

SECTION-C

**SPECIFIC TECHNICAL REQUIREMENT FOR
CIVIL STRUCTURAL & ARCHITECTURAL
WORKS**



COAL GASIFICATION UNIT FOR COAL
TO AMMONIUM NITRATE PLANT AT
LAKHANPUR, ODISHA
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1. SCOPE

The scope of this document is to provide design basis for Civil foundation work for CFBC Boiler, Gasifier, ESP, Chimney, Fans & ID duct supporting structure, Air Separation Unit. This document also covers the scope of Civil, Structural & Architectural works for Coal, Ash & Lime handling structures, CCR, CWPH, FOPH, DM Plant, CW treatment plant, DG building, etc. This document also indicates the general description of facilities, description of structural framing system, applicable design codes and standards, design philosophy basis, loading, analysis method, painting / finishing schedule proposed to be adopted for 2000 TPD Coal to Ammonium Nitrate Plant – LSTK-1 package.

2. PROJECT INFORMATION

Owner	:	Bharat Coal Gasification & Chemicals Limited
Project Title	:	BCGCL Coal to Ammonium Nitrate Project, Jharsuguda (LSTK-1 package)
Location	:	Lakhanpur, Jharsuguda, Odisha, India
Nearest Airport	:	Veer Surendra Sai Airport, Jharsuguda
Nearest Railway station	:	Belpahar



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3. APPLICABLE CODES AND STANDARDS

CODE / STANDARD	DESCRIPTION
IS 456: 2000	Plain and Reinforced Concrete
IS 800: 2007	General Construction in Steel
IS 806: 1968	Code of Practice for Use of Steel Tubes in General Building Construction
IS 816	Code of Practice for use of Metal arc welding for General Construction in mild steel
IS 875: Part 1: 1987	Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures Part 1 Dead Loads - Unit Weights of Building Material and Stored Materials
IS 875: Part 2: 1987	Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures: Part 2 Imposed Loads
IS 875: Part 3: 2015	Design Loads (Other than Earthquake) for Buildings and Structures - Code of Practice Part 3 Wind Loads
IS 875: Part 5: 1987	Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures Part 5 Special Loads and Combinations
IS 1081	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators
IS 1161	Steel tubes for structural purpose
IS 1172	Code of basic requirements for water supply, drainage & sanitation
IS 1361	Steel windows for Industrial Buildings
IS 1363	Hexagon head bolts, screws & nuts of product grade C: Part- I Hexagon head bolts (size range M5 to M64)
IS 1742	Code of practice for building drainage
IS 1786	High strength deformed steel bars & wires for concrete reinforcement
IS 1893:2016 (Part1)	Criteria for Earthquake Resistant Design of Structures: Part 1: General Provisions and Buildings
IS 1893:2016 (Part4)	Criteria for Earthquake Resistant Design of Structures: 4 Industrial Structures Including Stack - Like Structures
IS 1904: 2021	Indian Standard for General requirements for design and construction of foundations in soils
IS 1905: 1987	Code of Practice for Structural use of Unreinforced Masonry
IS 2062	Steel for general structural purposes
IS 2065	Code of practice for water supply in buildings
IS 2212	Code of practice for brickwork
IS 3370: 2021	Concrete Structures for Retaining Aqueous Liquids
IS 3757: 1985	Specification for High Strength Structural Bolts (Second Revision)
IS 4000: 1992	Code of practice for high strength bolts in steel structures
IS 4326	Earthquake resistant design and construction of buildings - Code of practice
IS 4923	Hollow Steel sections for structural use



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CODE / STANDARD	DESCRIPTION
IS 5525: 1969	Recommendations for detailing of reinforcement in reinforced concrete
IS 6477	Dimensions for wrought aluminium & aluminium alloys, extruded hollow sections
IS 6533	Code of Practice for design and construction of steel chimney
IS 6649:1985	Specification for Hardened and Tempered Washers for High Strength Structural Bolts and Nuts
IS 6494: 1988	Code of practice for water-proofing of underground water reservoirs and swimming pool
IS 9178: 1979	Criteria for Design of Steel Bins for Storage of Bulk Materials
IS 13920:2016	Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces
SP 06 (Part 1 to Part 7)	Handbook for Structural Engineers
SP 16	Design Aids for Reinforced Concrete to IS: 456
SP 34	Handbook on Concrete Reinforcement and Detailing
NBC	National Building Code of India: 2005
IRC 6	Code of practice for road bridges, Section-II Loads and stresses
IRC 19	Standard Specifications and Code of Practice for Water Bound Macadam
IRC 37	Design of flexible pavements
IRC 58	Design of rigid pavements



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4. MATERIAL OF CONSTRUCTION

SL. NO.	BUILDING	TYPE OF SUPER STRUCTURE	FLOORING /CLADDING & ROOFING
1	Boiler	BHEL -Trichy Scope	BHEL -Trichy Scope
2	Gasifier	BHEL -Trichy Scope	BHEL -Trichy Scope
3	ESP	BHEL - Ranipet Scope	BHEL -Ranipet Scope
4	Chimney	BHEL - Ranipet Scope	Not applicable
5	PA, SA & ID Fans	RCC	Not applicable
6	ID Duct Supp. Syst.	BHEL -Trichy Scope	Not applicable
7	CCR	RCC	RCC
8	CW Pump House	Steel Structure	Colour coated Metal cladding sheet on side & roof
9	IDCT	Concrete Structure	Concrete Structure
10	Clarifier PH & Tank	Steel Structure (Pump house) + Tank (RCC)	Colour coated Metal cladding & roof sheet (Pump House)
11	DMCW PH	Steel Structure	Colour coated Metal cladding & roof sheet
12	LDO AREA	Steel Structure	Not applicable
13	FOPH	RCC	Not applicable
14	DG Building	RCC	Brickwork
15	CO ₂ & CST Tanks	Steel Structure	Not applicable
16	STP	NA	NA
17	ETP	NA	NA
18	BFP	Steel Structure	Colour coated Metal cladding & roof sheet
19	CLO ₂ PLANT	Steel Structure	Colour coated Metal cladding & roof sheet



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SL. NO.	BUILDING	TYPE OF SUPER STRUCTURE	FLOORING /CLADDING & ROOFING
20	CW Treatment Plant	Steel Structure	Colour coated Metal cladding & roof sheet
21	LIN Storage Tank	BHEL -Trichy Scope (Package vendor scope)	BHEL -Trichy Scope (Package vendor scope)
22	Steam Heater/Turbine	BHEL -Trichy Scope (Package vendor scope)	BHEL -Trichy Scope (Package vendor scope)
23	Pipe Rack	Steel Structure	No flooring & no sheeting work
24	Compressor House	BHEL -Trichy Scope (Package vendor scope)	BHEL -Trichy Scope (Package vendor scope)
25	Cold Box	BHEL -Trichy Scope (Package vendor scope)	BHEL -Trichy Scope (Package vendor scope)
26	CHP Structures	Structural steel / RCC	Metal cladding / Brick Cladding
27	AHP Structures	Structural steel / RCC	Metal cladding / Brick Cladding
28	LHP Structures	Structural steel / RCC	Metal cladding / Brick Cladding



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5. DESIGN BASIS FOR STRUCTURAL WORKS

5.1 DESIGN LOADS

The following design loads shall be considered

1. Dead load including self-weight
2. Live load
3. Wind load
4. Seismic load
5. Equipment load
6. Crane Load
7. Temperature load / Friction load
8. Earth pressure / Hydrostatic Load
9. Blast load
10. Contingency Loads
11. Any other load not mentioned above, but applicable

5.1.1. DEAD LOADS (DL)

Dead load shall comprise of the weight of all permanent construction including walls, fire proofing, floors, roofs, partitions, stairways, fixed services and partitions and shall be taken as per IS: 875 (Part-I).

following unit weights shall be adopted for design.

Reinforce Concrete	: 2500 kg/m ³
Plain Concrete	: 2400 kg/m ³
Structural steel	: 7850 kg/m ³
Backfill Soil	: 1800 kg/m ³
Operating floor with grating	: 100 kg/m ²
Staircase (steel)	: 140 kg/m ²
Ladder	: 40 kg/m ²



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Dead loads shall include the weight of structure complete with finishes & fixtures. Following additional dust loads to be considered in CHP buildings

LOCATION	LIVE LOAD	UNIT
Dust load (flat roof)	150	Kg/ m ²
Dust load (inclined roof)	25	Kg/ m ²
Dust load - conveyor galleries walkway	50	Kg/ m ²

5.1.2. LIVE LOADS (LL)

Live loads shall, in general, be as per IS: 875. However, the following minimum live loads shall be considered in the design of structures to account for maintenance and erection phases; if equipment layout / vendor drawings indicate loads of greater magnitude, the same shall be adopted.

- a) Process Building / Technological Structure (Open / Enclosed type)
 - Operating area - 500 kg/m²
 - Maintenance area - 750 kg/m²
 - Ground floor - 1000 kg/m²
- b) Substation / Control Room
 - Panel floor - 1000 kg/m²
 - Miscellaneous partition - 100 kg/m²
 - Other areas - 500 kg/m²
- c) Office building
 - Office area - 300 kg/m²
 - Entrance lobby - 500 kg/m²
 - Exit way - 500 kg/m²
 - Miscellaneous partition - 100 kg/m²
 - Document Storage area - 100 kg/m²
- d) Laboratory
 - Upper floors - 400 kg/m²
 - Ground floor - 500 kg/m²
- e) Cooling Tower
 - Operating platform /cover slab of hot water basin & Sump - 300 kg/m²
- f) GT Building / DM Plant /ETP
 - Operating platforms - 300 kg/m²
 - Ground floor - 500 kg/m²
- g) Staircase



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- Process Building - 500 kg/m²
- Technological structure - 500 kg/m²
- Office - 500 kg/m²
- Substation/Control Room - 300 kg/m²
- Laboratory - 400 kg/m²
- Service platform - 250 kg/m²

Minimum Live Load

DESCRIPTION	LIVE / IMPOSED LOAD	UNIT
Cable gallery (in addition to actual cable load)	500	kg/m ²
MCC, switchgear and control building floors	1000	kg/m ²
Roof (with equipment)	150	kg/m ²
Roof (without equipment)	500	kg/m ²
Coal handling structures		
Accessible roof	150	kg/m ²
Inaccessible roof	75	kg/m ²
Conveyor galleries (sum of loads due to cable tray, firefighting etc.) (minimum)	125	kg/m
Others		
Pump houses operating floor	1500	kg/m ²
Covers for channels/trenches (any one)	400	kg/m ²
General		
Stairs, landings and balconies	500	kg/m ²
Toilets	200	kg/m ²
Chequered plates, grating floors	500	kg/m ²
RCC floors	500	kg/m ²
Walkway (general)	500	kg/m ²
Walkways (conveyor galleries)	300	kg/m ²
Cable and pipe trestle	400	kg/m ²
Grating/precast RCC covers for drain, trench, sump pit	2500	kg/m ²

In addition to earth pressure and ground water pressure, the surcharge load of 2000 Kg/m². shall also be considered for design of all underground structures.



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Road Culverts/Bridges and its allied structures including RCC Pipe Crossings and Road Crossing of Trenches. Design for class 'AA' loading (wheeled and tracked both) and checked for class 'A' loading as per IRC Standard.

For all other buildings not covered in above Table as well as roofs of various structures, the imposed loads shall be taken as specified in IS: 875 (Part II).

Live load on various types of roofs shall be as per the requirements given in IS: 875.

5.1.3. WIND LOADS (WL)

Wind loads shall generally be as per IS-875 (Part-3) except for switchyard structures and transmission towers for which IS: 802 shall be applicable. Basic wind speed shall be as per the Code which is 44 m/s. Wind force on structural elements shall be calculated using design wind pressure multiplied by elements frontal area, normal to wind direction multiplied by force coefficient as per Table 26, IS 875 Part-3.

In calculation of wind force frictional drag shall be considered where applicable.

All structures shall be designed for static & dynamic wind forces in accordance with IS:875 (Part-3) and as specified in this document. Design parameters to be adopted are given below in Table

Wind Load Parameters

Basic Wind Speed, V_b	44 m/s	as per IS 875
Terrain Category	Cat-2	as per IS 875
Risk Coefficient, k_1	1.07	as per IS 875
Risk Coefficient, k_2	Varies	as per IS 875 Cl 6.3.2.2
Topography Factor, k_3	1.00	as per Cl 6.3.3, IS 875 (Part-3):2015
Cyclonic factor, k_4	1.00	as per Cl 6.3.4, IS 875 (Part-3):2015
Wind directionality factor, k_d	Varies	as per IS 875 Cl 7.2.1
Area Averaging factor, k_a	Varies	as per IS 875 Cl 7.2.2 Table 4
Combination factor, k_c	Varies	as per IS 875 Cl 7.3.3.13

5.1.4. SEISMIC LOADS (SL)

All structures and equipment shall be designed for seismic forces. Project site at Jharsuguda comes under Seismic Zone-3, type of soil – hard, as IS:1893 (2015/2016). Following damping factors to be considered for design of structures:

DAMPING FACTORS



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Steel structures	5%
Reinforced concrete structures	5%
Reinforced concrete stacks	3%
Steel stacks	2%

Vertical acceleration spectral values shall be taken as 2/3rd of the corresponding horizontal values.

METHOD OF ANALYSIS

Since most structures in a LSTK-1 are irregular in shape and have irregular distribution of mass and stiffness, dynamic analysis for obtaining the design seismic forces shall be carried out using the response spectrum method. The number of vibration modes used in the analysis should be such that the sum total of modal masses of all modes considered is at least 90 percent of the total seismic mass and shall also meet requirements of IS:1893 (Part 1). Modal combination of the peak response quantities shall be performed as per Complete Quadratic Combination (CQC) method or by an acceptable alternative as per IS:1893 (Part 1).

In general, seismic analysis shall be performed for the three orthogonal (two principal horizontal and one vertical) components of earthquake motion. The seismic response from the three components shall be combined as specified in IS:1893.

5.1.5. EQUIPMENT LOADS

The weight of equipment category-I such as pumps, compressors, motors etc., shall be derived as far as possible from Manufacturer's data and shall include controls, auxiliary machinery, piping etc.

5.1.6. CRANE LOAD

For crane loads, an impact factor of 25% and lateral crane surge of 10% (of lifted weight + trolley weight) shall be considered in the analysis of frame according to the provisions of IS:875. The longitudinal crane surge shall be 5% of the static wheel load. Longitudinal surge and lateral surge shall not be considered to act simultaneously.

5.1.7. TEMPERATURE LOAD

For temperature loading, the total temperature variation shall be considered as 2/3 of the average maximum annual variation in temperature. The average maximum annual variation in temperature for this purpose shall be taken as the difference between the mean of the daily minimum ambient temperature during the coldest month of the year and mean of daily



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maximum ambient temperature during the hottest month of the year. The structure shall be designed to withstand stresses due to 50% of the total temperature variation.

Suitable expansion joints shall be provided in the longitudinal direction wherever necessary with provision of twin columns. The maximum distance of the expansion joint shall be as per the provisions of IS 800 and IS 456 for steel and concrete structures respectively.

5.1.8. EARTH PRESSURE / HYDROSTATIC LOADS

Hydrostatic pressure shall be adequately accounted for, in the design of structures, below ground water table.

5.1.9. BLAST LOADS

Control buildings located more than 30 m from a blast source shall be designed to resist maximum combination of loads in accordance with the following table:

DISTANCE VERSUS DESIGN PRESSURE

DISTANCE FROM PROCESS EQUIPMENT (m)	BLAST PRESSURE (kPa)	SUCTION BLAST PRESSURE (kPa)	WIND VELOCITY PRESSURE (kPa)
30 to 45	21	7	4
45 to 60	10	3	2
60 to 75	7	2	1
75 to 150	3	1	*
Over 150	*	*	*

LOAD COMBINATIONS WITH BLAST LOADS

- For Flexure

- 1.0(Dead load + Blast load)

- For Shear

- 1.2 (Dead load + Blast load)

Live load shall not be considered on the roof during blast.

SOIL BEARING CAPACITY

Design bearing pressure shall be taken as equal to twice the allowable static bearing pressure for load combinations with blast load.

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Factor of Safety in case of load combinations with blast load shall be as follows:

- Overturning - 1.2
- Sliding - 1.3

5.1.10. CONTINGENCY LOADS

5.1.10.1. RCC STRUCTURES

All floor slabs and beams shall be designed for a concentrated load of 10 KN acting simultaneously with the uniform live load, but not with actual concentrated loads from equipment, piping etc. This load shall be placed to result in maximum moment and / or maximum shear.

This load shall not be considered for the design of columns, foundations and in overall frame analysis. For floor slabs, the load shall be considered to be distributed over an area of 0.75 m x 0.75 m.

5.1.10.2. STRUCTURAL STEEL

For process plants, the following contingency additional loading shall be applied to individual beam elements, these shall be applied as point loads to produce worst shear and bending stresses:

- Platform Walkways : 300 kg
- Secondary Floor Trimmers : 500 kg
- Primary / Grid beams : 1000 kg

5.1.11. MISCELLANEOUS LOADS

Apart from the specified live loads, possible overloading during construction / hydro-test maintenance / erection shall also be considered in the design.

Hydrostatic pressure shall be adequately accounted for, in the design of structures, below ground water table.

All the handrails, parapets, parapet walls, balustrades shall be designed for horizontal load mentioned in Table 3 of IS-875 (Part-2).



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5.2 MAJOR LOAD CASES

Structural analysis and design shall take into consideration the worst combination of the loads tabulated below under different phases wherever applicable.

The design shall be governed by worst load combinations as per the procedures of relevant BIS codes.

SL NO	LOAD CASE TITLE	ABBREVIATION
1	Seismic X	ELX
2	Seismic Y	ELY
3	Seismic Z	ELZ
4	Dead Load Including Self Weight	DL
5	Live Load	LL
6	Equipment Dead Load	EQDL
7	Equipment Live Load/Material Load	EQLL
8	Belt Pull Load	BPL
9	Contingency Load	CTG
10	Static Wind(+XP)	WL(+XP)
11	Static Wind(-XP)	WL(-XP)
12	Static Wind(+ZP)	WL(+ZP)
13	Static Wind(-ZP)	WL(-ZP)
14	Static Wind(+XS)	WL(+XS)
15	Static Wind(-XS)	WL(-XS)
16	Static Wind(+ZS)	WL(+ZS)
17	Static Wind(-ZS)	WL(-ZS)
18	Temperature Load	TL
19	Dynamic Wind(+XP)	DWL(+XP)
20	Dynamic Wind(-XP)	DWL(-XP)
21	Dynamic Wind(+ZP)	DWL(+ZP)
22	Dynamic Wind(-ZP)	DWL(-ZP)
23	Dynamic Wind(+XS)	DWL(+XS)



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SL NO	LOAD CASE TITLE	ABBREVIATION
24	Dynamic Wind(-XS)	DWL(-XS)
25	Dynamic Wind(+ZS)	DWL(+ZS)
26	Dynamic Wind(-ZS)	DWL(-ZS)
27	Monorail	MRL
28	Crane Live Load	CRL
29	Pipe Friction Load	FL
30	Blast Load	BL
31	Hydrostatic Pressure	HSL

5.3 LOAD COMBINATIONS

Following Combinations are used:

5.3.1. Design of Steel structures, RCC structure & Foundation bolt:

i. For Serviceability criteria

- a) $DL + LL \pm TL$
- b) $DL + LL \pm WL/EL \pm TL$
- c) $DL \pm WL/EL \pm TL$

ii. For Strength criteria

- a) $1.5 * (DL + LL) \pm TL$
- b) $1.2 * (DL + LL \pm WL/EL) \pm TL$
- c) $1.5 * (DL \pm WL/EL) \pm TL$

iii. Stability Checks

- a) $0.9 * DL + 1.5 * WL/EL \pm TL$

EL: $ELX \pm 0.3 EL_Y \pm 0.3 EL_Z$

Seismic load shall be considered in all three direction as per IS 1893

5.3.2. Design of Foundation

i. For Shear & Moment:

- a) $1.5DL + 1.5LL \pm 1.5TL$
- b) $1.2DL + 1.2LL \pm 1.2WL/SL \pm 1.2TL$



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c) $1.5DL \pm 1.5WL/SL \pm 1.5TL$

d) $0.9 DL \pm 1.5WL/SL \pm 1.5TL$

ii. For Bearing Pressure:

a) $DL + LL \pm TL$

b) $DL + LL \pm WL/SL \pm TL$

c) $DL \pm WL/SL \pm TL$

25 % Increase in permissible bearing capacity of soil for wind/seismic load combination with dead & live load.

In case of Wind load, static wind load, dynamic wind load, diagonal wind load shall be considered as per IS 808.

For Seismic loads, seismic load combination in X, Y and Z directions shall be considered as per IS 1893.

“Lifted load” of crane/ monorails will not be considered during seismic condition.

Permissible stresses for different load combinations will be taken as per relevant IS and IRS codes.

For checking against uplift / tension case, 90% of Dead Loads with no Imposed Loads will be considered along with other Loads.

In case two cranes are provided and tandem operation is not envisaged, the load shall be taken as one crane fully loaded and second crane without lifted load but standing idle adjacent to first crane all through the building length.

Frictional forces between the pipes and supporting structure in longitudinal direction need not be considered along with seismic or wind forces.

No reduction in equipment loads, piping loads, ash loads and loads due to other permanent facilities shall be considered for calculation of seismic weight of the building/structure and for load combinations thereof.



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6. DESIGN BASIS FOR FOUNDATIONS

- Minimum 0.12% of reinforcement shall be provided on the top face of the foundation concrete on either direction and minimum percentage of reinforcement at bottom face of foundation shall be same as that stipulated for beam as per IS:456.
- For all RCC buildings, tie beams shall be provided at lintel level.
- The roads, ground floor slabs, trenches, pipe pedestals (except thrust blocks), channels/drains and staircase foundation with foundation loading intensity less than 4 T / m^2 may be supported on open / shallow foundations resting on virgin / controlled compacted filled up soil.
- The water table for design purpose shall be considered at Finished Ground Level.
- The minimum depth of foundation shall be 1.0 m below Finished Ground level.

6.1 SHALLOW FOUNDATIONS

FOUNDATION TYPE	ALLOWABLE SETTLEMENT (mm)
Foundations in unit areas, utility areas and Foundations for plant buildings including substation, Compressor house, control room, technological structures	25
Machine foundations and critical equipment with interconnected piping	25
Foundations supporting non-plant buildings	40

- For transient loadings, such as wind / seismic, allowable net bearing capacity based on shear criteria may be considered.



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- For load combinations including wind, the Safe Soil Bearing Pressure may be increased by 25%.
- For load combinations including earthquake, the Safe Bearing Pressure of Soil may be increased as permitted in IS: 1893 (2015/2016).

Allowable Loss of contact area between underside of foundation and soil (due to resultant Overturning Moment) under different loading conditions shall be as given below:

SL.NO.	LOAD COMBINATION DESCRIPTION	ALLOWABLE % LOSS OF CONTACT AREA
A	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 10%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 25%
B	Operating Load case (Plant operating, with or without Live Loads, for worst cases)	0 % to 20%
	Operating Load Case with Wind or Earthquake (with or without Live Loads, for worst cases)	up to 30%

Where

A = Foundations on Soil

B = Foundations on Rock

6.2 SOIL AND HYDROSTATIC PRESSURE ON WALLS BELOW GRADE

In the design of walls below grade, provision shall be made for the lateral pressure of adjacent soil. Due allowance shall be made for possible surcharge from fixed or moving loads. When a portion or whole of the adjacent soil is below a free water surface, computations shall be based on the weight of the soil, diminished by buoyancy, plus full hydrostatic lateral pressure.

The lateral pressure from surcharge loads shall be taken in addition the lateral earth pressure loads.

6.3 STABILITY OF FOUNDATIONS

Foundations shall be checked for stability against overturning, sliding & uplift. While checking against uplift, the following shall be considered.



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FOUNDATION DESIGN – FACTORS OF SAFETY

TYPE OF STRUCTURES	MINIMUM FACTOR OF SAFETY AGAINST OVERTURNING		MINIMUM FACTOR OF SAFETY AGAINST SLIDING		% WEIGHT OF OVERBURDEN OVER PROJECTED PLAN AREA OF FOOTING
	WITH WIND OR SEISMIC	WITHOUT WIND OR SEISMIC	WITH WIND OR SEISMIC	WITHOUT WIND OR SEISMIC	
All Buildings/ Structures / Eqpt. In Units	1.5	2.0	1.5	1.5	100
Pipe Rack (Offsite)	1.5	2.0	1.5	1.5	50
Flood Light Mast	1.5	-	1.5	1.5	50 **
Retaining Wall	1.5	2.0	1.5	1.75	100
Over Head water tank	1.5 (empty) 2.0 (full)	-	1.5	-	50 **
Blast Resistant Structures	1.5	2.0	1.5	1.5	100
Flare supporting Structures	1.5	-	1.5	-	50 **

** In case area is paved, overburden shall be based on NGL (for area under filling) or 600 mm below HPP, whichever is lower. In case of unpaved area, it shall be w.r.t. FGL.

Minimum factor of safety against uplift shall be 1.2 for all structure. (Note: In case of sumps, lining weight shall not be included). Beneficial load of backfill can be included on in circumstances where it will never be removed.

Buoyancy from high ground water levels shall be taken in to account in investigating stability against uplift.

6.4 MACHINE/EQUIPMENT FOUNDATIONS

Machine / Mechanical equipment foundations shall satisfy the requirements of IS: 2974 and any other parameters as per machine vendors.



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Generally, foundations and structures supporting rotating machinery shall be so proportioned that their natural frequency shall not fall within the range of 0.8 to 1.2 of normal operating speed of the equipment. Further for major rotating machinery such as main compressor, the amplitude of foundation of structure during normal operation shall not exceed the allowable amplitude specified by the equipment manufacturer. The above consideration may be omitted for centrifugal pumps and fans and other minor rotating equipment weighing less than 1 ton or if the mass of the rotating parts is less than 1/100th of the mass of foundation installed directly on concrete provided that the weight of foundation is not less than 3 times of the equipment weight. In such cases, dynamic analysis is not necessary.

Foundations shall be so designed that natural frequency of the foundation system shall not resonate with the following:

- a) Operating speed of the motor / turbine
- b) Operating speed of the machine
- c) 2 x Operating speed of the machine
- d) Critical speed of the machine (for centrifugal machines)

6.5 FOUNDATION BOLTS

All holding down bolts or threaded rods for non-post tensioned applications shall be out of Mild Carbon steel conforming to IS: 2062 with $F_y = 250$ MPa. For scrubbing section and acid storage section, holding down bolts should conform to SS 316.

Minimum cover to Foundation Bolts

Minimum distance between a Standard Holding down Bolt or Anchor Sleeve and the face of Foundation/pedestal shall not be less than 6 x (dia of bolt) mm.

6.6 PEDESTAL HEIGHTS

Pedestals for structural columns	: As per design requirement
Open paved area	: 300 mm (min.) OR as indicated in Equipment Layout drawing
Open unpaved area	: 300 mm
Covered area (building etc.)	: 300 mm (min.) OR as indicated in drawing
Storage tank foundation	: As per equipment layout
All equipment supporting foundations / pedestals	
Open area	: As required but not less than 300 mm
Covered area	: As required but not less than 150 mm



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Stair Pedestals : 300 mm (min.) OR as indicated in equipment
layout drawing.

Ladder pedestals : 300 mm

6.7 EQUIPMENT FOUNDATION

For equipment of static weight up to 1.5 T, the equipment may be supported on the ground floor slab by locally thickening the slab. Thickening of the ground floor slab shall be done up to an extent of about 0.6 m beyond the plan area of the equipment on all the sides. Further, the load intensity below the equipment shall be limited to 4 T/m².

For equipment's of static weight between 1.5 T and 20 T, the equipment may be supported on compacted sand filling from Natural Ground Level (NGL) or excavation level of nearby footing whichever is deeper with the load intensity below the equipment limited to 4T/m². The minimum depth of foundation is 1.0m below FFL

For equipment of static weight more than 20 T, the equipment foundation shall be taken to the founding level or shall be built up with PCC from the level as mentioned in the Table 10. The pedestal of equipment foundation or the foundation Block shall be isolated from the adjoining floor slab by providing bitumen impregnated fibre board of minimum 50 mm thick, conforming to IS: 1838 all around the equipment pedestal for the full depth of the floor slab.

Structural steel columns, about 300 mm height of steel columns above the top of paving level shall be provided with at least 125 mm thick encasement with minimum reinforcement to prevent corrosion of the steel columns from surface water.



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7. DESIGN BASIS FOR REINFORCED CONCRETE STRUCTURES

Limit state method as per IS: 456 shall be followed for the design

All skeletal structures shall be of frame type construction, and detailing shall be as per provision of IS: 13920.

Where the specified design depth of groundwater table so warrants, all underground pits, tunnels, basements, etc. shall be leak-proof R.C.C. construction using water proofing compounds.

Following conditions shall be also considered for design of liquid retaining structures, basement, trenches and other underground structure: -

- a) Only water pressure from inside and no earth pressure, groundwater pressure or surcharge from outside wherever such a condition is likely to exist either in operation or during installation / testing.
- b) Earth pressure, surcharge pressure or ground water pressure from outside and no water pressure from inside.
- c) Base slab shall also be designed for the empty condition during construction and maintenance stages with maximum ground water table. Pressure Relief Valves shall not be used.
- d) Intermediate dividing walls of pump sumps shall be designed considering water in one pump only and the other sump being empty for maintenance.

The walls and base slabs of liquid retaining storage structures shall be provided with reinforcement on both faces for thicknesses greater than 150 mm.

In all liquid retaining structures, PVC water bars (230 mm wide, 6 mm thick) shall be provided at each construction joint. PVC water bars shall be of minimum 230 mm width and 6 mm thickness, and generally shall be rified/serrated type with a central bulb Kicker type PVC water bars shall be used for the base slab and in other areas where it is required to facilitate concreting. Material quality of PVC water stops shall confirm to IS 12200.



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7.1 CONCRETE GRADE

Minimum grade M30 shall be used for underground structures, all sub-structures (foundations etc) manholes except for grade slabs / paving for which M20 may be used. M25 grade shall be used for all super-structures.

Pre-cast concrete shall be of minimum grade M35.

75 mm thick PCC of grade M15 (nominal mix) shall be provided under all RCC foundations except under base slab of liquid retaining structures where 100 mm thick concrete of mix M15 (nominal mix) shall be used.

Concrete for encasing shall be M20 with 10 mm down aggregate.

Plain cement concrete (PCC) of grade M15 (nominal mix) of minimum 150 mm thickness shall be provided under all masonry wall foundations.

Plain cement concrete of grade M20 of minimum 40 mm thickness shall be provided as dampproof course, at plinth level of all masonry walls and to be coated with 3 mm thick bitumen emulsion.

Lean concrete of grade 1:5:10 shall be used as filler material wherever loose subgrade exists by removing the loose soil/fill.

7.2 GRADE OF MATERIALS

SL. NO.	NAME OF STRUCTURES	GRADE OF MATERIAL
1	Structural Steel	E250 A/BR & E350 B0
2	Reinforcement Steel	Fe 500D
3	Concrete (RCC) – Superstructure	M25
4	Concrete (RCC) – Foundation	M30
5	Concrete (RCC) – Grade slab	M20
6	PCC	M15
7	Lean Concrete	1:4:8
8	Pre-cast Concrete	M35

7.3 REINFORCEMENT BARS

HYSD Fe500D and Fe550, confirming to IS: 1786, shall be used in foundations and super structure. The minimum diameter of reinforcement bar shall be 8mm.

7.4 MINIMUM THICKNESS OF STRUCTURAL CONCRETE ELEMENTS



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Footings (All types with or without beams) Note: Tapered footings shall not have thickness less than 150 mm at the edges.	300 mm
Basement walls	150 mm
Basement slab with beams / without beams	200/300 mm
Slab thickness in raft foundations with beam & slab construction	150 mm
Floor / roof slab, walkway, canopy slab	150 mm
Cable / Pipe Trench, Launder Walls & Base Slab	125 mm
Parapet	100 mm
Louvre/Fin (not in contact with liquid)	100 mm
Louvre (in contact with liquid)	100 mm
Precast Trench Cover / Precast Floor Slab Liquid retaining / Leak proof structures, Underground Pits	125 mm
Walls	150 mm
Base slab with beams	200 mm
Base slab without beams	300 mm

7.5 MINIMUM COVER TO REINFORCEMENT

The following minimum clear cover shall be provided to all steel reinforcement including links

Slab (roof & floors, canopy, cantilever, waist slab)	30 mm
Beam (roof, floor tie, & lintel)	30 mm or dia. of bar whichever is greater
Column, Pedestal	40 mm above FGL, 50 mm below FGL
Retaining wall, Basement and Pit Wall	
a. Face in contact with earth	50 mm
b. Free face	30 mm or dia. of bar whichever is greater
Liquid retaining structure	
a. Face in contact with liquid	30 mm or dia. of bar whichever is greater
b. Face away from liquid but in contact with earth	50 mm
c. Free face	30 mm or dia. of bar whichever is greater
Foundation slab, base slab, plinth beam	50 mm



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7.6 EXPANSION JOINTS

Expansion points in concrete structures shall be provided at 30-35 m center. The expansion joint shall be provided preferably by way of twin columns on a common foundation.

7.7 DEFLECTIONS

Deflections in concrete structures shall in general be limited by adherence to the limits on span by depth ratio for beams and slabs and length to lateral dimension ratios for columns as prescribed in IS: 456. Where special functional / serviceability requirements or large spans demand actual deflections and / or crack widths shall be calculated and the following limits adhered to:

Total vertical deflection due to all loads including the Effects of temperature creep and shrinkage	Span/250
Crack width (for non-liquid retaining structure)	0.3 mm
Crack width (for liquid retaining structure)	As per design requirement
Total horizontal deflection between two floors	Storey height/200

7.8 PLINTH PROTECTION

Each building shall be provided with 1.0 m wide concrete M10, 100 thick laid on 75 mm thick M7.5 concrete as plinth protection. Surface brick drain of minimum width & depth of 300 mm to be provided along-with plinth protection which shall be connected to the drainage system.

7.9 RAMPS

Ramps for building entrance shall be cast in situ R.C.C. designed as a grade slab and the slope of ramps shall not be less than 1 in 10. Minimum thickness of the slab shall be 150 mm.

7.10 HOT BITUMEN PAINT

All underground structures including top surface of foundations shall be painted with two coats of hot bitumen paint of grade 20/30 with quantity of bitumen at least 1.2 kg/m² per coat.



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7.11 MASONRY WALL

All masonry walls from ground floor shall be placed on R.C.C. grade beams. However, light internal partitions may be placed on ground floor slab.

All brick masonry (M 7.5 MPa) grade walls shall be considered as 230 mm thick, except for partition walls which will be 115 mm thick. However, for fire barrier walls minimum thickness shall be considered as 350 mm.

Bricks shall be fly ash lime bricks confirming to IS 12894 class designation 7.5

7.12 ANTI-TERMITE TREATMENT

Anti-termite treatment shall be provided under all buildings as per IS:6313. Materials shall be as per IS: 8944.

7.13 BUILDING SLABS ON GRADE

SL. NO.	DESCRIPTION		FLOORING TYPE
1.a	Sub Grade	Earth fill base compacted to 95% dry density	Yes
1.b		Rubble soling	230 Thick
2.a	Structural Grade Slab	Lean concrete 1:4:8 over 1.b layer	50 Thick
2.b		Grade M20 concrete (Reinforced with 8 mm dia bars @ 200 c/c both ways) over lean concrete	150 Thick
			R/F placed centrally
3	Finish	Floor finish	As per Architectural detail



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8. DESIGN BASIS FOR STEEL STRUCTURES

Structure and its elements shall normally, be designed by the limit state method. Where the limit states method cannot be conveniently adopted, the working stress design may be used. Steel structures adequately braced in vertical and horizontal planes, consistent with functional requirements, shall be preferred over structure having moment connections. Moment connections, if adopted, shall be fully rigid as per IS:800. Where fully rigid joints are adopted they shall generally be confined to the major axis of the column member.

Steel staircases shall have channels provided as stringers with minimum clear width of 750 mm and maximum slope of 41 degree. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 230 mm wide made of grating (with curved chequered plate nosing) spaced equally so as to restrict the rise to maximum 200 mm

Hand rails, 1000 mm high, shall be provided to all walkways, platforms, staircases. Toe plate (100 mm x 5 mm) shall be provided for all hand railing (except for staircases). Spacing of uprights shall be 1500 mm (maximum).

Electro-forged/Welded hot dip galvanized MS gratings shall be minimum 25 mm deep. The maximum size of voids in the grating shall be limited to 30 mm x 55 mm. The minimum weight for galvanizing shall be 610 g/m² and shall comply with relevant IS Codes. Gratings shall be suitable for the operation and maintenance loads for the floors.

Welded connections shall be adopted as far as practicable, except for cases where bolted connections are required. Structural connections shall have minimum two bolts of 16 mm dia. unless otherwise limited by the size of members.

Lock nuts shall be provided for anchor bolts of tall structures, tall process columns, vibrating equipment, etc.

Minimum two nuts shall be used for all anchor bolts except for ladder, stair and hand rail.



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8.1. EXPANSION JOINTS

Expansion joints shall be provided at 80 – 100 m centres, where possible, column bracing shall be provided at the center of a longitudinal frame, rather than at the ends so as to avoid constraints on free expansion.

8.2. STEEL GRADE

Structural steel shall be of yield stress of 250 MPa, conforming to grade A, Grade B0 & BR for Plates & Grade C for crane Girder as per IS: 2062. For heavily loaded structures, Grade E350 B0 may be used. Tubular steel shall conform to Yst 310 of IS: 1161 & IS: 4923. Structural pipes shall be either seamless or mild welded. Spiral welded pipe is not acceptable.

8.3. LIMITING DEFLECTION

The limiting permissible vertical deflection for structural steel members shall be as specified below: - (Where “L” represents the span)

The limiting permissible horizontal deflection for multi storied steel structure/ Building including flare stack shall be Height/325.

The limiting vertical and horizontal deflection of various steel members under normal loading conditions is specified below in Table. For calculation of deflections in structures and individual members dynamic effects will not be considered. Also, no increase in deflection limits will be allowed when wind or seismic loads are acting concurrent with normal loading conditions.

Deflection Limits

SL. NO.	VERTICAL DEFLECTION	LIMITING DEFLECTION
1.	All purlins, cladding runners, roofing / cladding sheets	Span / 250
2.	For latticed framework and beams of floors other than drive floor	Span / 325
3.	Beams directly supporting drive machinery	Span / 500
4.	Manually operated cranes & monorail supporting beams	Span / 500
5.	Beams supporting Electric overhead cranes Up to 50 t capacity	Span / 750



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SL. NO.	VERTICAL DEFLECTION	LIMITING DEFLECTION
6.	Beams supporting Electric overhead cranes over 50T capacity	Span / 1000
7.	Vertical deflection of metal deck sheet for floor	Span / 250
8.	Gantry girder for electric overhead crane (Capacity up to 50T)	Span/750
9.	Gantry girder for electric overhead crane ((Capacity over 50T)	Span/1000
10.	Gantry girder for manually operated crane	Span/500
11.	Girder beam for supporting dynamic equipment/hoist	Span/450
12.	Grating / Chequered plate	Span/200 or 6mm, whichever Is less

SL. NO.	TRANSVERSE DEFLECTION IN STATIC WIND	LIMITING DEFLECTION
1.	For Trestles and transfer points (Transverse deflection) at Conveyor gallery supporting level)	Height / 1000
2.	For Trestles and transfer points (Along) at Conveyor gallery supporting level)	Height / 500
3.	Pipe rack and cable rack	Height / 325

8.4. MINIMUM THICKNESS

Structural Components

The minimum thickness of various structural components (Rolled Steel sections) shall be as given:

Trusses, Purlins, Side Girts, Bracings	6 mm
Columns, beams	7 mm
Gussets in trusses & girders	
i. up to and including 12 m span	8 mm



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ii. above 12 m span	10 mm
Stiffeners	8 mm
Base plates	10 mm
Chequered plate	6 mm (over plain)
Flats in Grating	5 mm
Pipe sections, SHS & RHS	4 mm

8.5. PAINTING

Painting including shop primer to structural steel shall be Epoxy as per the painting specification for this project.

8.6. PAINTING OF STEEL SURFACES

SI No.	PRIMER COAT	INTERMEDIATE COAT	FINAL COAT
1	All steel surfaces shall be provided with two component moisture curing zinc(ethyl) silicate primer coat (having minimum 80% of metallic Zinc content in dry film, solid by volume minimum 60% $\pm 2\%$) of minimum 70 micron DFT to be applied over blast cleaned surface conforming to Sa 2½ finish of ISO 8501-1 with surface profile 40-60 Micron. The primer coat shall be applied in shop immediately after blast cleaning by airless spray technique. Zinc dust	Primer coat shall be followed with the application of Intermediate coat of two component polyamide cured epoxy with MIO Content (containing lamellar MIO minimum 30% on pigment, solid by volume minimum 80% $\pm 2\%$) of minimum 100 micron DFT. This coat shall be applied in shop after an interval of minimum 24 hours (from the application of primer coat) by airless spray technique.	Intermediate coat shall be followed with the application of finish coat of two pack aliphatic Isocyanate cured acrylic finish paint (solid by volume minimum 55% $\pm 2\%$) with Gloss retention (SSPC Paint Spec No 36, ASTM D 4587, D 2244, D 523) of Level 2 (after minimum 1000 hours exposure, Gloss loss less than 30 and colour change less than 2.0ΔE) and minimum 70 micron DFT. This coat shall be applied shop after an interval of minimum 10 hours and within six (6)



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	composition and properties shall be Type-II as per ASTM D520-00.		months (from the completion of Intermediate coat), Colour and shade of the coat shall be as approved by the Employer.
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8.7. GROUTING

For structural columns : As required but not less than 25 mm

For equipment : As required but not less than 25 mm

8.8. METAL CLADDING

Troughed permanently colour coated sheet (roof & cladding) of approved shade and colour shall be

i) either of steel with minimum 0.6mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade Y250 as per IS 15961 / grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150

or

ii) of minimum 0.5mm BMT (i.e. excluding the thickness of galvanizing/aluminium zinc coating and painting) of grade Y350 as per IS15961/ grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150.

or

iii) of steel of minimum 0.4mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade Y550 as per IS 15961/ grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275 / aluminium-zinc alloy coating to class AZ150.

8.9. METAL DECK ROOF MATERIAL

Troughed permanently colour coated metal decking sheets shall be

i) either of steel with minimum 0.8mm bare metal thickness (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G250 as per AS1397 / grade SS255 as per ASTM A653M / grade S250GD as per EN 10326 with zinc coating to class Z275.

or



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ii) of minimum 0.6mm BMT (i.e. excluding the thickness of galvanizing/aluminium zinc coating and painting) of grade G350 as per AS1397 / grade SS340 class 4 as per ASTM A792M / grade S350GD as per EN 10326 with zinc coating to class Z275.

or

iii) or of steel of minimum 0.6mm BMT (i.e. excluding the thickness of galvanizing/aluminium-zinc coating and painting) of grade G550 as per AS1397 / grade SS550 as per ASTM A792M / grade S550GD as per EN 10326 with zinc coating to class Z275.

Translucent sheets (minimum 3 mm thick) shall be provided, in non-process areas only, intermittently where day lighting is required. Rainwater gutters of Galvanized / Zinc coated sheets and UPVC rainwater pipes shall be provided for proper roof drainage.

8.10. DESIGN REQUIREMENTS FOR PIPERACK

For designing the pipe rack superstructure and foundation the following loads shall be considered:

A) VERTICAL LOADING

Actual weights of pipes coming at each tier shall be calculated. In calculating the actual weight of pipe, the class of pipe, material content and insulation, if any, shall be taken into consideration. In case of gas / steam carrying pipes, the material content shall be taken as one-third volume of pipe filled with water. To obtain the design uniformly distributed load, over the entire span, the u.d.l. obtained as above, shall be assumed to be spread over the entire span. However, minimum loading for any pipe rack shall not be less than 1.25 kN/m².

B) FRICTION FORCE (LONGITUDINAL & TRANSVERSE)

Where the pipes are of similar diameter and service conditions, the friction force at each tier on every portal both in longitudinal and transverse directions, shall be 10% of the design vertical loading of the pipes for four or more pipes supported on a tier and 30% of the design vertical loading of the pipes, for single to three pipes supported on a tier. Longitudinal friction force shall be considered as uniformly distributed over the entire span of the beam at each tier and transverse friction force shall be considered as a concentrated load at each tier level.



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Friction forces on T-supports and trestles shall be taken as 30% of the vertical loading. Both longitudinal and transverse friction forces shall be considered to be acting simultaneously.

C) ANCHOR AND GUIDE FORCE (THERMAL LOAD)

Anchor and guide force (thermal load) in transverse and longitudinal direction shall be as per piping data.

D) LOADING ON INTERMEDIATE BEAM AT TIER LEVEL

Intermediate beam at tier level shall be designed for 25% of load on main portal beams in transverse direction. A reduction of 10% in vertical loading shall be considered for main portal beams, if intermediate beams are provided.

E) LOADING ON LONGITUDINAL BEAMS

Longitudinal beams connecting portal columns shall be sufficiently strong to sustain 25% of the load on the transverse beams. The total load shall be assumed as two equal concentrated loads acting at 1/3rd span. Other longitudinal axial forces coming on it from the design of the supporting system shall also be simultaneously taken in to account in the design of the longitudinal beam.

F) WIND LOAD

Wind loading shall be as per IS:875 (Part-3)

G) SEISMIC LOADS

Seismic loads shall be as per IS: 1893 (2015/2016). Pipe racks should be adequately braced in all possible directions, consistent with function requirements.

9. ROAD

Road cross section shall be designed, including roads for crane access, as per IRC 37. Ruling gradient shall not exceed 1 in 20

9.1. PAVEMENT TYPE

Concrete pavement at all roads to be used for crane movement (Requirement of crane movement route and its specification to be finalised in consultation with client /PMC). Approach Road to units, Parking and other Road shall be Asphalt paving.

Extents: As per Plot Plan / Equipment Layout drawing / scope drawing.

9.2. MINIMUM CROSS SECTION

- i. Sub base: The sub base shall be 300 mm layer of crushed / broken size stones on well compacted earth or approved fill.
- ii. Base course: The base course shall be 225 mm stone size thick water bound macadam consisting of 3 layers of 75 mm each or Wet mix macadam roads.



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- iii. Bituminous wearing course / RCC: The wearing course shall be 75 mm thick for roads with crane duty and 50 mm thick for roads without crane duty. However, roads for crane movement, concrete pavements shall be provided.

9.3. ROAD WIDTH

SL NO	CATEGORY	WIDTH *	CARRIAGEWAY WIDTH
1	Road around unit and its Primary access	12.5 M	10.5 m (three lane road or width to suit crane type)
2	Roads for High Lifts Crane	2.0 M+, C.W. WIDTH	3 m + outer width of crawlers of required capacity crane.
3	Plant Approach Road	9.0 M	7.0 m (two lane)
4	Roads Around Tank Farm	7.5 M	5.5 M
5	Access to Building	5.5 M	3.5 M
6	Foot Path	1.0 M	----

* Width of the road to be finalised as per site condition / plot plan requirements in consultation with client / PMC.

CAMBER : 1 in 50

SLOPE : 1 in 100 (minimum)

RADIUS OF CURVE: 12 m for 8 m wide carriage way roads, 8 m for 5.5 m wide Carriage way width & 15 m for roads of higher carriageway width.

Clearance: Minimum 8.0 m to underside of pipe racks

9.4. CROSSINGS

a	Pipe Ways under roads & rails	RCC Box Culverts
b	Storm Water Culverts Under road / rail	RCC Box Culverts
c	Electric / Instruments Cable	RCC duct bank with PVC Pipe Class – 1 (IS 4985)

9.5. CONCRETE PAVING (WITHIN PLANT AREAS)

RCC paving to be done for entire battery limit and extend up to the adjacent roads around the unit. The scope is limited to units' peripheral roads. Heavy duty paving shall be designed for heavy vehicular traffic movement as per IRC Loading.

Concrete paving shall be laid in cast-in-situ panels of 3.0 meter x 3.0 meter size, with expansion joints spaced approximately 15.0 m c/c, each panel being cast in a single pour.



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9.6. JOINTS

Expansion joint of 20 mm shall consist of 20 thick impregnated fibre boards. Filled at top with joint sealing compound 20 x 25.

Equipment / column pedestals will be separated from paving with 20 thick sand fill and Sealing compound 20 x 25.

9.7. MINIMUM REQUIREMENTS OF PAVING IN VARIOUS AREAS

a. Paving within Process & Utility : Type – I (200 mm thick RCC)

areas for maintenance compatible

to crane movements / dropout

/ Loading / Unloading areas /

Vehicular movement areas

b. Non-vehicular movement areas

i. Unit : Type –II (150 mm thick RCC)

ii. Offsite pump station : Type –II (150 mm thick RCC)

iii. Bullet Area : Type –II (150 mm thick RCC)

iv. Utilities : Type –II (150 mm thick RCC)

c. Pipe rack : PCC 1:3:6 (100 mm thick)

9.8. SURFACE TREATMENT

AREA	RCC PAVING	ASPHALT PAVING	50 THICK PCC 1:3:6 ON 115 THK BRICK SOLING	GRAVEL	100 THK PCC 1:3:6	ACID /ALKALI PROOF COATING
Operating Areas of Process units (including Roads for crane movement)	YES					
Roads (excluding roads having crane movement)		YES				
Approaches to units		YES				



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Tank farms			YES			
Acid / alkali / storage / handling area						YES
Parking		YES				
Hardstands	YES					
Pathways	YES					
Pipe ways					YES	

9.9. STORM WATER DRAINAGE

Storm water drains shall be sized for the higher discharge arising out of either rain water or firefighting water.

Rain water run-off shall be computed by the formula:

$$Q = KIA / 360$$

K is run-off coefficient given below.

A is area (hectares) contributing to the drain

I is rain fall intensity (mm / hr.)

Q is the discharge.

Design of drains shall be based on Manning's formula:

$$V = R^{2/3} S^{1/2} / n$$



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V is velocity of flow m/s,

R is hydraulic radius,

S is slope,

n is roughness coefficient taken as 0.013 for plaster surface, 0.015 for cast-in-situ concrete, 0.017 for brick lined.

The following parameters are to be ensured to be within limits specified while sizing

Minimum velocity of drains	: 0.6 m/s
Maximum velocity of drains	: 2.4 m/s
Minimum depth of drains	: 300 mm
Minimum width of rectangular drains	: 300mm (for depth<500mm)
Minimum width of drains	: 500 mm (depth > 500mm)
Run off coefficient 'K'	
a. paved area concrete	- 1.0
Bituminous	- 0.9
b. unpaved areas	- 0.7
c. unusable areas like Green belt	- 0.4

10. DESIGN PHILOSOPHY FOR ARCHITECTURAL WORKS

The design philosophy defines the minimum design requirements and procedures for carrying out architectural design and engineering of buildings covered under this project. Relevant criteria shall be taken into consideration to achieve satisfactory and trouble-free performance of the facilities.

10.1. PARAPET

Parapets shall be of RCC for all buildings with minimum 500 mm high for non-approachable roof and 1100 mm high for approachable roof



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10.2. ROOF GUTTER

Gutter with rainwater pipes shall be provided for all the buildings / sheds for roof water drainage. Sizing of the gutter shall be based on areas to be drained and number of outlets. Gutters shall be of RCC or sheet metal depending on type of structure.

10.3. RAIN WATER PIPES

PVC rain water pipes shall be provided for roof water drainage. Number of rain water pipes shall be decided on the basis of roof area, slope and rainfall intensity as per NBC-IX, Section-2. Rain water pipes shall be concealed as far as possible. RCC or GI spouts may be used for drainage of chajja / small canopies of ground floor. Dia of rain water pipe shall be 150 mm minimum.

10.4. STAIRCASES

Number of staircases shall be based on building / shed sizes, emergency exit requirements, and travel distances to exit points as per statutory regulations. More than 500 sq m ground covered area shall have at least two stairs in line with NBC-Part-IV. At least one staircase shall be provided for access to the flat roof tops for maintenance.

a)	Stairs width	:	1500 mm minimum, (1000 mm minimum for emergency exit)
b)	Tread	:	300 mm minimum
c)	Riser	:	150 mm maximum
d)	Ratio of tread & riser	:	2 Riser + Tread = 600 to 650 mm

10.5. UNDER DECK INSULATION

Under deck insulation below RCC roof and over false ceiling (both locations) shall be provided for air-conditioned office / space.

10.6. WATERPROOFING ON ROOFS

Water proofing (for all open terraces) of all buildings shall be done by water proofing PU coating with treatment also, of approved Brand and make. Wherever there is human/machine movement anticipated, it is preferable to use Brickbat waterproofing over roof.

10.7. FINISHING SCHEDULE

10.7.1. INTERIOR FINISHING SCHEDULE



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SL NO	DESCRIPTION OF AREA	FLOOR FINISH	WALL FINISH	CEILING FINISH
1	Control Room	Vitrified tiles	POP punning & plastic emulsion paint	Aluminium false ceiling
2	Pump House	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)
3	Staircase	18 mm thick Granite slab	Polished Granite stone up to 1.2m.ht. & Acrylic Distemper above dado	Acrylic Distemper
4	Entrance lobby, Corridor lobby	Granite flooring	Granite stone cladding and plastic emulsion paint	White / colour wash, plastic emulsion paint
5	Office areas of Buildings	Vitrified tiles in glazed or matt finish / Marbo-granite tiles	POP punning & plastic emulsion paint	Gypsum board false ceiling or Armstrong false ceiling or combination of both
6	Corridor / Passage etc. excepting Entrance lobby	Granite or Vitrified tiles or combination	POP punning & plastic emulsion paint	White / colour wash, plastic emulsion paint
7	Rack Room, Office Rooms, Operators Room	Heavy Duty Decorative Ceramic Tiles.	POP punning & plastic emulsion paint	Gypsum board false ceiling
8	Switchgear Room/ Electrical Room	Kota Stone Flooring	Plastic emulsion paint	Plastic emulsion paint
9	Battery Room	Acid resistant epoxy coating over IPS-flooring	Acid resistant epoxy coating over cement plaster up to 2100 height. Plastic emulsion paint above 2100 height.	White / colour wash, plastic emulsion paint
10	Toilet	Anti-skid ceramic tile	Granite stone cladding / Marble / Ceramic tiles	Gypsum board false ceiling



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SL NO	DESCRIPTION OF AREA	FLOOR FINISH	WALL FINISH	CEILING FINISH
11	AHU/ AC Plant room/Cable vault	Cement concrete with Metallic hardener topping	Acrylic distemper	Acrylic distemper (except metal deck area)

10.7.2 EXTERIOR FINISHING SCHEDULE

SL NO	DESCRIPTION OF AREA	WALL AND PROJECTIONS	SOFFIT PROJECTIONS
1	Auxiliary building in steel framed structure.	Weather proof Exterior Acrylic Emulsion paint over suitable primer of water proof cement paint over plastered surface Approved colour/colour combination of colour coated metal cladding	Weather proof Exterior Acrylic Emulsion paint over suitable primer of water proof cement paint over plastered surface Approved colour/colour combination of colour coated metal cladding
2	Building with concrete frame work, etc.	Weather proof Exterior Acrylic Emulsion paint over suitable primer of water proof cement paint over plastered surface	Weather proof Exterior Acrylic Emulsion paint over suitable primer of water proof cement paint over plastered surface
3	Steel Structure, trestles, etc.	Epoxy paint of approved specification and shade	-----

10.8. WALL

Following schedule shall be adhered to for wall material and thickness:

1	Blast Proof Wall	Min 230 mm thick RCC wall
2	Rain water duct / shaft	Min. 230 mm thick hollow/ solid concrete block work
3	External walls	230 mm thick hollow/ solid concrete block work



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4	Fire wall (Around transformers)	240 thick RCC or 355 mm (including plastering) thick hollow / solid concrete block work wall OR as per Electrical requirements. (IER/TAC)
5	Internal partition wall	230 / 115 mm thick hollow/ solid concrete block work wall depending on the overall length and height of the wall (Refer notes below)

10.9. DOORS, WINDOWS & VENTILATORS

DOORS

Blast resistant Control room entry door shall be provided with blast resistant baffle wall in front of entry door and shall have 45 degree / 90 degree overlap on both sides as per relevant standard/codes.

All frame works shall be in Sal/chap wood in size 125 x 65 mm.

- a) All doors in Toilet / WC / Bath 35 mm flush door laminated with 01mm laminate from both sides.
- b) All doors of Electrical Room, A.C. Plant Room, Battery Room Pressed steel frame with pressed steel shutter (or as specified in Electrical section).
- c) Inside Control Room Fire check door with 2 hours rating as required in perfect partition wall separating various fire zones (or as specified in Instrumentation section)
- d) All other doors of Control Room / Satellite Rack Room / Substation Glazed, powder coated Aluminium door with decorative etching (or as specified in Instrumentation section).

WINDOWS & VENTILATORS

Glazed, powder coated aluminium window / ventilator.

For the purpose of ventilation, total openable area of the windows / ventilators shall be as per Factories Act subject to a minimum of 10% of the floor area to be ventilated

All glasses in windows & doors shall be toughened glass. Outside glasses shall be tinted toughened.

10.10. SANITARY FITTINGS

- a) Water Closet for Control Room

Wall hung type coloured European designer type WC.

- b) Water Closet (Indian).

Orissa type (Indian) pan white WC.



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c) Wash basins for Control Room.

Round wash basin white / coloured housed in granite counter with electronic sensors for water control, approved quality mirror. Front portion below the counter shall be covered with shutters of laminated boards.

d) Plumbing fixtures.

Stainless steel bib cock, stop cock etc. fittings.

e) Urinals of approved Brand, Make, size, shape and colour shall be provided in Control Room with Electronic sensors for water control, along with Glass partitions of approved brand, make size and shape etc.

10.11. BUILDING REQUIREMENTS

Floor slab in WC areas shall be sunk by 500 mm and toilet, pantry, kitchen floor slabs shall be sunk by 200 mm at all levels.

All partition walls within toilet kitchen areas shall be 115 mm thick and 2200 mm high.

Preferably all cut out in slab shall be provided with 200 mm high kerb.

a) Toilet, b) Drinking water, c) First Aid enclosures shall be mandatory requirement for all buildings / sheds.

Flooring shall be done in panels, preferably in 3000X3000 mm size with expansion joints provided at 25000 mm c/c.

11. CHP & AHP STRUCTURES

11.1. TRANSFER POINTS



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The over ground portion of all transfer houses shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding (from lowest working floor level till top) and RCC floors comprising of RCC slab over profiled metal deck sheets (to be used as permanent shuttering without considering any composite action effect of metal deck sheet) over structural beams. Shear anchor studs shall be provided through metal deck at regular interval on all top flange/flange plate of structural beams. However, the lower portion of side cladding, at ground, for a minimum height of 0.9 m above the finished floor level shall be one brick thick wall plastered on both side. In some areas like MCC floors etc., one brick thick wall cladding shall be provided. Brick wall cladding shall be supported on encased wall beams and suitably anchored to adjoining columns and beams. Vertical bracings shall be provided only on four sides along the periphery. Grade slab with brick cladding of 0.9 m height, plastered on both sides shall be provided for all transfer houses. Bottom of the base plate of the columns of the transfer houses in Main Plant Block Area shall be kept 1.2m below the finished floor level. Adequate steel doors and windows for proper natural lighting and ventilation shall be provided. In addition to steel windows, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting.

The roof of Transfer points shall be provided with pre-fabricated insulated metal sandwich panels. Pre-Fabricated Insulated Metal Sandwich Panel for Roofing shall be laid to specified slope. Polyurethane foam shall be used as Insulation material in Metal Sandwich Panels. Adequate slope shall be provided for quick drainage of rain water.

The polycarbonate sheet to be used for cladding and glazing purpose in Transfer points & shall have toughed profile to match with the metal cladding profile. Minimum 3.0mm thick fire retardant and UV resistant polycarbonate clean sheet of approved make shall be used. The polycarbonate sheet shall be installed along with the metal cladding so as to have a watertight lapping arrangement. Suitable detailing shall be made to cater for the thermal expansion. IS 14434 to be referred for other details.

Outside stairs to transfer points shall be open type. However, sheeting shall be provided at the top.

Suitable kick plates/Curb beams shall be provided around the floor openings, stair case landings, in the transfer points, crusher house and other buildings.

Floors of transfer points shall have cross slope of not flatter than 1: 80, towards the floor washing drainage outlets, for efficient drainage. For ground conveyor & crusher house slope shall be 1:100.



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The whole structure is modelled, analysed and designed by using software STAAD pro and common element like base plate, monorail beam, staircase stringers, purlins and side runners are designed separately by using MS excel spread sheets. The self-weight of the structural elements is calculated using self-weight command in STAAD with a factor of 1.1 to include the weight of gussets and bolts of the connections. The dead loads of the materials such as sheeting and the concrete are considered as per IS-875 part-1. The live loads are considered as per IS-875 part -2.

The Equipment Dead loads, Live loads and Belt loads are taken from respective mechanical GA and considered as concentrated loads on the respective beams. The conveyor loads are calculated from the STAAD reactions of corresponding conveyor design files and acted as concentrated loads on the supporting beams.

The wind loads are calculated as per IS-875 part-3 pressure coefficient method. Both Dynamic Method (Gust factor method) and Static method are used to calculate the wind load on the structure. The wind load is considered in X, Z directions for both internal pressure and suction conditions. The diagonal wind is also considered for the analysis and design of structure.

The various Loads acting at different points on beams are transferred to the nearest columns through the grid of beams. The lateral loads at various floors are transferred to end frames of the TPs through RCC slab or plan bracing as applicable. The end frames are braced structures, which in turn will transfer load to respective foundations.

Individual members of the frame shall be designed for the worst combination of forces such as bending moment, axial force, shear force, torsion, etc., The different load combinations shall be taken as per IS: 875 (Part-5) and other relevant IS Codes as covered in section 4.2 of this document.

11.2. OVERHEAD / GROUND CONVEYOR GALLERIES AND TRESTLES

Overhead conveyors for trough belt conveyor shall be located in a suitably enclosed gallery of structural steel. The overhead gallery shall consist of two vertical latticed girders having rigid jointed portal frame at both ends. Cross beams at floor level supporting conveyor stringer beams shall be made of single rolled steel beam ISMB or plate girder. Horizontal bracings are to be provided at top & bottom plan of the gallery (latticed girders shall be braced together in plan at the top and bottom). Common end portal frame shall not be used for adjacent conveyor spans. Roof truss shall be provided at upper node points of latticed girders to form an enclosure.

The maximum span of overhead gallery shall be limited to 25 meters unless higher span is required due to site conditions, which shall be subject to approval of the Engineer. The tubular steel section shall be of circular/rectangular/square shape. The circular steel tube shall



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conform to IS:1161 and rectangular/square steel sections shall conform to IS:4923. The steel structures using tubular sections shall be designed and fabricated as per IS:806 – “Code of Practice for use of steel tubes in general building construction.” and EN 1993-1-8:2005. Seal plates under the conveyor galleries shall be provided in such a way that complete gallery bottom shall form a leak proof floor.

Grade slab with brick toe wall and plinth protection along with drains shall be provided throughout the length of the ground conveyors. Top of pedestal for ground conveyor portals shall be 300mm above FFL. Bottom of the base plate of the columns of the trestles in Main Plant Block Area shall be kept 1.2m below the finished floor level of ground floor of Main Power House.

For double stream conveyor gallery, two side and one central walkway of minimum width 800 mm and 1100 mm respectively shall be provided. The minimum width of two side walkways for single stream conveyor gallery shall be 800 mm and 1100 mm respectively. Both sides of central and side walkways shall be provided with pipe handrails all along the conveyor gallery. Hand railing should not be supported on conveyor supporting stringers. The walkways shall be chequered plate construction with anti - skid arrangement. The anti - skid arrangement will consist of welding of 10 mm square steel bars at a maximum spacing of 500 mm along the length of the gallery. Where the slope of walkway is more than 10o, chequered plate steps with nosing and toe guard shall be provided. The floor of conveyor gallery all along the gallery length, shall be provided with minimum 12-gauge thick seal plates (suitably stiffened) and other drainage arrangements as specified elsewhere. Trough belt conveyor gallery shall have permanently colour coated steel sheet covers on roof and both sides. However, in roof, a panel of minimum 1.5 m x 1.5 m area at about 6.0 m centre

A continuous slit opening of 500 mm shall be provided on both sides just below the roof sheeting. Adequate provision of windows shall be kept on both sides of conveyor gallery as appended in Mechanical Section (Belt conveyor system). Windows shall be provided with wire mesh as specified elsewhere in this specification.

Cross - over with chequered plate platform and ladder for crossing over the conveyors shall be provided at approximately every 90m intervals of conveyor. Crossover shall preferably be located over four-legged rigid trestle location.

Conveyor Gallery structure shall be designed considering both conveyors operating simultaneously.

Conveyor gallery and supporting trestles located between transfer houses / buildings shall be arranged in following ways.



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In between transfer houses / buildings, four legged trestles shall be placed at a maximum interval of 90 metres. The arrangement shall be such so as to ensure that force in the longitudinal direction (i. e. along the conveyor length) of conveyor gallery of length not more than 90 m is transferred to any four-legged trestle. In the space between each successive four-legged trestles, two legged trestles shall be provided at regular intervals. The end supports resting on the four-legged trestle can have either ends hinged or one hinge and the other on slide type depending on the arrangements. Slide type support shall be with PTFE bearings to allow both rotation & longitudinal movements.

End of conveyor gallery which will be supported over transfer house, shall be so detailed that only vertical reaction is transferred from conveyor gallery and no horizontal force in longitudinal direction is transferred from conveyor gallery to transfer house structure and vice - versa.

For trestles and trestle foundations for conveyor galleries located adjacent to existing structures, over ground and underground facilities, location and details of these trestles and foundations shall have to be decided such that there is no interference both underground as well as over ground with existing structures and facilities. Base plates of trestle columns shall be kept 300 mm above the finished ground level.

11.3. CRUSHER HOUSES

The crusher house shall be framed structure of structural steel work with permanently colour coated profiled steel sheet side cladding. However, panels of suitable size to suit the architectural treatment and made of translucent sheets of polycarbonate material shall also be provided on the side cladding for natural lighting. The lower portion of side cladding, at ground, for a height of minimum 0.9m above the finished floor level shall be of one brick thick wall plastered on both faces. Floors shall be of RCC comprising of RCC slab over profiled metal deck sheets (to be used as permanent shuttering without considering any composite action effect of metal deck sheet) over structural beams. Shear anchor studs shall be provided through metal deck at regular interval on all top flange/flange plate of structural beams. Within this building, cubicles for resting room of operators shall be constructed with one brick thick brickwork having both sides plastered and roof slab. Adequate steel doors and windows for natural lighting and ventilation shall be provided. Vertical bracings shall be provided only on four sides along the periphery.

The roof of crusher house shall be provided with pre-fabricated insulated metal sandwich panels. Pre-Fabricated Insulated Metal Sandwich Panel for Roofing shall be laid to specified slope. Composition of Insulated Metal Sandwich Panels shall be as described in relevant section of Technical Specification. Adequate slope shall be provided for quick drainage of rain water.



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Crushers shall be supported on RCC deck, which in turn will rest on suitable vibration isolation system consisting of springs and dampers. This RCC deck shall be isolated from the floor. However, the vibration isolation system consisting of springs and dampers may rest on main building framework.

11.4. MCC BUILDINGS

These shall be RCC framed building with RCC roof and floor. Cladding shall be of brickwork with plastering on both sides. Roof shall be provided with roof water proofing treatment, as specified in the Technical specification. Suitable arrangement shall be provided so as to prevent ingress of water into the cable trenches inside the building from cable entry locations.

All air - conditioned areas, shall be provided with the false ceiling system (details specified elsewhere) with under deck insulation. Adequate aluminium doors and windows shall be provided for natural lighting, ventilation and view. All windows in air-conditioned rooms shall have hermetically sealed double glazing.

11.5. PUMP HOUSES

These shall be framed structure of structural steel work with permanently colour coated profiled steel sheet roof, grade slab and RCC foundations etc. Roof shall be provided with troughed profile permanently colour coated sheet with slope of 1 in 5 for quick drainage of rain water. Brick wall cladding (1m height above FFL) shall be provided all around the periphery of pump houses.

11.6. CABLE GALLERY/TRESTLES

Cable galleries/trestles shall be made of structural steel. Rolled sections or tubular steel sections used for design. The tubular steel section shall be of circular/rectangular/square shape. The circular steel tube shall conform to IS:1161 and rectangular/square steel sections shall confirm to IS:4923. The steel structures using tubular sections shall be designed and fabricated as per IS:806 – “Code of Practice for use of steel tubes in general building construction.” and EN 1993-1-8. Galvanised gratings shall be provided for walkways as per approved electrical drawings. Ladders shall be provided for access from ground to cable galleries at maximum 100m intervals.

11.7. CONTROL ROOM (MCC)

Control Room building shall be designed as RCC framed structure. Besides housing of control panel/ operator’s consoles, Engineering console room, process operator’s room, HVAC/ Air handling room(s), UPS and UPS battery room, toilet, rest rooms etc. shall be accommodated in the control room building in general.



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11.8. PIPE RACK

Structural steel pipe-rack with RC foundations having multiple tiers for supporting pipes with suitable platforms for control valve operations and walkway, having grating, MS handrails on both sides with local ladders. Open steel staircase for operation & maintenance at required places to be provided from ground to top level with landing at appropriate locations.