annunciate the fault which has tripped equipment along-with the cause for tripping
- iv) To prevent restarting of the equipment until safe conditions have been restored.
- v) To retain maximum flexibility of operation consistent with safety.
- vi) To prevent mal-operation of equipment on interruptions.
- vii) To stop all the running equipment simultaneously by pressing Emergency Stop Push Button.
- viii) To stop running equipment in the reverse order with time lag during normal stop.

CDB's (Control Distribution Board) shall be furnished, manufactured and installed for feeding power supply to the field instruments/CCTV.

5.3.2 Equipment Specification

Equipment Specification shall strictly adhere to the following general guidelines:

- i) The makes and the specifications of every aspect and in totality of the

Server, LED Displays (Large), Operating Terminals, LED monitors, Network Printer (A3/ A4), PLCs (including CPU, Communication Processors), DI/DO, AI/AO and RTD modules), Uninterrupted power supplies and all Network Components and accessories including Managed Network Switches, Media Converters, Cat5e (STP), Multicore Cables for Field Instruments etc. shall be of the latest available make and shall conform to applicable industry standard. The type, make and model of all boughtout items supplied shall be subject to approval during detail engineering stage.

ii) The enclosures for Control equipment i.e., PLCs placed in control room shall be of IP- 54/55 and IP-66/67 standard for the ones placed in Fields.

5.3.2.1 Server

The Server shall be of industrial grade with high computing power, suitable for communication equipment networking and industrial automation. Server shall be with twelve processor execution cores. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking along with a hot standby system. The changeover shall be smooth. Hard disks shall mirror the data bases required. Standard keyboards, mouse controllers shall be included, with CD/DVD read/write drives, and tape backups.

Servers shall be commercial class with efficient computing power in order to maximize memory through unprecedented capacity and bandwidth for maximum performance, suitable for high-speed communication equipment networking and industrial automation. Independent expansion of processors, memory, networking and storage I/O on the same scalable platform shall be possible and shall be a server-class computer with support up to 2 sockets with 10 cores of processing power. Each processor should have its own independent system bus to reduce data bottle necks

while maximizing processing throughput and multitasking along with a hot standby system. The changeover shall be smooth. Hard disks shall mirror the data bases required. Standard keyboards, mouse controllers shall be included, with CD/DVD read/write drives.

Technical Data

Processor	E7-4850v3 with 14 CPU cores in a 2-socket
Clock Speed	2.8 GHz
Cache Memory Size	35 MB Cache
Memory Types	DDR4-1333 MHz
Hard Drive	2 TB (4X500GB) HOT PLUG SAS(with flexible hot-swap storage with up to 8 HDDs or up to 16 SSDs)
Communication Ports	Parallel Port-1 Serial Ports (Universal)-3.USB Ports-8
Power Source	240 V AC,50/60 Hz
Network card	4 ports of 10 Gigabit Ethernet (GbE) and DCB support with 4 Fibre Channel ports supporting 2, 4, and 8 Gbps full duplex
Permissible Humidity	20%-80%
Design Ambient Temperature	45°C
DVD	Min. 4.7 GB DVD RAM (R/W) drive
DAT	Min. 4 GB DAT as software media and storage

5.3.2.2 The LED (VDU)

Shall display all lock gates, pump motors & instruments data and sub-systems represented individually in approved manner. Each position/level shall be indicated. Other data/information as required (Selection, fault Indication, outputs, equipment locations and other information required shall be shown or displayed on demand in different colours. The graphic displays

shall be subject to the approval of the Employer but shall be field programmable. The video graphic display unit shall be suitably placed in the Control room. The VDU shall be capable to display graphics or pictures in 1080p high-definition resolution, with the highest level of quality and reliability.

LED screen shall be used for displaying operation of gates & pumps mimics, with full high-definition capability and using the latest in display technology. They shall have the highest level of quality, reliability and resolution.

Technical Data:

Power Source	240 V AC,50/60 Hz
Display Type	Compensated TN, Full color LED Luminance:400 cd/m2
Resolution	At least 1920*1080
Size	32-inch Diagonal
Operating Condition	Temperature: 0°C - 40°C Humidity: 20% - 80%
Contrast Ratio	5,000,000:1
Viewing Angle	140°H, 140°V
Safety Standards	UL6500/C-UL

5.3.2.3 Data terminal computers

Data Terminal CPU shall be of Industrial grade having high computing power, suitable for communication equipment networking. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking. They shall be complete with standard keyboards, 21-inch LED colour monitors, mouse controllers, CD/DVD drives, network cards.

Data terminal computers shall have high computing power, suitable for communicating equipment networking. They shall also include compatible standard keyboards and standard mouse and licensed operating system and other necessary licensed software.

Technical Data:

Processor	Intel Xeon i5, 3.00 GHz 12 MB cache
Random Access Memory	4 GB- DDR4, 1333 MHz
Hard Drive 1 Optical Drive	1000 GB SATA CD/DVD R/W
Operating System	Windows Server 2008
Communication Ports	Parallel Port: 1, Serial Ports (Universal): 3, USB Ports: 8
Power Source	240 V AC, 50/60 Hz
Network card	Redundant Gigabit/10/100 MBPS Ethernet PCI-E Network Card
Permissible Humidity	20%-80%
Design Ambient temperature	45°C

5.3.2.4 LED monitors

LED monitors shall be used for wide range of digital applications, with full high-definition display technology. They shall have the highest level of quality, reliability and resolution.

LED monitors shall be used for wide range of digital applications, with full high-definition capability and using the latest in display technology. They shall have the highest level of quality, reliability and resolution.

Technical Data:

Power Source	240 V AC, 50/60 Hz
Display Type	Compensated TN , Full 1080p Display
Resolution	At least 1040*768 (NI)

Size	21-inch Diagonal
Operating Condition	Temperature: 0°C - 40°C Humidity: 20% - 80%
Contrast Ratio	10M:1 Dynamic contrast Ratio
Viewing Angle	140°H, 140°V
Safety Standards	UL6500/C-UL

5.3.2.5 *Network Printer*

At Control room, Scheduling and Planning Terminals shall be suitable for large work groups, and for high-quality, high-volume printing. The printers shall enable high-speed color or monochrome printing of up to 40 pages per minutes for optimal productivity and shall have the capacity to print high-quality, complex documents quickly. Large work groups shall be able to produce professional, impressive-looking documents every time. Printers shall be equipped with paper feeders and paper cassettes for at least A3 and A4 paper.

The printers shall enable high-speed color for optimal productivity and shall have the capacity to print high-quality, complex documents quickly. Large work groups shall be able to produce professional, impressive-looking documents every time. Printers shall be equipped with paper feeders and paper cassettes for at least A3 and A4 paper.

Technical Data:

Power Source	240 V Ac, 50/60 Hz
Printer Type	Color Work Group Laser printer
Operating Condition	Temperature: 16°C-32°C Humidity: 8% -80%
Print Quality	Selectable up to 1200x1200 dpi
Communication Port	USB
	10/100 Base Ethernet Port

Processor	300 MHz processor
Memory	64MB (320 Max)

5.3.2.6 The Programmable Logic Controllers PLCs

PLCs shall be Redundant and of rugged design and quality to meet the functional requirements, capable of withstanding/bypassing high electric noise, electromagnetic interferences, vibrations etc. The microprocessor-based systems shall be of modular design and suitable for mounting in standard racks.

It shall be equipped with latest Processor modules, Communication Modules, Data processing software, Logic Implementation software, other required interfaces complete with all accessories. It shall have adequate functional capacity for handling the I/O Unit's, external interfaces and data bus interfaces. It shall be enclosed in IP-54 degree of protection panels.

The microprocessor-based systems shall be of modular design and suitable for mounting in standard racks. Each module including rack/mount base shall be individually metal enclosed dust and vermin proof for withstanding worst environmental and ambient conditions etc. Remote input/output cabinets shall be suitable for mounting on walls/columns.

The memory shall be RAM type and sufficient battery backup must be provided. The execution cycle of the PLC shall meet the functional requirement of plant. The memory capacity of the PLC shall be adequate to perform the required functions satisfactorily and with 100% spare capacity for use in the future. Redundancy (100% hot standby) shall be provided in the PLC's such that in case of failure of any of the processors, the hot standby processor shall take over automatically. The changeover shall be

smooth. Redundancy shall be provided for the complete Controller including CPU, memory, communication processor and power supply.

In event of power failure during battery replacement the memory contents shall not be lost for at least 30 minutes. Battery down alarm/indication shall be available at least 20 days in advance at the CCR.

Each CPU shall be complete with required number of modules, main power supply unit, marshaling box, interconnection cables etc. and shall have screw type terminals for I/O connections.

A processor failure condition shall be indicated in the control room and change over to redundant systems shall also be indicated. Extensive diagnostics shall be available for all intelligent modules of the system. The processor shall execute the programs for the plant operation at very high speed. Signals to each remote interface unit shall be transmitted by means of the network.

PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal value.

The status indications for power 'ON', control supply healthy, overloads, by means of LED's should be available on the power supply unit. The equipment must be capable of accepting wide voltage fluctuations + 10% voltage + 3% frequency.

The Contractor shall furnish the power load details of his system and shall keep 30% spare capacity in the power supply excluding allowances for transformers, cable losses etc.

Three Wire RTD signals shall be processed in the PLC through an analog input/RTD module which will be programmed for alarm and tripping the relevant motor in case of abnormal temperature of any RTD. Winding temperature shall also be available on color monitor VDU (in the fault window) and in mimic panel of the control desk, when required by the operator.

Each Controller shall be complete with required number and type of modules, main power supply unit, marshaling box, interconnection cables etc. and shall have screw type terminals for I/O connections.

Input/output units shall be capable of accepting discrete, analog, RTD, digital input and output devices. If the number of slots for input and output modules in the controller rack is not sufficient expansion units shall be connectable to the CPU by means of interface modules. Signals to each remote interface unit shall be transmitted by means of the network.

I/O modules shall have status indications to indicate the proper functions of the modules and scanning of signals by the processor. Each Input and Output module shall be electrically isolated through opto-couplers or isolation transformers and shall withstand severe voltage transients without damage or adverse effect on the controller. Output modules shall incorporate self-contained damping networks and voltage limiting devices to prevent false triggering of outputs and to suppress line voltage spikes. Each output card shall have fuses to protect its circuitry from over current and overloads. PLC power supply units must have self-test facilities for detecting under voltage and also must be able to give alarm and switch over to UPS mode in case the output voltage is + 20% above the normal

value. The status indications for power 'ON', control supply healthy, overloads, by means of LED's should be available on the power supply unit. The equipment must be capable of accepting wide voltage fluctuations + 10% voltage + 3% frequency. The Contractor shall furnish the power load details of his system and shall keep 30% spare capacity in the power supply excluding allowances for transformers, cable losses etc.

The Contractor shall provide separate grounding system for the PLC based automation system equipment supplied with independent earth pits and earth grid of 8 SWG G.I. wire with PVC sleeve.

Digital and Analog Input Output Modules which shall be required for future expansion of the Lock gates shall be procured at that time by the Contractor.

The PLC control system is envisaged to control all Navigational lock operations from the control desk located at the control room on the top floor of the control room building.

(i) All the major equipments shall be controlled from the PLC and Remote I/O Panels (located in Local Control Panel rooms) such as

- a) LCP Mitre Gate-(Leaf-1) PUSH BUTTONS OPEN / CLOSE
- b) LCP Mitre Gate-(Leaf-2) PUSH BUTTONS OPEN / CLOSE
- c) LCP Mitre Gate-(Leaf-3) PUSH BUTTONS OPEN / CLOSE
- d) LCP Mitre Gate-(Leaf-4) PUSH BUTTONS OPEN / CLOSE
- e) LCP Radial Gate-1 PUSH BUTTONS – UP/DOWN
- f) LCP Radial Gate-2 PUSH BUTTONS – UP/DOWN
- g) LCP Radial Gate-3 PUSH BUTTONS – UP/DOWN
- h) LCP Radial Gate-4 PUSH BUTTONS – UP/DOWN

- i) Submersible Pump Motors (4 Nos.) – PUSH BUTTONS START / STOP
 - j) Capstan Motors for Caisson Gate (2 Nos.) – PUSH BUTTONS START / STOP
- (ii) The PLC and remote I/O panel (at Local Control Rooms) shall also have provisions for various indications / status of various equipments such as:
- a) All Mitre Gates LED OPEN / CLOSE
 - b) All Radial Gates LED UP / DOWN
 - c) Submersible Pump Motors LED ON / OFF
 - d) Capstan Motors LED ON / OFF

The system shall consist of all the required panels, components, inter-connection cables, field sensors on all the equipment, junction boxes etc. to achieve the required functions. Basic interface of PLC, RIOs with field devices is shown on Control Architecture **Drawing No. ENL012**.

5.3.2.7 Remote Input Output (RIO)

Remote Input Output shall accept the command from main PLC; also, it shall send and receive the data from Control Room PLC. It shall have RS-485 (Modbus RTU port interface to communicate with controllers) It shall have communication interface with necessary signal/ baud rate converters. No redundancy required for I/O modules. The input modules circuit voltage shall match with Power control centre voltage PCC's (MV Switchgear). It shall also have DI, DO, AI, AO and RTD etc. modules of suitable channel density, numbers and with appropriate spare channel capacity, Supply Voltage Rating, Current input/output is 4-20mA DC for AI/AO. Voltage input/output of 24V DC and/or 240V AC for DI/DO to suit the functional requirements. Also include appropriate spare capacity on I/O rail/rack.

It shall be an intelligent Remote Input/output unit and shall have communication processors / interfaces to communicate with PLC system. It shall send and receive the data from PLC. It shall have Mod-bus-RTU, RS-485 port interface to communicate with Local

Control Panels.

It shall have communication interface with necessary signal/ baud rate converters. The input modules circuit voltage shall match with Power control center voltage PCC's (MV/LV Switchgear). They shall be suitable for field mounting with IP 55 degree of enclosure protection inside transfer towers or at outdoors.

A) Digital Input Module

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	3 mA
Isolation	Isolation should check with 1000VAC (isolation byopto-couplers)
Dimensions (Max)	As per standards
Operating Condition	Temperature: 8°C-65°C Humidity: 8% -95%
Input Voltage For signal "1"	110 VAC Or other approved to meet the operational requirements
Input Current	5mA to 50 mA
No. of Channels	32/16 per module

B) Digital Output Module

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Short circuit protection of the	As recommended per channel

output	
Isolation	Isolation should be checked with 500V DC (isolation by opto-couplers)
Dimensions (Max)	As per standards
Operating Condition	Temperature: 8°C-65°C Humidity: 8% - 95%
Output Voltage For signal "1"	110VAC or any approved to meet the operational requirement
Output Current For signal "1" max for signal "0" residual current max	2A 3mA
No. of Channels	32/16 per module

c) Analog Input Modules

Technical Specifications:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	225 mA
Isolation	Isolation should be checked with 1000VAC
Address space per module	4 bytes
Dimensions (Max)	As per standards
Operating Condition	Temperature: 8°C - 65°C Humidity: 8% - 95%
Measurement Type/range	4 to 20 mA / 0 to 24 VDC
Overflow / underflow	Disable/enable
Resolution Temperature errors	13 bit or more + 0 to 2% K
No. of Channels	16/8 input channels
Status information/alarms/diagnostics	Process alarm (yes)
Scan time (all channels)	25 ms

d) RTD Modules

Technical Specification:

Supply Voltages	24 VDC Reverse Polarity Protection
Current Consumption	150 mA

Isolation	Isolation should be checked with 1000VAC
Address space per module	4 bytes
Dimensions (Max)	As per standards
Operating Condition	Temperature: 8°C - 65°C Humidity: 8% - 90%
Overflow / underflow	Disable/enable
Resolution Temperature errors	13 bit or more + 0 to 2% K
No. of Channels	8 Channel RTD
Temperature Sensor	2/3/4 wire RTDs (PT 100 type)
Scan time (per channel)	50 ms

5.3.2.8 The UPS

UPS shall be provided for components/locations wherever necessary with rated output powers to suit the load in each case. Redundant UPS shall be provided in the Control Room. The rating of UPS shall be based on the total load calculation of the equipment's in Control Room. The status of UPS shall be indicated at CR-VDU. Lead Acid maintenance free storage battery units with closed top cells of capacity to meet the 1-hour UPS backup requirements shall be complete with all accessories and devices.

Technical Specifications:

Rated output power	To serve the loads for 1 hour.
Input	415 Volts, AC + 10% at 50 Hz + 5%
Output	240/110 Volts, AC, 50 Hz
Static Output Tolerance	+ 1 %
Dynamic Output Tolerance	+ 5 % (without Battery)
Switch over Time	Less than 10 milliseconds
Design Reference Ambient Temperature	45°C

Stationary type Lead Acid storage battery units with closed top cells of capacity to meet the 1-hour UPS backup requirements shall be complete with all accessories and devices. While sizing each battery the following factors shall be taken into consideration:

- a) Aging factor as 0.8
- b) Temperature correction factor
- c) Backup period - 1 hour
- d) Power Factor- Unity
- e) Manual bypass option shall be provided

5.3.2.9 Ethernet Switches

Ethernet Switches should be of managed industrial-grade type that provides very high-speed Fast Ethernet and Gigabit Ethernet with Copper and Fiber Optic media connectivity for deployment in harsh environments. They should be able to operate in environments suitable for industrial networking.

The Ethernet Switch shall allow expansion of network securely. It shall be optimized for maximum system availability, with fully redundant stacking, redundant power options. Network security shall be provided through IEEE 802.1Q VLANs, IEEE 802.1x port authentication, access control lists (ACLs), denial-of-service (DoS) prevention, and MAC- based filtering. Web-based configuration shall be secured using SSL

5.3.2.10 The Ethernet UTP cable

Shall meet the EIA/TIA-568/569 and shall be suitable for use in noisy environment. It shall be of Cat5e/Cat6 type.

5.3.2.11 Fiber-Optic Cable

As required, shall be 8 core Single Mode Armoured Cable. FO Cable should be internally wrapped with dielectric tape and corrugated steel tape armouring and shall be suitable for outdoor laying.

5.3.2.12 Control and Instrumentation Cable

Shall be suitable for laying in perforated trays, pipes, ducts, closed trenches and directly buried underground. All cables shall be armoured type. Cables shall be provided with additional overall Shielding with Aluminium Mylar tape with 100% coverage and 25% overlap on laid up cores for shielding against static/ electromagnetic interference. The voltage rating shall be 1100V with an ambient temperature of 45°C. The conductor shall be of plain annealed high conductivity copper stranded wires which before stranding shall be generally circular in section, smooth, uniform in quality and free from scale spills, splits and other defects. The conductors shall conform to relevant IS specified. The insulation shall be chemically cross-linked polyethylene XLPE conforming to the physical, electrical and ageing properties as required to relevant IS specified. Armouring shall be arranged over the inner sheath for the cable consisting of two or more cores. The armour of cables shall be either of galvanized steel wires or galvanized steel strips. A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armouring to offer a high degree of mechanical protection against abrasion. Additional compound shall be applied under and over each layer. In order to prevent adhesion, a coating of lime wash or other suitable material shall be applied to the outside of the cable. Outer sheath shall be FRLS.

5.3.2.13 The RS485 STP cable

RS 485 Cable shall be shielded twisted pair copper cable with minimum of four cores. These cables shall be insulated and PVC sheathed FRLS cables for serial data communication purposes.

5.3.2.14 Other Control Subsystems

The Different Local Control Panels, RIOs Panels for Gates & Pump motors with required Cabling and Accessories shall be provided by the Respective Contractors and shall be integrated with the Main PLC Control System.

5.3.2.15 Networks

The automation network shall be real-time Open universal network, requiring long time continuous operation. During normal operations, the system cannot be shut off and it shall be possible to replace the components without shutting off the power. It shall be feasible to program the system online. The response time of the system shall be such as to minimize the spillage of material on the belts under emergency stop conditions.

The management network shall be full duplex with full redundancy. Proper care should be taken in the data transfer in order to achieve quick response while transmitting control and management information. The response time should not be more than one millisecond. The network system shall have fault clearance functions, secure transmission of data through error checking routines on all data transmitted. The networks shall use open systems technology, support multiple industrial standards, allow a combination of multiple communications agreements, and shall have the capability to join wider networks in the future.

The networks shall use MODBUS RTU RS 485 Cable to connect PLC to RIO Panel. In general fiber optic cable shall be used for distances greater than 500 meters. The data cable shall be suitable to communicate between RIO (Remote Input Output Panel), other Control Subsystems like LCP's shall be connected to the Central Control Operator (PC/PLC) station to meet the functional requirements. The baud rate or transmission rate shall be 10/100 Mbps. It shall be a high-speed data access control type capable of handling critical time functions. This network shall be used up to 32/64/128/256/1024-devices. Redundancy in the control network shall ensure that at all times signals shall be available to all interfaced components. The management network shall exchange plant related information between various information and data terminals (PC consoles) and Control Room/Master Control Unit. Redundancy in the management/control network shall ensure that at all times signals shall be available to all interfaced components.

5.3.3 Software

5.3.3.1 General

Software provided shall be based to the maximum extent on standard packages to minimize complex programming tasks and facilitate support, maintenance and upgrading. Software shall be "user friendly".

The development of the application software shall be done in consultation with the Employer's Engineer in a number of stages (requirements definition, functional specifications, design, implementation and testing, maintenance and training) with each stage to the Employer's Engineer's

approval. The final version of the software will be subject to the approval of the Employer.

The software shall meet the requirements of this specification for all of the management and control system functions and operations, and it shall be possible to develop it in further detail on site to meet the management and operating needs of the Employer.

Programs shall be rationally structured, well readable, easily revisable, and with man-machine interfaces displayed in English.

The software shall be suitable for use with multiple methods of English character input. Manuals shall be provided for all software in English

Proprietary software packages forming part of the software provided will include permanent run-time licenses. If any part of the software requires annual license fees, the cost of such fees will be indicated in the bid.

In any case the Employer shall have the right to freely develop, modify, maintain the application software, and shall provide the source code and all relevant manuals and information needed for this purpose.

Utility programs shall be included in the software supply, including network management, multi-level password protection, on-line help, virus protection, and back-up and archiving, word processing, statistics, simulation and data communication (like MS Office, Recommended (McAfee/Trend Micro/Windows one live) Antivirus, Adobe Reader). Whenever an operator input data, a text window will be prompted on the display.

The Software's that are required for different field devices shall be provided by the respective vendors, and it shall be the responsibility of the Contractor to install third Party software's in respective Terminals.

5.3.3.2 Management Software

Management software shall include system software, and application software based on the use of a commercial database Package.

All the operations, displays and print-outs in the management information system will be in the English Character.

The management system software will operate in parallel with the control system and will continuously and automatically poll the real-time control network database to acquire current data for the management system. To optimize the CPU utilization updating will be done on an exception basis whenever a data element is changed.

The system software shall ensure, that the two network workstations will always have identical databases, so that if one fails, the "stand-by" unit will be able to continue operations with the minimum of interruption feasible; and that the database of the failed unit is immediately updated when it is restored to service.

The application software shall be independent of the system hardware, and be easily transferable. It shall be capable of further developing and operating the management system.

The data required in the data bases shall be entered manually or transmitted from remote systems, or automatically obtained via the control network management network.

The goal of the system is to centralize information and planning for the Material Handling solution operations and to optimize the utilization of all facilities. The system shall also be a central clearing house of information on material and equipment. All records shall be cross-linked between inventory and shipping databases, with the intention that the source, destination, location and movement schedule of all current, previously and future stored material is known and movements can be planned as far in advance as possible. It should be possible, through the system, to know the position, type, Employer, consignee, quantity, age and any other relevant details of every quantity of material stored in the Plant. A maintenance database shall be provided to track equipment operation, faults and availability, and used to automatically schedule maintenance.

The software shall be customized off-the-shelf or custom as required to deliver the features described herein. Custom software shall be completed in an accepted and common programming language such as C++, VB, JAVA, MY SQL SERVER or equivalent approved by the Employer's Engineer and shall be provided complete with soft and hard copies of documented source code, development tools and program libraries, along with an undertaking by the manufacturer to provide a minimum of 10 years support. Off-the-shelf software shall also come with a manufacturer's undertaking to provide a minimum of 10 years support.

Secure logons shall be used and users shall be grouped according to access needs, offering limited read-only, unlimited read-only, unlimited read and limited-write, and full read/write access, depending on user needs. The number of persons with full read/write access shall be kept to a minimum.

Users input to the databases shall be tagged with the time, username and write made, in order to allow security auditing and error tracking.

Remote login shall be enabled to allow data to be added by persons who shall have business with the handling facilities. They shall be assigned unique secure logins and shall be allowed appropriate levels of access. Their entries shall also be tagged with time, username and data entered to allow security auditing and error tracking.

With regards to remote sessions connections, preference shall be given to systems providing a standard gateway, such as secure web-based or other, to eliminate the need to disseminate custom client software to remote operators. Tight security must be provided, with IP logging, and ideally remote sessions should be restricted to 'white-listed' remote IP's to reduce the change of inadvertent access.

5.3.3.3 Control Software

The control software shall be used mainly to:

- Control the process flow operations
- Process operating instructions
- Control operating cycles and interlocking sequence logic
- Collect data automatically on equipment status and fault indication
- Collect and process data in real-time
- Transmit data and communicate with RIO's/ Subsystems/associated control devices
- Automatically diagnose faults in the complete system
- To provide a human interface for the operators on SCADA
- Update the software programs.

The PLC programming language (**IEC-61131-3**) shall be of ladder type, functional block description, or other approved standard type. It shall be possible to program the system on-line. Facilities shall be provided to monitor the system on-line in addition to programming, using either mounted on PLC hardware or separately through a programming workstation so that forcing of I/Os, changing of timer/counter values, contact monitoring, error analysis etc are possible. The PLC/PCs shall read or write data

from/to the RIO's, workstations, associated control devices indicated on the Control Architecture Drawing and elsewhere in this specification.

All displays shall be dynamic and updated continuously, irrespective whether they are actually shown on the screens or not at the time. All page/graphic displays shall be programmable so they can be changed at any time to add additional information needed by a software engineer at the site off-line.

The software shall display the fault and alarm status of the plant components and shall be available in the data base at all times. The fault and alarm status shall be transferred to maintenance operator automatically.

The data base and data formats in the control system shall be identical to the management system databases.

Control Room and Related Rooms

The Control Room will be housed on the First floor which will house the Store Room, Pantry, Rest Room & toilet.

In Control room the following equipment will be installed:

- Server Station;
- PC Operating Cum Programming Terminals;
- PLC and associated control equipment
- Printers;
- Network Video Recorder for CCTV;
- CCTV Monitoring Terminal
- UPS;
- Third Party Control Systems for Field Instruments (VDU, Total Station and Automatic Data Acquisition System)

The consoles shall be low profile, laid out ergonomically in an arc shaped pattern, to accommodate the equipment and the operators to permit efficient operations with a minimum of fatigue. The layout will be subject to the approval of the Employer's Engineer. Appropriate non-glare lighting shall be provided in the Control Room, which shall be fully air conditioned and shall have sound absorbing panelling ceilings and walls.

The control equipment room will house equipment such as PLC panels, I/O panels, distribution panels, control power panels. The computer room will accommodate the network file workstations, network devices; system engineers work stations and printers. The UPS and associated batteries will be in a separate room. The Control Room First Floor will be air conditioned. False floors shall be used in the Control Room First Floor to accommodate cabling and connections. The Contractor shall supply four revolving, ergonomic office chairs, media storage, bookcases for manuals, and filing cabinets.

5.3.4 Network Components & Accessories

5.3.4.1 Ethernet Switch

Ethernet Switches should be of managed industrial-grade type that provides very high-speed Fast Ethernet and Gigabit Ethernet with Copper and Fiber Optic media connectivity for deployment in harsh environments. They should be able to operate in environments suitable for industrial networking.

The Ethernet Switch shall allow expansion of network securely. It shall be optimized for maximum system availability, with fully redundant stacking, redundant power options. Network security shall be provided through IEEE 802.1Q VLANs, IEEE 802.1x port authentication, access control lists (ACLs), denial-of-service (DoS) prevention, and MAC- based filtering. Web-based configuration shall be secured using SSL.

For Power over Ethernet (PoE), automatic load sensing in the power-control circuitry detects PoE on the end device before providing power. For safety, each port shall have independent overload and short-circuit protection, along with LED indicators to show power status. The switch shall provide PoE power on up the Ethernet ports for powering PoE-enabled wireless access points.

It shall integrate into Supervisory Control and Data Acquisition (SCADA) systems, and any other facilities. The switches shall have industrial-grade components, a compact form factor, convection cooling, and relay output signalling to extend intelligent services such as enhanced security, high availability, and advanced quality of service (QoS). A large number of protocols supported make sure that the system will interoperate with other

Ethernet- enabled devices and IP applications and enables integration between business office applications and industrial equipment.

It shall have device manager software which allows users to easily configure and monitor the switch using a standard Web browser. Customers can easily initialize the switch with Web-based set up. In addition, a standalone network management application shall be provided so that operator can simultaneously configure and troubleshoot multiple switches. The bundled software shall reduce the cost of deployment by enabling less- skilled personnel to set up switches quickly.

Technical Specification

No of Ports	24 No's of 100/1000 Ethernet port copper modules and 4 Fiber Optic Ports
Managed	Yes
Power inputs	240 VAC at 50 Hz
Industry Specifications	IEEE 1588 Precision Time Protocol, IEC 61850-3 (substations), ODVA Common Industrial Protocol, IEEE 1588v2, NEMA TS-2 (ITS)
Mounting	DIN-rail, mount option, desktop and wall, rack Stackable
Intrusion protection rating	IP 20
Operating temperature	32 to 113°F (-40 to 70°C)
Operating relative humidity	10 to 95% (condensing)

5.3.4.2 Patch panel

Patch panel shall provide ultra-high-density connection while facilitating cable routing and patch cord management. They shall be of Rack-mount

and Wall-mount they should be totally modular and scalable to accommodate future fiber build-out.

Patch panel unit housings shall be of 1U, 2U and 4U or small, medium and large (depending on whether it is rack or wall mounted) size (as per the number of terminations), in titanium color. The front patch cord tray and rear cable tray shall be removable for easier access during the installation.

Technical Specification

Rack Mount	No of Adaptor Strips
a) 1U Rack Mount	2
b) 2U Rack Mount	4
c) 4U Rack Mount	8
Splice Trays	
a) 1U Rack Mount	1 x 8 in.
b) 2U Rack Mount	2 x 8 in.
c) 4U Rack Mount	4 x 8 in. or 4 x 12 in.
Wall Mount	
No of Adaptor Strips	
a) Small Wall Mount	2
b) Medium Wall Mount	4
c) Large Wall Mount	8
Splice Trays	
a) Small Wall Mount	1 x 8 in.
b) Medium Wall Mount	2 x 8 in. or 2 x 12 in.
c) Large Wall Mount	4 x 8 in. or 4 x 12 in.

5.3.4.3 Media Converter

Media converters shall be installed for use in optical field-bus networks. They shall allow the conversion of electrical interfaces (RS-485 level) into optical interfaces and vice versa. The modules shall be integrated in existing field-bus networks with the known advantages of optical

transmission technology. A complete field-bus network shall be set up with modules in a linear (bus), star or preferably ring topology as well as any combination of these topologies. To increase the reliability of the field-bus network in case of failure, redundant ring wiring topology shall be supported.

Technical Specifications

Number of Ports	Device/Network Dependent
Operating voltage	24 V DC safety extra low voltage
Current consumption	Max. 200 mA
Output voltage for bus termination RS-485 (D-sub jack, pin 6)	-5 V DC+5/-10%,
Signaling Contact Function	floating contact, opens in case of error
Signaling Voltage	Max. 50 V DC/30 V AC safety extra low voltage
Signaling Current	max 1.0 A
Signal transmission rate	Network dependent
Transmission rate setting	Device/Network Dependent
Electrical channel type	RS-485
Electrical channel voltage	-7 V... +12 V
Optical channel wavelength	Device/Network Dependent
Maximum Distance Transmitted	Device/Network Dependent
Connector	BFOC/2.5
Safety	IEC 60950
Hazardous Locations	ANSI/ISA-12.12.01-2000 compliant (up to CLASS 1, DIVISION 2, GROUPS A, B, C AND D, T4)
Operating temp	-25 °C...+60 °C
Storage temp	-40 °C...+70 °C
Relative Humidity	<95% non-condensing

Protection class	IP 42
Enclosure material	stainless steel
Installation position	Vertical
Mounting	DIN Rail Mounted/Rack Mounted

5.3.4.4 Jack Panel

- Performance should meet EIA/TIA 568.
- Highly compact with 24 information outlets.
- 19" Rack mountable.
- Size of Jack Panel should be 1 U.

5.3.4.5 UTP Cable (Ethernet Cable)

- Should meet the EIA/TIA-568/569 Category 6.
- Should meet the category 6 standard.
- Must be in minimum 4 pair, unshielded twisted pair cable.
- Suitable for use in factory (noisy) environment.
- Suitable tested till 600Mhz

5.3.4.6 UTP Patch Cords

- Unshielded twisted pair 100ohms multi standard and highly flexible.
- Should meet EIA/TIA 568 Category6.
- RJ-45 connectors with Resistance of 20 mega ohms.
- RJ-45 connectors are three-piece two-layer design connectors.
- Size of patch cords should be 2 meters

5.3.4.7 UTP to OFC Converter

- Converters to be directly connect to the 10/100 Mbps L-2 Switch.
- L-2 side connection is RJ-45 port and OFC with SC Port.
- UTP to OFC converter should suitable for the 19" rack mounting.
- Input power supply 240 VAC, 50 Hz also vendor can suggest with 24 VDC supply.

5.3.4.8 OFC Cable

Fibre optic cable shall be Single Mode (9/125 μM) armoured, having 8 cores. These cables shall be perfect immunity to noise. These cables shall be suitable to communicate between Field Interface and PLC terminals to meet the functional requirement.

The core in fibre-optic cable shall be made from a combination of highly purified silicon and germanium. The cladding shall be made by pure silicon. Surrounding the cladding is a buffer material which acts as a shock absorber to protect the core and cladding from the damage. The outer jacket shall protect against abrasion and environmental damage. The fibre optic cable shall be armoured.

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark and year of manufacture of the cable indented or embossed on the cable. The indentation or embossing shall be done only on the outer sheath.

Fibre optic cable shall meet all the functional and technical requirements in this specification

Technical Specifications for Single Mode Fibre optic cable:

Fibre Size	9/125 micro meter
Maximum Length	5km
Fibre Material	Glass
Permissible Temperature	-20°C to 60°C
Permissible Humidity	75% on average
Outer Sheath	Poly Ethylene
Bend Radius (Long Term)	10D
Bend Radius (Short Term)	20D

Tensile Load	2500N
Operating Wavelength (nm)	1310/1550
Jacket Type	Loose tube
Max Attenuation (db/km)	0.35/0.25
Zero Dispersion Wavelength (nm)	1312±12
Cable Cut off Wavelength (nm)	≤.1260
Polarized Mode Dispersion (PMD)	≤ 0.2
Mode Field Diameter (MFD)	9.2±0.4/10.4±0.6
Number of Fibers	8
Strength Member	Aramid yarn / Steel music wire
Armour	Steel
Buffer	Gel filled and PBT tube
Compliance standards	TIA/EIA-568-C.3 IEC 60793 IEC 60794
Color Code Standard	TIA/EIA-598-B

5.3.4.9 OFC Patch cord

- Should meet EIA/TIA 568.
- Patch cord should suitable for single/multimode fiber application.
- Plastic molded plug or metallic body connectors.
- Fiber patch cord SC-SC type duplex.

5.3.4.10 UTP Information Outlets

- Information Outlets should be of dual points.
- Surface mount box should fit single or dual information outlets.
- Should meet EIA/TIA 568 Category 6.
- Should have insulation resistance of 500 M-ohms minimum and contact resistance of 20 M-ohms max.
- Information Outlets should have cable entry points on all 4 sides and one in the center.

5.3.5 Associated Control Devices/Sub-Systems

The Contractor shall be responsible for the interconnection of all such associated devices/ sub-systems with the control system under this specification and their integration with the software supplied by the Contractor. Please note that the interconnections shall be such that the status of all devices/sub-systems shall be transmitted to the control network irrespective of whether a motor is in the “local” or “auto” mode. All third parties interface shall be hooked to Control Room in RS-485 Port /Optical Data highway link (as applicable) compatibility.

5.3.5.1 Control Wiring Installation

Control wiring shall be done by Flame Retardant Low Smoke (FRLS) insulated stranded copper conductor wires. Terminals emanating from various control devices of conveyors like pull cord, belt sway, belt speed, belt take up limit switches, Local Control Station etc. shall be brought to a junction box by PVC insulated, control cables.

One ‘NC’ contact of all switches shall be interconnected in series by 2.5 sq.mm copper cables and brought to the junction box mounted at an interval of 200 M i.e., at crossover points for long conveyors or at head/tail end of the conveyors.

Also, one ‘NO’ contact of all switches shall be interconnected in parallel and brought to the above referred junction box.

Similarly, control terminals (intended for sequential interlocking and/or indication in Control Room) emanating from each of the other system such as winches, dust control, belt-weighers, metal detector, magnetic

separators, hoist, level detectors/controllers etc. shall be brought up to their respective junction boxes located suitably and terminated therein.

It is to be noted that individual cores from each safety device mentioned above shall be connected in the junction box properly identified by interlocking ferrules and no looping is permitted in this junction box.

The cables shall be laid over ladder type/pre-fabricated GI cable trays, which shall be mounted on short posts all along the conveyor.

5.3.5.2 Local Control Panel

The local control panels shall be mounted adjacent to the equipment and exposed to normal ambient environment and shall have IP65 degree of protection.

This panel shall house the essential monitoring instruments. Alarm/annunciation system, command station like control switches, start/stop push buttons, indicating lamps, ammeters etc. required for start-up operation/maintenance of the equipment/sub- system/system locally.

All panels shall be of free-standing welded construction and shall be robustly constructed of cold-rolled sheet steel of thickness not less than 2 mm.

All panels shall have (left off type) doors, capable of being opened through 180 deg. A pocket shall be provided on panel door for cable termination charts which are also in the Contractor's scope. All doors shall be supplied with built-in locking facility. All doors, removable covers and plates shall be gasketed all around with 4 mm neoprene gaskets. The enclosure shall be vermin-proof, dust-proof and weather-proof.

The interior of each panel shall be suitably illuminated through fluorescent lamps operated by a panel door-switch.

Panel heaters suitable for 240 V, single phase, AC shall be provided on each panel bottom to prevent moisture condensation. Heater should be designed to maintain panel temperature 5°C above the ambient. Suitable miniature circuit breaker and thermostat for the heater shall be provided.

All panels shall be supplied complete with foundation and removable lifting eye bolts along with the panel base-frame for foundation.

Wiring, fuses, switches and terminal boards shall be properly color coded, routed and neatly run in insulated cleats/trays if required in such a manner that wherever practical it can be checked against the wiring diagrams. Wire sizes and layout shall conform to the relevant standards and to Employer's approval.

AC and DC bus-wires shall be kept separate from all other wiring and DC wirings shall be segregated from all other circuits. Supply to various equipment shall be directly tapped, from a through bus-bar and looping for the same shall not be used.

All wires shall be properly numbered and identified with ferrules at both ends to Employer's approval. Incoming and outgoing wires shall be suitably segregated wherever possible as per **relevant IS**.

One-piece moulded 1100V grade terminal blocks complete with insulated barriers terminal studs, washers, nuts and identification strips shall be used. Terminal blocks may be of clip-on or insertion type. Individual terminals shall be suitably insulated and spaced apart to enable access to the same

and preferably of Elmex/Jyoti make. Terminal blocks shall be numbered for identification and grouped according to function. Minimum clearance between rows should be 100 mm. In case terminal blocks are mounted vertically suitable slanting shall be provided for ease of termination. At least, 20% spare terminals shall be provided in each row of terminals, after all cable cores, including spare cores have been terminated. For incoming AC and DC supplies, separate terminal blocks shall be provided. These terminals shall be suitably shrouded.

Panel internal wiring shall be done with 1100V grade PVC insulated copper wire of size not less than 2.5 sq. mm. Insulation of wiring shall be flame retardant type and shall not deteriorate at ambient temperatures.

All wires shall be suitably terminated with solder less crimping type tinned copper lugs which firmly grips the conductor and insulation.

Tapping/jointing of wires is not permitted and looping of wires shall be avoided to the maximum. In no case, the number of wires per terminal shall exceed 2. All accessories such as packing glands, crimping type tinned copper lugs, supporting clamps and brackets etc. shall be supplied by the Contractor.

Undrilled cable gland plates and cut-out covers for cable and pipe entry shall be provided. Cable entries shall be suitably sealed with an approved non-inflammable seal material. Cable gland plates shall be at least 250 mm above floor/ground. Necessary number of cable glands shall be supplied fitted on this gland plate and the same shall be specified by the Employer during detail engineering stage.

Suitable isolating switches and fuses, preferably HRC cartridge type mounted on plug-in- type fuse bases (both made out of moulded insulating material) shall be provided for incoming power supplies to the panel. It should be possible to change fuses with the circuit alive

Each electrical drive motor shall have two modes of operation; 'Local' and 'Auto', manually selectable by a three-position selector switch "Local-Off-Auto' Each heavy-duty selector switch shall be located close to and within view of each drive motor (except in the case of the multi motor for which see below). Start-Stop, Forward-Reverse push button shall be provided next to or integrated with each L-O-A as required. It shall be feasible to lock the L-O-A switch in the 'Off' position, so that the locking key can be retained by maintenance staff for working on the driven equipment in safety.

In the cases of conveyors with multiple motor drives, a single L-O-A switch shall be provided per conveyor near only one of the drive motors. However:

A maintained contact emergency stop switch shall be provided near the other drive motor(s).

The emergency stop switch shall have at least three sets of NC/NO potential free contacts rated 10amp at 110V AC in an IP-65 protected enclosure. A red mushroom type of actuator shall be used. There shall be two cable entries suitable for double compression glands (or better) for up to 10 x 2.5 sq mm copper conductor armoured control cable. Earthing terminals shall be provided on the enclosure.

5.3.5.3 Control devices

"Control devices" generally consist of sub-systems complete with:

- Individual control panels (usually at or near the sub-system),
- Internal control logic,
- Internally wired components

These units shall be integrated with the Control System and shall be connected and interfaced to the System by the Contractor. Physical installation of such devices or sub-systems, their internal electrical connections. However, the interconnecting cables between the control panels of such sub-systems and the components of the control system supplied under this specification shall be the Contractor's responsibility. The Contractor shall coordinate with the suppliers of such control devices/sub-systems to ensure that the functional requirements are fully satisfied. In the case of such sub-systems as for rail and truck loading, the Contractor shall ensure smooth transmission of data to and from the workstations PLC or Controller / PC's supplied. These shall be interface/interlocked/ integrated with the control system through Modbus - RTU/hardwired Mode, etc.

5.3.6 Cables and Wires

5.3.6.1 Control Cables

This specification covers the requirements for Voltage Grade 1100 V armoured, multi core XLPE (cross linked polyethylene) insulated and PVC sheathed, FRLS cables for control purposes.

All cables shall be designed and manufactured such that no damage occurs during transportation, installation and operation of the cables under stipulated conditions.

The cables shall be suitable for laying in trays, pipes, ducts, closed trenches and directly buried underground. All cables shall be armoured type.

Cables shall be provided with additional overall Shielding with Aluminum mylar tape with 100% coverage and 25% overlap on laid up cores for shielding against static/electromagnetic interference.

System Particulars

- Voltage : 1100 V grade
- Ambient Temperature : 50°C.

5.3.6.2 Conductors

The conductor shall be of plain annealed high conductivity copper stranded wires which before stranding shall be generally circular in section, smooth, uniform in quality and free from scale spills, splits and other defects. The conductors shall conform to relevant IS. The stranded conductor shall be clean and uniform in size and shape and its surface shall be free from sharp edges.

5.3.6.3 Insulation

The insulation shall be chemically cross-linked polyethylene XLPE conforming to the physical, electrical and ageing properties as required by relevant IS. Only natural unfilled compounds shall be used for insulation of cables. The insulation shall be free from micro voids and shall be heat resistant.

5.3.6.4 Inner Sheath

For all cables having two or more cores, the individual cores shall be laid up and then be surrounded by common covering applied either by extrusion or wrapping or filling material containing a thermoplastic material. A proofed or plastic tape may be applied over the common covering when a wrapped common covering is employed. It must be ensured that the circularity of the cable is maintained.

5.3.6.5 Armouring

Armouring shall be arranged over the inner sheath for the cable consisting of two or more cores. The armour of cables shall be either of galvanized steel wires or galvanized steel strips.

5.3.6.6 Outer Sheath

A tough outer sheathing of PVC insulating material in standard colours shall be provided over the armouring to offer a high degree of mechanical protection against abrasion. Additional compound shall be applied under and over each layer. In order to prevent adhesion, a coating of lime wash or other suitable material shall be applied to the outside of the cable. Outer sheath shall be FRLS.

5.3.6.7 Colour Scheme for Identification of Cores

Cores shall be identified by colour scheme of PVC/ XLPE insulation. The following colour scheme shall be adopted:

- Up to five cores- Red, Yellow, Blue, Black and Grey.

For cables having more than five (5) cores, two adjacent cores (counting and directional) in each layer may be coloured blue and yellow respectively and the remaining cores may be light grey.

5.3.6.8 *Manufacturer's Identification*

The manufacturer shall be identified throughout the length of the cable by manufacturer's name or trademark, voltage grade and year of manufacture of the cable indented or embossed on the cable. The indentation or embossing shall be done only on the outer sheath.

5.3.6.9 *Serial Data Cable (RS485)*

These shall be shielded twisted pair copper cable with minimum of four cores. These cables shall be insulated and PVC sheathed FRLS cables for serial data communication purposes.

All cables shall be designed and manufactured such that no damage occurs during transportation, installation and operation of the cables under stipulated conditions.

5.3.6.10 *Junction Boxes*

All the JB's (Junction Box) shall be metal enclosed, suitable for mounting on wall (or) sheet structure in material dust laden atmosphere. The enclosure shall be made of high quality Polycarbonate (shock proof, rust free, corrosion free, acid and chemical resistant, fire retardant, having high impact [IK 08], totally insulated [class II] made of halogen and silica free recyclable material), UV resistant, having high grade gasket made of Polyurethane, should withstand glow wire test at 960°C in accordance with IEC 60 695-2-11, should be flame retardant, self-extinguishing the Junction

box should have test certificate in accordance with IEC 60 670-22 The JBs shall be dust and vermin proof and shall have IP- 66/67 degree of protection as per relevant code. The JBs shall be suitable for both top & bottom cable entry and shall be provided with removable undrilled gland plates or knockouts. Clip-on type/screw terminal shall be mounted on the base chalked in the JBs. The base channel shall have space for accommodating another 20% extra terminal. Two numbers of earthing points suitable for 12 SWG GI wire shall be provided on the body of the JBs.

5.3.6.11 Packing and Marking

The cable shall be wound on a wooden drum and packed as per the requirement of relevant IS. The ends of the cable shall be sealed by means of non-hygroscopic sealing material.

The cable shall carry the following information either stenciled on the drum or contained in a label attached to it:

- Reference to Indian Standard
- Manufacturer's name or trade-mark
- Type of cable and voltage grade
- Number of cores
- Nominal cross-sectional area of conductor
- Cable code
- Length of cable on the drum
- Number of lengths on the drum (if more than one)
- Direction of rotation of drum (by means of an arrow)
- Gross mass

- Year of manufacture.
- Dispatch

The cables shall be dispatched in suitable drums with weatherproof packing.

5.3.7 CCTV Surveillance System

5.3.7.1 General

Surveillance CCTV system is required to ensure surveillance of required locations as well as create secured record for post event analysis. The system shall provide an online display of video images on LED monitors located at different locations. System shall facilitate viewing of live and recorded images and controlling of all IP cameras by the authenticated/authorized personnel. The core of the surveillance system shall be NVR servers. System shall also have operating systems, appropriate software, networking equipment and other essential components.

The communication between the cameras and the Camera Control Room shall take place to ensure the maximum availability, Real time Delivery of the Datagrams and further maximize determinism. In addition to the Wireless, Backbone of the network an additional fibre optic as optional backbone has to be built in order to ensure the failsafe working of the CCTV surveillance in the event of unexpected failure of the system components such as wireless routers etc.

System shall have expansion possibility with the available hardware (system shall have the facility of additional camera installations beyond the originally planned capacity). It shall be an open standard based integrated system with IP network aimed at providing high- speed automatic operation

for best performance. It shall use video signals from various types of outdoor cameras installed at different locations. Joystick and mouse-keyboard controller shall be used for Pan, Tilt, Zoom, and other functions. System shall have a combination of Digital colour video cameras with individual IP address. It shall also have raid backup device of recording, application software, colour video monitors and keyboards.

Camera server shall be NVR server based with appropriate Audio and Video Management System backup system and software. Each camera server shall handle 60 or more cameras. CCTV system shall ensure that once recorded, the video cannot be altered; ensuring the audit trail is intact for evidential purposes. System shall provide sufficient storage of all the camera recordings for a sufficient period. The recording resolution and frame rate for each camera shall be user programmable.

5.3.7.2 Equipment Specifications for CCTV Surveillance System

A) NVR Server

The NVR shall have enterprise class reliability with a RAID 6 hard drive configuration and the option for redundant power supplies. In addition, both the hard drives and the power supplies shall be hot-swappable for online repairs. The NVR shall have upto 10 TB effective recording capacity that is expandable using a storage expansion unit. Quality Video Resolution: 640 x 480, 320 x 240 (default), 192 x 144. The Image Quality shall be of JPEG (favour clarity, standard, and favour motion) and MPEG4. It shall support a Frame Rate of 30 frames/sec (640 x 480, 320 x 240 or 192 x 144).

It shall support IPv4/v6 Dual Stack Supported Network Protocols. It shall support Simultaneous Viewing with simultaneous accesses with Image Transfer via E-Mail (SMTP) or FTP, SMTP, FTP, and HTTP etc. It shall be complete with standard keyboard, 21-inch X VGA LED colour monitor, mouse controller, CD/DVD drives, network cards.

B) Workstations

Data terminal computers shall have high computing power, suitable for communication equipment networking. Each processor should have its own independent system bus to reduce data bottle necks while maximizing processing throughput and multitasking. They shall be complete with standard keyboards, 21-inch X VGA LED colour monitors, mouse controllers, CD/DVD drives, network cards.

Processor	Intel i5 processor,
Clock Speed	3.6 GHz
Random Access Memory	4GB- DDR2-ECC-SDRAM Clock Frequency = 1667MHz
Hard Drive 1 Optical Drive	320 GB SATA CD/DVD read write
Communication Ports	Parallel Port-1, Serial Ports (Universal)-3, USB Ports-8
Power Source	240 V AC, 50/60 Hz
Network card	Additional Gigabit/10/100 MBPS Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%
Design Ambient temperature	50°C
Operating System	Windows 7/ 8/ 10
Power Source	240 V Ac, 50/60 Hz
Display Type	Compensated TN ,Full colour TFT LED Luminance :1150cd/m2
Resolution	At least 1280*1024 (NI)

Size	21 inch Diagonal
Operating Condition	Temperature : 0°C-40°C Humidity: 20% - 80%
Contrast Ratio	30000:1
Viewing Angle	140°H, 140°V
Safety Standards	UL6500/C-UL

C) Optical Fibre Cables

Multimode/Single mode (depend upon the distances), armoured optic cable standard cable shall be used. It shall have rugged design for industrial applications indoors and outdoors. It shall have high immunity to noise and electro-magnetic fields and shall be Tap-proof and radiation shall be limited to applicable standards. It shall also be silicon free and free from varnish-moistening substances.

D) Ethernet Cable (Cat 5e)

Category-5e cables shall be built tough enough to withstand the harsh environmental conditions and mechanical stresses. The cable shall also provide more stable electrical performance with less attenuation and greater resistance to EMI/RFI.

E) Cameras

All the cameras shall be IP based. They shall have an enclosure of minimum of IP-67 while outdoor cameras to be of IP-67. They shall also be outdoor ready with day/night functionality 36x (Optical Zoom) PTZ Camera and an Image Sensor with CCD sensor, approx. with wireless capability with advanced digital Signal Processing Capability, High Horizontal Resolution, Day and night Type, 360-degree continuous Pan Rotation with complete powersupply and accessories.

Image Device	Better format CCD sensor
Optical Zoom	36 X or better
Number of pixels	1280X960 or above
Scanning system	PAL
Pan Travel	360° continuous
Tilt travel	0 - 90° continuous
Iris Control	Auto
Focus	Auto
White Balance	Auto
Electronic shutter	Auto
S/N ratio	>= 40 dB
Frame Rate	PAL – up to 30 frames per second in all resolution
Operating Temperature	- 10 ° to 60 ° C.
Operating Range	Up to 190 meters
Mounting Frame	Aluminum (or any which suits whether conditions)

F) Mounts

All the cameras shall have appropriate mounts based on the camera design and the functional requirement of the same.

G) Enclosures

All the cameras shall have IP-67 appropriate dust tight enclosures ready for use in small Particle and dusty environments it shall also include Heater, Blower, Air Funnel Kit, Sun Shield and Sun Visor depending on the mounting location and requirement.

H) Video Management Software

Processor	Intel Xeon i5 processor
Clock Speed	3.86 GHz
Cache Memory Size	12 MB Cache L3 1333 MHz front side bus
Random Access Memory	8 GB DDR4 Clock Frequency: 1333 MHz

Hard Drive 1	10 TB (7,200rpm) SAS
Hard Drive 2	6 TB GB SOS
Communication Ports	Parallel Port-1, Serial Ports (Universal)-3, USB Ports-8
Power Source	240 V AC, 50/60 Hz
Network card	Additional Gigabit Ethernet PCI-E Network Card (in total 2 network connections)
Permissible Humidity	20%-80%
Design Ambient Temperature	50°C
Operating System	Windows

The software shall be IP-Surveillance software that works with the network cameras to provide video monitoring, recording and event management functions. It shall enable recording of video continuously, on schedule, on alarm and/or on motion detection. The software shall have multiple search functions for recorded events. Remote viewing and playback shall also be possible with the use of the client software.

5.3.8 Recommended Equipment/Component Vendor List

Make of the equipment under supply items shall be selected as per the following list. Employer, however, reserves, the right to select the particular make during detailed engineering for uniform design and inventory. Approval of makes for items not mentioned in this list shall be obtained from Employer/Employer's Representative Engineer before initiating procurement action.

ITEM	RECOMMENDED VENDORS
Servers	Hewlett Packard / IBM / Dell
LED (32")	Samsung / Sharp / Panasonic / LG / Sony
Workstation Terminals	Hewlett Packard / Dell / IBM
LED Monitors (21")	Sony/Samsung / LG / AOC/ Hewlett Packard

Network Printers	Hewlett Packard / Canon / Epson / Samsung / Lexmark
UPS	APC / Eaton / Toshiba/Best Power / Emerson Hi-Rel
PLC	Siemens / Allen Bradley / ABB / Schneider/Honeywell / Yokogawa / GE
CCTV	Honeywell/ Bosch
Network Components and Accessories	
Jack Panel	Molex / Sign Amax / Brand-Rex
Cat5e Cable (UTP)	Amp / D-Link / ADC
Cat6 Cable (UTP)	Amp / D-Link / ADC
UTP To OFC Converter	Moxa / D-Link
LIU (Light Guide Interconnect Unit)	D-Link / Moxa
Ethernet Switches	D-Link / Cisco / Moxa / Siemens / Nortel
UTP Patch Cords	AMP / ADC / D-Link
UTP Information Outlet	D-Link / Molex / ADC
Instrument Cable	Cords Cables / KEI / Associated Cables / Universal Cables
Panel/Cabinets	Rittal / ICA / Pyrotech
JB/Cable Gland/Plugs	Hensel / Rittal / Emitter
OFC Cable	Molex / D-Link / Finolex / RPG Cables Ltd. / Sterlite Industries
Other Equipment's	
RTD	Pyroelectric Equipment's/General Instruments A.N. Instruments
Relays	Omron / OEN / Jyoti

NOTE: - Makes like 'or equivalent' are not acceptable. Other makes proposed shall be submitted to the Employer with back-up documents and PTR (Proven Track Record) for prior approval.

6. SPECIFICATION – HYDROMECHANICAL

6.1 GENERAL

A Navigational lock requires closure gates at both ends of the lock so that the water level in the lock chamber can be varied to coincide with the upstream and downstream approach channels. The sequence of “locking” a vessel upstream is: (i) lower the water level in the lock to the downstream water level; (ii) open the lower gate and move the vessel into the lock chamber; (iii) close the lower gate and fill the lock chamber to the level of the upper pool; and (iv) open the upstream gate and move the vessel out of the lock. Lockage of a vessel downstream involves a similar sequence in reverse order.

Two (2) nos. Mitre Gates are proposed one at upstream and another at downstream of the lock to facilitate the opening and closing operation.

Two (2) nos. floating type of Caisson Gates are proposed for replacement / repair / maintenance of Mitre Gate. Gates will be installed vertically at both end of the lock for stopping water flow from U/S and D/S of lock chamber only when Mitre gates are required to be attended for repairs.

Four (4) Nos. Radial gates are proposed, 2 Nos. at u/s and 2 Nos. at d/s at both side of lock for filling and emptying of the lock chamber to facilitate navigation of IWT vessels.

For repair of Radial gates, there will be bulkhead gates in front of each radial gate so that water flow from the lock basin is arrested. Hence total eight (8) bulkhead gates will be required.

6.2 MITRE GATE

6.2.1 Structure

The opening and closing of lock entrance and exit points are controlled by Mitre Gate structure by using 2 leaves. Mitre Gate structure shall be designed based on horizontal framing. The skin plate of a horizontally framed gate shall be supported by horizontal members which will be straight girders acting as beams. Each such horizontal member will be supported by the vertical quoin post at one end and the mitre post at the other. All water load will be transmitted through the girders and quoin blocking into the gate monoliths.

The conceptual general arrangement plan of the gate is enclosed in Drawing Nos ENL007-SH1, ENL007-SH2 and ENL007SH3.

6.2.2 Construction

The entire gate shall be weld fabricated with shipbuilding quality steel plate as per IS: 3039 for skin plate and primary structural members. For secondary structural members IS:2062 quality steel shall be used.

6.2.3 Control System

The gate shall be operated through electro-hydraulic system to achieve opening and closing time preferably in 3 mins (max. 5 mins.)

The electro-hydraulic system shall be proven and selected from reputed manufacturer who had supplied similar system in Navigational lock and the same is working satisfactorily for at least 10 years. A performance certificate from the users for similar system designed and installed by the manufacturer shall be submitted along with the offer.

It is proposed to install the hydraulic power packs at both side of the lock near the each leaf of the gate. A remote-control operation of the gate is envisaged from central control and also local control from the room where hydraulic power packs will be located.)

The hydraulic system shall include hydraulic power units using variable displacement, axial-piston pumps, manifolds, stainless steel reservoirs, hydraulic cylinders, piping etc. as well as safety and instrumentation system.

The speed of the mitre gate will be determined by the output flow of the pump controlled by an electrically operated valve.

The cylinders will be directly attached to the Mitre gate. As the cylinder extends, water level is adjusted when mitre gates close. This seals the lock chamber from u/s or d/s approach channel. Once the water levels are equal, the cylinder retract to open the mitre gates so that the barges can pass.

The control system shall be PLC based. Fibre optic technology is proposed as communication mode for the lock operating system. The preferred protocol for the control system shall be suitable for the operations and shall be selected by the manufacturer/supplier of the control system. The entire remote-control system will be located in the centre of the lock as shown in drawing No. FL-003.

6.2.4 Fixing Arrangements

Adequate space shall be provided in the lock wall to accommodate the components of the hydraulic units based on the manufacturer's

recommendations. Contractor has to co- ordinate between his civil designer and hydraulic power pack manufacturer for keeping such provision in the design of lock. Similarly for fixing the hinges of the gate in the lock wall, a suitable provision shall be kept in civil design in consultation with the gate designers.

Sill and side walls at gate grooves should be made of polished granite as per IS codes 14223 (Part-I) as mentioned in Design Criteria, keeping suitable provision in civil works in consultation with gate manufacturer. The rubber/timber seal of suitable grade as required shall be placed properly for water tightness of structure.

6.2.5 Painting

Before fabrication all steel shall be shot blasted to SA 2½ quality standard and primed immediately after blasting with one coat of approved shop primer. Thereafter the skin plate, structural/frames, fittings shall be coated with anticorrosive and antifouling paint system to achieve minimum guarantee life to first maintenance of 15 years based on ISO 12944. Contractor shall select a proven painting schedule from reputed paint manufacturer to ensure guarantee life.

6.2.6 Test / Trials

The mitre gates will be tested after installation to verify the opening/closing time and to certify the performance of the control system from centralized control room and local control room.

6.2.7 Training

The Contractor shall arrange to train lock operators/staff nominated by Employer to operate the mitre gate safely and to familiarize them with various operating features of the gate.

6.2.8 Design & Drawings

The following documents in hard & soft copy shall be submitted:

- As built drawings of the gate showing G.A & Detailed Structural Arrangement
- Design calculation for structure & electro-hydraulic system
- Electro-hydraulic Operating System with hydraulic circuit diagram
- Detailed list of all components of electro-hydraulic system with part numbers.

6.2.9 Operation & Maintenance Manual

The contractor shall provide detailed O&M manual which shall include the following in hard and soft copy:

- Description of all elements
- Method & Material used in construction
- As built construction drawings
- Drawings showing gate operation
- Details of electro-hydraulic system
- Detailed part list of electro-hydraulic system
- Detailed maintenance schedule

6.2.10 Spares

Suitable number of commissioning and successful running for 2 years, spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

6.3 CAISSON GATE

6.3.1 Structure

The entire gate shall be weld fabricated with shipbuilding quality steel plate as per IS: 3039 for skin plate and primary structural members. For secondary structural members IS:2062 quality steel shall be used.

It shall comprise of deck, bulkheads, face plates so that various tanks and chambers can be arranged for ballasting and de-ballasting required for sinking and raising operations of the gate.

The structural arrangement of the gate shall be such so that adequate strength and stiffness shall be achieved during sinking and raising operation under the specified load conditions.

The shape of the gate shall be designed in such a manner so that the structure can be floated at a required light ship draft with adequate stability for manoeuvring and maintained sufficient stability during sinking and raising operation.

Provision shall be provided for the manoeuvre of caisson gate using tug boat and maintained sufficient stability manoeuvring operation.

The profile of the keel should properly match with the contour of the lock floor. Proper sealing arrangements shall be provided with vertical and horizontal face of the lock chamber for the placement of the caisson gate in the grooves as shown in civil drawing no.FL-004. The meeting face shall be provided with rubber seal of suitable grade and shall be placed in an epoxy grout and fitted properly using bolts for tight tolerance.

Sill and side walls at gate grooves should be made of polished granite as per IS codes 14223 (Part-I) as mentioned in Design Criteria, keeping suitable provision in civil works in consultation with gate manufacturer.

The conceptual arrangement of tanks and chambers for water ballast and permanent ballast is shown in the General Arrangement of the caisson gate (Refer Drawing Nos. FL- 037, FL-038, FL-039, FL-040, FL-041).

The contractor has to make his detailed design based on the design criteria stipulated in the tender and may modify the structural arrangements if needed to suit the operational requirements of the caisson gate. Any modification/addition of tanks or chambers if required from stability point of view the same can be considered without changing the clear opening width of the lock based on which gate dimension has been planned.

6.3.2 Miscellaneous items / fittings and fixtures

a) Fixed Ballast – Steel / concrete block

Loose Ballast – Cast iron blocks

The requirements of the ballast for operation of the caisson gate shall be decided by the contractor while designing the caisson and stability of the gate.

b) Bollards – At four corners of the top deck suitable beyond the operating platform ~~in~~ up the gate with lock wall /shore structure.

c) Fair Leads / Mooring Bits – Near the end of the top deck in four corners.

d) Fixed Hard Rails – At each side of the top deck over full length in 3 tiers duly supported by galvanized steel stanchions. Handrails around bollards/ fairleads shall be removable type.

- e) **Vertical Ladders** – At both side in both ends up to the gate securing place.
- f) **Ring Plates** – Suitable ring plates shall be provided for handling the caisson when afloat.
- g) **Cathodic Protection** – Aluminum anodes shall be provided on the skin plate and inside tanks/chambers to achieve design life mentioned in design criteria.
- h) **Draft Marks** – shall be made from M.S. Roman numbers and welded on each side of the caisson near each stem and also printed in white denoting the draft in meters.

6.3.3 Control System

The sinking and raising operation of the gate shall be carried out through suitable valve arrangement without requiring any external assistance. The sequence of valve operations and the conditions of various tanks/chambers (full or empty) before starting the raising or lowering of the caisson shall be decided by the contractor depending on the design.

Each valve or cock shall have a separate control to operate from the top deck as well as from local. The valve controls shall be operated by electrical mode and manually from the top deck. All controls shall have suitable indicators showing the position of level for the valve or cock. Suitable piping arrangement shall be provided to connect these valves.

6.3.4 Submersible Pumps and Blowers

As an alternative arrangement for pumping due to any emergency, electric driven submersible pumps shall be provided in the tanks / chambers for emptying river water to achieve required buoyancy.

Blowers of required capacity shall be provided for proper ventilation of enclosed space with wirings, switch and socket.

6.3.5 Electricals

Control panel for operation of ballasting system, valves etc. shall be attached to the handrail on the top deck. The panel shall be within a weather proof enclosure. Sufficient lights with watertight fittings suitable under water application with all the cables and gears etc. shall be provided below main deck. The cables shall be enclosed in watertight GI pipes.

6.3.6 Painting System

Before fabrication all shall be shot blasted to SA 2 ½ quality standard and primed immediately after blasting with one coat of approved shop primer. Thereafter the skin plate, tanks, frames, fittings shall be coated with anticorrosive and antifouling paint system to achieve minimum guarantee life to first maintenance of 15 years based on ISO 12944. Contractor shall select a proven painting schedule from reputed paint manufacturer to ensure guarantee life.

6.3.7 Testing for Air/Water Tightness

The entire caisson gate shall be tested for water or air tightness as the case may be separately for individual compartment and jointly as a complete gate as specified by classification society. All water pipes and valve bodies shall be also tested in accordance with the manufacturer's specification and relevant IS codes.

6.3.8 Inclining Test

The metacentric height of the gate at lightship draft shall be calculated by means of an inclining test during commissioning.

6.3.9 Trials

A demonstration trial shall be carried out at the project site to prove that the gate along with the ballasting/de-ballasting system is in good condition and to familiarize the operation to the lock operators.

The following trials will be carried out before acceptance:

- a) The gate shall be placed and position in the landing face of the lock basin be to check the perfect sealing of the gate. There should not be any leakage from the gate i.e., in between the lock face and caisson seals.
- b) The above trial shall be shown for both the side of the caisson one after another.
- c) Ballasting/de-ballasting time in 30 mins or less.
- d) Emergency lifting of the gate by using submersible pumps.

6.3.10 Training & Familiarization

The Contractor shall arrange to train lock operators/staff nominated by Employer to operate the caisson gate safely and to familiarize them with various operating features of the gate.

6.3.11 Design & Drawings

Contractor shall submit As Built Drawings of the gate covering G.A. and structural details along with following design calculations and drawings in hard & soft copy:

- a) Design of gate
- b) Buoyancy calculations

- c) Structural strength calculations and flooring design calculations inclusive of solidballast, water ballast etc.
- d) Stability calculation in dry and wet conditions
- e) Operation system of machineries
- f) Walkway on top of the gate
- g) Docking plan.

6.3.12 Operation & Maintenance Manual

The contractor shall provide detailed O&M manual which shall include the following in hard and soft copy:

- Description of all elements
- Method & Material used in construction
- As built construction drawings
- Drawings showing gate ballasting
- Drawings showing gate ballasting
- Drawings showing gate operation
- Stability curves, static & dynamic stability and inclining experiment reports
- Displacement vs. draft curves
- Detailed procedure for gate sinking/raising and gate maneuvering into and out of lockentrance
- Detailed maintenance schedule.

6.3.13 Spares

Suitable number of commissioning and successful running for 2 years, spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

6.4 RADIAL GATES

6.4.1 Construction

The radial gates shall consist of curved skin plate as per IS:2062 steel quality clad with corrosion resistant steel conforming to IS:1570 Part V. The skin plate shall be supported on suitably spaced vertical stiffeners which are supported on horizontal girders. The horizontal girders shall be supported by radial arms emanating from the Trunnion hubs located at the axis of the skin plate cylinder. The arms shall transmit the water thrust to yoke girder. Suitable sealing arrangement shall be fixed with the help of stainless-steel screws so as to ensure positive water pressure to prevent leakage.

Conceptual General Arrangement of the gate is enclosed in Drawing No. ENL008-SH1 AND ENL008-SH2.

6.4.2 Horizontal Girders and Stiffeners

The horizontal girders shall be so spaced that the bending moments in the vertical stiffeners at the horizontal girders as a continuous beam are about equal. When more than three girders are provided, the bending moment in the vertical stiffener at the top most girder, of a higher value than at the other girders may be allowed so as to adequately stress the skin plate. The girders shall be designed considering the fixity at arms support. In case of inclined arms used, the girder shall be designed per compressive stress induced. Girder shall be checked for shear at the points where they are supported by arms. The spacing and design of the bearing and intermediate stiffeners shall be governed by relevant portion of IS: 800-1984.

6.4.3 Arms

The arms shall be designed under combined axial compression and bending in accordance with the provisions contained in IS: 800-1984 and taking into consideration the type of fixity to the girder.

The total compressive stress shall not exceed the permissible limit of such stress for various values of l/r where 'l' is the effective length and 'r' is the least radius of gyration. Joints between arms and horizontal girders shall be designed for the side thrust due to the inclination of the arm.

Arms shall be suitably braced. The bracings connecting the arms that shall be so spaced, that the slenderness ratio of the arms in both the longitudinal and transverse directions is nearly equal.

6.4.4 Trunnion Hubs

The arms of the gate shall be rigidly connected to the hubs to ensure full transfer of loads. The hubs shall be sufficiently long so as to allow arms of the gate to be fixed to the respective limbs of the hub without having to cut and shape the flanges of the arms. The limbs of the hubs shall be on the apex of a cone with the base of the cone along the joints of the arms and the horizontal girders. The thickness of the webs and flanges of each of the limbs of the hub shall be greater than that of arms to the extent so as to provide adequate space for the weld. Sufficient ribs and stiffeners shall be provided in between its webs and flanges to ensure rigidity of the Trunnion hubs.

6.4.5 Trunnion Pins

The Trunnion pin shall be supported at both ends on the Trunnion brackets which are fixed to the support girders. The Trunnion pins shall be designed for bending for the total load transferred through the Trunnion hub. The load shall be taken as uniformly distributed over the length of the pin bearing against the hub. The provision for periodical greasing of the bearing shall be made on the outer surface. The Trunnion shall be medium fit in the bearing lugs of the support and shall be locked against rotation. Suitable arrangement for greasing the outer surface of Trunnion pins shall be made. The Trunnion pin shall be made of Corrosion Resistant Steel Gr. 20 cr 13/30 cr 13 conforming to IS: 6603/IS: 1570 Part (V).

6.4.6 Trunnion Bush / Bearing

Trunnion bush / bearing shall be of self-lubricating plain bearings type. These shall be force fit in the Trunnion hub and running fit on the Trunnion pin.

6.4.7 Trunnion Brackets

The Trunnion brackets shall be rigidly fixed to the support yoke girders by bolts or welding and shall transfer the total load from the Trunnion to the anchorages. The arm of the bracket shall be designed to transfer the load from each Trunnion bearing. The arms of the bracket shall also be designed to resist any bending which may be encountered by them due to the component of the load parallel to the base of the Trunnion bracket. Ribs and stiffeners shall be provided on the Trunnion bracket to ensure sufficient structural rigidity.

6.4.8 Seals

The seals shall be fixed to the gate leaf by means of counter sunk screws made of stainless steel / corrosion resistant steel. The screws shall be designed to take up full shear likely to develop during raising or lowering of the gate under maximum head of water between the seal and bearing plates. The screws shall be adequately tightened to a constant torque and locked by punch mark. Minimum threaded length equivalent to one -and-half times the diameter of screws shall be screwed to ensure against their loosening under vibrations during operations.

Fluorocarbon clad rubber seals for sides and top shall only be used. Suitable chamfer shall be provided at the bottom of the skin plate / clamp plate to accommodate the bottom wedge seal in compressed position.

6.4.9 Guide Plates and Guide Rollers

Guide roller shall be provided to the sides of radial gate to limit the lateral motion or side sways of the gate to not more than 6mm in either direction. Rollers shall be adjustable and removable. These shall travel on wall plate but the portion of wall plates on which they travel shall be made of structural steel. Roller shall be provided with plain Aluminium Bronze Bushings, turning on fixed steel pins. Suitable provision for greasing shall also be made.

6.4.10 Gate Anchorage System

The gate anchorage system shall consist of steel Trunnion girders, anchor girder, load bearing anchor rods. The anchorage system shall be designed to withstand the total water load on the gate and transfer it to the piers and abutments either by bond stress between anchors and concrete or in

bearing as bearing stress between concrete and the embedded girder at upstream end of the anchors.

6.4.11 Trunnion Girder or Yoke Girder

The Trunnion girders shall about the downstream face of the piers. It shall be of structural steel fabrication. Trunnion girder and its design shall be determined by the magnitude of the bending shear and maximum torsion occurring when the gate is partially raised and the lock chamber is on the maximum water level.

6.4.12 Anchor Bolts or Anchor Plates

The anchorages shall be provided in the 1st stage concrete, with suitable block out openings to hold the 2nd stage embedded parts. The anchor bolts in 2nd stage concrete shall be with double nuts and washers.

6.4.13 Tolerances

The tolerances for embedded parts and components of radial gates shall as per Appendix 'E' of IS: 4623-2000. The face-to-face distance between the wall plates shall be true in vertical plane within a tolerance of 3mm. The Trunnion shall be coaxial, at the same elevation and perpendicular to the centre line of the gate opening.

6.4.14 Control System

The gate shall be operated through electro-hydraulic system to achieve opening and closing time preferably in 1 min. (max. 2 mins.)

The electro-hydraulic system shall be proven and selected from reputed manufacturer who had supplied similar system in Navigational lock and the same is working satisfactorily for at least 10 years. A performance

certificate from the users for similar system designed and installed by the manufacturer shall be submitted along with the offer.

It is proposed to install the hydraulic power packs at both side of the lock near each leaf of the gate. A remote-control operation of the gate is envisaged from central control and also local control from the room where hydraulic power packs will be located.

The hydraulic system shall include hydraulic power units using variable displacement, axial-piston pumps, manifolds, stainless steel reservoirs, hydraulic cylinders, piping etc. as well as safety and instrumentation system.

The speed of the radial gate will be determined by the output flow of the pump controlled by an electrically operated valve.

The control system shall be PLC based. Fibre optic technology is proposed as communication mode for the lock operating system. The preferred protocol for the control system shall be suitable for the operations and shall be selected by the manufacturer/supplier of the control system.

6.4.15 Painting

Before fabrication all steel shall be shot blasted to SA 2½ quality standard and primed immediately after blasting with one coat of approved shop primer. Thereafter the skin plate, structural / frames, fittings shall be coated with anticorrosive and antifouling paint system to achieve minimum guarantee life to first maintenance of 15 years based on ISO 12944. Contractor shall select a proven painting schedule from reputed paint manufacturer to ensure guarantee life.

6.4.16 Training

The Contractor shall arrange to train lock operators/staff nominated by Employer to operate the radial gate safely and to familiarize them with various operating features of the gate.

6.4.17 Tests

The radial gates will be tested after installation to verify the opening/closing time and to certify the performance of the control system from centralized control room and local control room.

6.4.18 Design /Drawings

The following documents copies in hard & soft copy shall be submitted:

- As built drawings of the gate showing G.A & Detailed Structural Arrangement
- Design calculation for structure & electro-hydraulic system
- Electro-hydraulic Operating System with hydraulic circuit diagram
- Detailed list of all components of electro-hydraulic system with part numbers.

6.4.19 Operation & Maintenance Manuals

The contractor shall provide detailed O&M manual which shall include the following in hard and soft copy:

- Description of all elements
- Method & Material used in construction
- As built construction drawings (GA & structural details)
- Drawings showing gate operation
- Details of electro-hydraulic system
- Detailed part list of electro-hydraulic system

- Detailed maintenance schedule.

6.4.20 Spares

Suitable number of commissioning and successful running for 2 years, spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

6.5 BULKHEAD GATES

6.5.1 Structures

The gate frame consists of bearing plate/roller tracks, seal seats, girder and guides and the structure shall be welded construction. Conceptual G.A. Drawing is enclosed (Ref. Drawing No. ENL009-SH1 and ENL009-SH2).

The gate frames, gate leaf and embedded parts shall be fabricated from structural steel as per IS: 2062.

6.5.2 Seals

Rubber seals shall be provided as per relevant IS codes and the sealing arrangement should be such as to make the gate watertight. Provision shall be made to pressurize the back of the top and side seals with water in order to obtain water tightness.

6.5.3 Guide Rollers

Guide rollers shall be provided at the sides of the gates both near the top and bottom. The guide rollers shall be effective in both longitudinal and transverse directions. Bottom guide roller shall be provided with shear screws and top roller shall be provided with non-shearing screw capable of withstanding the load arising due to tilting of the gate.

6.5.4 Track / Bearing Plates

It shall be provided on downstream side of the gate slot.

6.5.5 Seal Seat

Side seal seat face shall be in common plane without off sets or gaps at joints. The bottom seal seat shall be flush with adjoining concrete surface.

The arrangements of fixing should be such to ensure water tightness.

6.5.6 Sill Girders

The bottom seal seat shall be provided on a suitable girder of structural steel to safely withstand the gate loads and impacts due to sudden closure of the gate.

6.5.7 Operating Mechanism

The bulkhead gate shall be operated by electrically operated rope drum hoists. The rope drum hoist shall be designed and manufactured as per IS: 6938. Suitable alternative arrangement of manual operation by hand shall also be provided. All components of hoist system shall conform to IS: 6938. The lifting speed shall be 0.50 m / min. Lubrication of the mechanical parts should be by means of high-pressure grease system. The electrical system shall consist of motors, electro-magnetic brake, limit switches, control panel etc.

A gate position indicator shall be provided for indicating the position of the gate at any time. It should be dial type with meter graduation marked clearly and to be placed in a weather proof cover.

6.5.8 Tests

The gate hoists shall be tested at 125% of safe working load when all functions to be checked for satisfactory operations. The bulk head gates will

be tested after installation to verify the lifting speed and to certify the intended functions of the gate.

6.5.9 Painting

Before fabrication all steel shall be shot blasted to SA 2½ quality standard and primed immediately after blasting with one coat of approved shop primer. Thereafter the skin plate, structural/ frames, fittings shall be coated with anticorrosive and antifouling paint system to achieve minimum guarantee life to first maintenance of 15 years based on ISO 12944. Contractor shall select a proven painting schedule from reputed paint manufacturer to ensure guarantee life.

6.5.10 Design / Drawings

The following documents copies in hard & soft copy shall be submitted:

- As built drawings of the gate showing G.A & Detailed Structural Arrangement
- Design calculation for structure & hoist system
- Details of hoist system with all components.

6.5.11 Operation & Maintenance Manuals

The contractor shall provide detailed O&M manual which shall include the following in hard and soft copy:

- Description of all elements
- Method & Material used in construction
- As built construction drawings (GA & structural details)
- Drawings showing gate operation
- Details of hoist system

6.5.12 Detailed part list of hoist system

- Detailed maintenance schedule.

6.5.13 Spares

Suitable number of commissioning and successful running for 2 years, spares list shall be submitted for approval and spares as per approved list shall be supplied free of cost.

7. SPECIFICATIONS - FIRE FIGHTING SYSTEM

The equipment and materials covered by this specification are subject to the referenced attachments. The Contractor shall be responsible for and governed by all the requirements of this Specification and Standard Conditions of the Contract.

All designs, specifications and other technical data shall be based on the metric systems of measurement.

7.1 SCOPE OF WORK

The Scope of Work is for the installation of Fire Fighting Systems in the Control Room of Farakka Navigational Lock. The firefighting system shall consist of dry powder stored pressure by nitrogen gas with inbuilt pressure gauge to indicate pressure.

S. No.	Area	Class of Fire	Classification of Occupancy	System Proposed
1	Control Room	A, B & C	Ordinary Hazard	Dry power stored pressure confirming to IS:13849. Pressurized by nitrogen gas with inbuilt pressure gauge to indicate pressure.

However, if in the opinion of the tenderer, the above requirement needs to be enhanced for better performance or any other imperative criteria, the same shall be quoted separately as an alternative.

8. DRAWINGS

8.1 DRAWING LIST

No.	Title of Drawing
ENL001	Index Plan of The Existing and New Navigational lock, Farakka
ENL002	Topography Survey of The Navigational lock Farakka
ENL003	General Arrangement Drawing of Existing Navigational lock
ENL004	General Arrangement Drawing of Parking Bay
ENL005	General Arrangement Drawing of Mooring Equipment
ENL006	General Arrangement Drawing of Bank Protection
ENL007-SH1	General Arrangement Drawing of Mitre Gate
ENL007-SH2	General Arrangement Drawing of Mitre Gate
ENL007-SH3	General Arrangement Drawing of Mitre Gate
ENL008-SH1	General Arrangement Drawing of Radial Gate
ENL008-SH2	General Arrangement Drawing of Radial Gate
ENL009-SH1	General Arrangement Drawing of Bulkhead Gate
ENL009-SH2	General Arrangement Drawing of Bulkhead Gate
ENL010-SH1	General Arrangement Drawing of Caisson Gate
ENL010-SH2	General Arrangement Drawing of Caisson Gate
ENL010-SH3	General Arrangement Drawing of Caisson Gate
ENL011	Power Single Line Diagram of Existing Navigational lock , Farakka
ENL012	Basic Control Architecture of Existing Navigational lock , Farakka
ENL013	General Arrangement Drawing of Bank Protection, Parking Bay, Storm Water Drainage and Road
ENL014	General Location Plan of Monitoring Instrument of Existing Navigational lock , Farraka