



SUPPLY AND CONSTRUCTION OF ASH POND AND ALLIED SERVICES AT TALCHER FERTILIZERS LIMITED, NIT NO : PNP/PC-183/E/206/NCB, Dated- 14 June 2022
AMENDMENT No.: II Dated 07.07.2022



Sl. No.	Reference of Bidding Document				Existing Clause	Amended Clause
	Vol-II/ Sec	Page No.	Clause No.	Subject / Heading		
SECTION VI						
PROJECT DESCRIPTION & SCOPE OF WORK						
1	SEC-VI-1.0	5 of 7	4.00	Scope of Work-Civil	The nature of work generally involves site clearance, excavation in all types of soils/ ash/ rock, foundation preparation, dewatering, shoring, backfilling, formation of dyke embankment with the material of specified quality from the specified or approved borrow areas, laying of impervious liner(LDPE) forming aggregate filter, bottom ash chimney & blanket, Bottom ash filter, upstream and downstream slope protection, Instrumentation, forming drains, RCC spillways, supplying & laying of RCC Hume pipes & road works etc. and other ancillary works associated with the completion of dyke embankment as per specifications, drawings, Schedule of Items and directions of the Engineer.	The clause is modified as below: The nature of work generally involves site clearance, excavation in all types of soils/ ash/ rock, foundation preparation, dewatering, shoring, backfilling, formation of dyke embankment with the material of specified quality from the specified or approved borrow areas, laying of impervious liner(Bituminous Geo-membrane lining) forming aggregate filter/bottom ash chimney & blanket if required, Bottom ash filter, upstream and downstream slope protection, Instrumentation, forming drains, RCC spillways, supplying & laying of RCC Hume pipes & road works etc. and other ancillary works associated with the completion of dyke embankment as per specifications, drawings, Schedule of Items and directions of the Engineer.
2	SEC-VI	621 of 944	Section - VI. / 7.0 to 7.3	Design Philosophy & Technical Specification – Civil & Structural	-Design Philosophy & Technical Specification – Civil & Structural	Entire section –VI. /7.0 to 7.3 STAND DELETED and replaced with revised section –VI.7.0 to 7.3 (Rev.1) attached with this amendment.

**SUPPLY AND CONSTRUCTION OF ASH POND AND ALLIED SERVICES AT TALCHER FERTILIZERS
LIMITED, NIT NO : PNP/PC-183/E/206/NCB, Dated- 14 June 2022
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Sl. No.	Reference of Bidding Document				Existing Clause	Amended Clause
	Vol-I/ Sec	Page No.	Clause No.	Subject / Heading		
3	SEC- VI			List of Drawing & Documents	Layout and section drawing of Ash Pond	Earlier drawings attached in NIT is being replaced with revised drawings of Layout and section drawing for Ash Pond (Rev. P1) are attached alongwith this amendment.
4	SEC- VII			Schedule of Rates / BOQ	Schedule of Rates / BOQ	Revised Schedule of Rates / BOQ (Rev1) is attached. Bidder to quote as per latest BOQ (Rev.1) uploaded in CPP Portal.
5	General				Nil	<i>The word LDPE lining wherever is mentioned in CIVIL SECTION OF NIT, the same shall be read as Bituminous Geo-membrane lining (BGM).</i>


Ashwini
07/07/2022
(Project Manager)

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DESIGN PHILOSOPHY & TECHNICAL SPECIFICATIONS
FOR
CIVIL, STRUCTURAL WORKS


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TECHNICAL SPECIFICATIONS
FOR
CIVIL, STRUCTURAL
AND
OTHER ALLIED WORKS

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1.0 GENERAL

- 1.1 Specifications of materials and workmanship shall be as described in the Central Public Works Department Specifications Vol. I & II (latest) include latest amendments, unless otherwise specified. These CPWD Specifications shall be deemed to form part of this contract. The **CONTRACTOR** shall procure and maintain copies of the latest CPWD Specifications at site for reference.
- 1.2 These technical Specifications shall be supplementary to the specifications contained in the CPWD specifications, wherever at variance, these Particular Specifications shall take precedence over the provisions in the CPWD Specifications.

2.0 REFERENCE CODES & STANDARDS

- 2.1 Wherever reference of IS Specifications/ or IS Codes of Practice are made in the Specifications/ Schedule of Rates or Preambles, reference shall be to the latest edition of IS (Bureau of Indian Standards).

IS - 383	Coarse & Fine aggregates from natural sources for concrete.
IS - 427	Distemper, dry, colour as required.
IS - 432	Mild Steel & Medium tensile steel bars.
IS - 456	Code of Practice for Plain and Reinforced Concrete.
IS - 515	Natural and Manufactured aggregates for use in mass concrete
IS - 730	Hook bolts for corrugated sheet roofing
IS - 800	Code of Practice for General Construction in Steel
IS - 1079	Hot rolled carbon steel sheets & strips
IS - 1081	Code of practice for fixing and glazing of metal (steel & aluminium) doors, windows and ventilators.
IS - 1161	Steel tubes for structural purposes.
IS - 1285	Wrought aluminium & aluminium alloy extruded round tube and

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hollow sections



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 - 1367	Technical supply conditions for threaded steel fasteners
IS - 1566	Hard - Drawn steel wire fabric for concrete reinforcement.
IS - 1786	High strength deformed steel bars & wires for concrete reinforcement.
IS - 2062	Steel for general structural purposes.
IS - 2116	Sand for masonry mortars.
IS - 2212	Code of practice for brickwork.
IS - 2386	Methods of test for aggregates.
IS - 2835	Flat transparent sheet glass
IS - 4021	Timber door, window and ventilator frames
IS - 4923	Hollow Steel sections for structural use.
IS - 4925	Concrete batching and mixing plant.
IS - 5410	Cement Paint
IS - 6477	Dimensions for wrought aluminium & aluminium alloys, extruded hollow sections.
IS - 7318	Fusion welding of steel.
IS - 10262	Recommended guidelines for concrete mix design.
IS - 14871	Products in Fibre Reinforced Cement – Long Corrugated or Asymmetrical Section Sheets and Fittings for Roofing and Cladding - Specification

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3.0 EARTHWORK


3.1 Excavation

- 3.1.1 Excavation shall be carried out in soil of any nature and consistency, in the presence of water or in the dry, met on the site to the lines, levels and contours shown on the detailed drawings and **CONTRACTOR** shall remove all excavated materials to soil heaps on site or transport for use in filling on the site or stack them for reuse as directed by the Engineer-in-Charge.
- 3.1.2 Surface dressing shall be carried out on the entire area occupied by the buildings including plinth protection as directed without any extra cost. The depths of excavation shown on the drawings are the depths after surface dressing.
- 3.1.3 The site around all buildings and structures to a width of 3 metres beyond the edge of plinth protection, ramps, steps, etc. shall be dressed and sloped away from the buildings.
- 3.1.4 Black cotton soil, and other expansive or unsuitable soils excavated shall not be used for filling in foundations, and plinths of buildings or in other structures including manholes, septic tanks etc. and shall be disposed off within the contract area marked on the drawings, as directed, levelled and neatly dressed.
- 3.1.5 In case of trenches exceeding 2 metres depth or where soil is soft or slushy, the sides of trenches shall be protected by timbering and shoring. The **CONTRACTOR** shall be responsible to take all necessary steps to prevent the sides of trenches from caving in or collapsing. The extent and type of timbering and shoring shall be as directed by the **Engineer-in-Charge**.
- 3.1.6 Where the excavation is to be carried out below the foundation level of adjacent structure, the precautions to be taken such as under pinning, shoring and strutting etc. shall be determined by **Engineer-in-Charge**. No excavation shall be done unless such precautionary measures are carried out as per directions of **Engineer-in-Charge**.
- 3.1.7 Specification for Earth work shall also apply to excavation in rock in general. The excavation in rock shall be done such that extra excavation beyond the required width and depth as shown in drawings is not made. If the excavation done in depth greater

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than required /ordered. The **CONTRACTOR** shall fill the extra excavation with concrete of mix 1:5:10 as the foundation concrete at his own cost.



- 3.1.8 **CONTRACTOR** shall make all necessary arrangements for dewatering / defiling as required to carry out proper excavation work by bailing or pumping out water, which may accumulate in the excavation pit from any cause/ source whatsoever. In addition to this, if required, contractor shall also install continuous dewatering pump-sets to lower the ground water table below the working level to make the area fit and safe for working.
- 3.1.9 **CONTRACTOR** shall provide suitable draining arrangements at his own cost to prevent surface water entering the foundation pits from any source.
- 3.1.10 The **CONTRACTOR** is forbidden to commence the construction of structures or to carry out concreting before **Engineer-in-Charge** has inspected, accepted and permitted the excavation bottom.
- 3.1.11 Excavation in disintegrated rock means rock or Boulders including brickbats which may be quarried or split with crow bars. This will also include laterite and hard conglomerate.
- 3.1.12 Excavations in hard rock - meant excavation made in hard rock to be done manually, or by blasting using only explosives and / or pneumatic hammers. In case of blasting, control blasting should be adopted depending on site conditions. For using explosives **CONTRACTOR** shall follow all provisions of Indian Explosives Act / Rules 1983, corrected / revised up to date.
- 3.1.13 In case of hard rock excavation to be carried out using explosives the, **CONTRACTOR** shall obtain the written approval in advance.
- 3.1.14 The measurements for excavations shall be restricted and limited to minimum excavation line as per drawing for payment purposes.
- 3.1.15 Adequate protective measures shall be taken to see that the excavation does not affect or damage adjoining structures. The **CONTRACTOR** shall take all measures required for ensuring stability of the excavation and safety of property and people in the vicinity. The **CONTRACTOR** shall erect and maintain during progress of work, temporary fences around dangerous excavations at no extra cost.

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- 3.1.16 Excavation in ordinary soil means excavation in ordinary hard soil including stiff heavy clay, hard shale, or compact moorum, or any materials, which can be removed by the ordinary application of spades, shovels, picks and pick axes. This shall also include removal of isolated boulders each having a volume not more than 0.50m³.
- 3.1.17 Excavation in soft rock includes limestone, sandstone, laterite, hard conglomerates, etc. or other rock which can be quarried or split with crowbars or wedges. This shall also include excavation of tarred pavements, masonry work and rock boulders each having a volume of not more than 0.25m³.
- 3.1.18 Excavation in hard rock includes any rock bound in ledges or masses in its original form or cement concrete for which in the opinion of the Engineer-in-Charge, requires the use of compressed air, equipment, sledge hammer and blasting or non-explosive materials viz. Acconex manufactured by A.C.C. Ltd. Specifications and instructions for use shall be as per manufacturer.
- 3.1.19 In case of any difficulty concerning the interpretation of type of soil as mentioned above, the Engineer-in-Charge shall decide whether the excavation in a particular material is in ordinary soil, soft rock or hard rock and his decision in this matter shall be final and binding on the CONTRACTOR and without appeal.
- 3.2 **Filling**
- 3.2.1 Back filling of excavations in trenches, foundations and elsewhere shall consist of one of the following materials approved by **Engineer-in-Charge**.
- Soil
- Sand
- Moorum
- Hard-core
- Stone/gravel
- All back filling material shall be approved by the **Engineer-in-Charge**.

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- 3.2.2 Soil filling - Soil material shall be free from rubbish, roots, hard lumps and any other foreign organic material. Filling shall be done in regular horizontal layers each not exceeding 20 cm. depth.
- 3.2.3 Back filling around completed foundations, structures, trenches and in plinth shall be done to the lines and levels shown on the drawings.
- 3.2.4 Back filling around pipes in the trench shall be done after hydro testing is done.
- 3.2.5 Back filling around liquid retaining structures shall be done only after leakage testing is completed and approval of **Engineer-in-Charge** is obtained.
- 3.2.6 Sand used for filling under foundation concrete, around foundation and in plinth etc. shall be fine/ coarse, strong, clean, free from dust, organic and deleterious matter. The sand filling under foundation shall be rammed with Mech. compactor. Sand material shall be approved by **Engineer-in-Charge**.
- 3.2.7 Moorum for filling, where ordered, shall be obtained from approved pits and quarries which contain siliceous material and natural mixture of clay. Moorum shall not contain any admixture of ordinary earth. Size of moorum shall vary from dust to 10 mm.
- 3.2.8 Hard-core shall be of broken stone of 90 mm to 10 mm size suitable for providing a dense and compact sub grade. Stones shall be sound, free from flakes, dust and other impurities. Hard core filling shall be spread and levelled in layers, 15 cm thick, watered and well compacted with ramming or with mechanical / hand compacts including hand packing wherever required.
- 3.2.9 If any selected fill material is required to be borrowed, **CONTRACTOR** shall make arrangements and procure such material from outside borrow pits after obtaining all necessary permissions from statutory authorities. The material of source shall be subject to prior approval of **Engineer-in-Charge**. **CONTRACTOR** shall make necessary access roads to borrow areas and maintain the same, if such access roads do not exist, at no extra cost.
- 3.2.10 Plinth filling shall be carried out with approved material as described earlier, in layers not exceeding 200 mm, watered and compacted with mechanical compaction machines. **Engineer-in-Charge** may however permit manual compaction by hand tampers in case he is satisfied that mechanical compaction is not possible. When

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filling reaches the finished level, the surface shall be flooded with water, unless otherwise directed, for at least 24 hours, allowed to dry and then the surface again compacted as specified above to avoid settlements at later stage. The finished level of the filling shall be trimmed to the level specified. Compacted surface shall have at least 95% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done.

3.2.11 Whenever the fill material (earth or soil) is purchased, **CONTRACTOR** shall get the approval of Engineer-in-Charge. The CONTRACTOR shall arrange to determine the following properties of the soil (at outside NABL accredited laboratory without any cost to owner) and shall get the approval of **Engineer-in-Charge**.



1. Clay content : 15% to 20%
2. Laboratory dry density (MDD) : Not less than 1600 kg/m³
3. Plasticity Index : Not more than 20
4. Optimum Moisture Content (OMC) : 8% to 12%

3.2.12 The fill shall be compacted using a vibrating compactor of not less than 1.5 tonne. The fill shall be thoroughly compacted in layers as directed but not more than 200 mm thick. Adequate water shall be used for compaction and the density after compaction shall be not less than maximum dry density obtained in test of IS: 2720 Part-8. Compacted surface shall have at least 95% of laboratory maximum dry density. A minimum of one test per 250 sq. meters of compacted area shall be done for each layer.

3.2.13 The Gravel fill shall be non plastic granular material, well graded, strong, with maximum particle size of 50 mm, with not more than 15% passing a 4.75 mm IS sieve, free of all debris, vegetable matter and chemical impurities.

3.2.14 All clods, lumps etc. shall be broken before compaction.

3.2.15 In case of grading/banking successive layers of filling shall not be placed, until the layer below has been thoroughly compacted to satisfy the requirements laid down in this specification.

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Prior to rolling, the moisture content of material shall be brought to within +/-2% of the optimum moisture content as described in IS 2720 Part-7. The moisture content shall preferably be on the wet side for potentially expansive soil.

After adjusting the moisture content as described, the layers shall be thoroughly compacted by means approved by Engineer-in-Charge, till the specified maximum laboratory dry density is obtained.

General, fill shall be placed in layers not exceeding 200 mm thickness and shall be thoroughly compacted to achieve a compaction of at least 95% of laboratory maximum dry density up to entire depth of filling. Final fill of 600 mm thickness shall consist of preferably natural material in, as dug condition except that stones larger than 100 mm shall be removed. It shall be placed in layers not exceeding 200 mm thickness and compacted to achieve of at least 95% of laboratory maximum dry density. Each layer shall be tested in field for density and accepted by Engineer-in-Charge, subject to achieving the required density before laying the next layer. A minimum of one test per 250 sq meters for each layer shall be conducted.

If the 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 Engineer-in-Charge to obtain the required density.

The filling shall be finished in conformity with the alignment, levels, cross-section and dimensions as shown in the drawing.



Extra material shall be removed and disposed off as directed by the **Engineer-in-Charge**.

4.0 PLAIN AND REINFORCED CONCRETE WORK

This specifications deals with cement concrete, plain or reinforced, for general use, and covers the requirements for concrete materials, their storage, grading, mix design, strength & quality requirements, pouring at all levels, reinforcements, protection, curing, form work, finishing, painting, admixtures, inserts and other miscellaneous works.

4.1 Materials

4.1.1 Cement: Any of the following cements may be used as required.

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IS - 8112	43/53 Grade ordinary Portland cement
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4.1.2 Water: Water used for mixing and curing concrete and mortar shall conform to the requirements as laid down in IS: 456. Sea water shall not be used for concrete work.

4.1.3 Aggregates: Coarse and fine aggregates for cement concrete plain and reinforced shall conform to the requirements of IS 383 and / or IS 515. Before using, the aggregates shall be tested (at outside NABL accredited laboratory without any cost to owner) as per IS: 2386.

Coarse aggregate: Coarse aggregate for all cement concrete work shall be broken or crushed hard stone, black trap stone obtained from approved Quarries or gravel.

Sand: Fine aggregate for concrete work shall be coarse sand from approved sources. Grading of coarse sand shall be within grading zones I, II or III laid down in IS: 383, table 4. If required the aggregates (both fine and coarse) shall have to be thoroughly washed and graded as per direction of **Engineer-in-Charge**.

4.2 **Mixing**

All cement concrete plain or reinforced shall be machine mixed. Mixing by hand may be employed where quantity of concrete involved is small, with the specific prior permission of the **Engineer-in-Charge**. 10% extra cement shall be added in case of hand mixing as stipulated in IS-456.

For large and medium project sites the concrete shall be sourced from ready- mixed concrete plants or from on site or off site batching and mixing plants (IS 4926)



4.3 **Water Cement Ratio, Laying & Curing**

Water Cement Ratio, Laying & Curing shall be done as per IS:456.

4.4 **Grades of Concrete**

4.4.1 Grades lower than M 25 shall not be used in reinforced concrete.

4.4.2 A sieve analysis test of aggregates shall be carried out (at outside NABL accredited laboratory without any cost to owner) as and when the source of supply is changed

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without extra charge notwithstanding the mandatory test required to be carried out as per CPWD specification.

4.4.5 All tests in support of mix design shall be maintained as a part of records of the contract. Test cubes for mix design shall be prepared by the CONTRACTOR under his own arrangements and at his costs, but under the supervision of the **Engineer-in-Charge**.

4.5 **Design Mix Concrete**



4.5.1 Design mix shall be allowed for major works where it is contemplated to be used by installing weigh batch mixing plant as per IS 4925. At the time of tendering, the CONTRACTOR, after taking into account the type of aggregates, plant and method of laying he intends to use, shall allow in his tender for the design mix i.e., aggregate/cement and water/cement ratios which he considers will achieve the strength requirements specified, and workability for concrete to be properly finished.

4.5.2 Before commencement of concreting, **CONTRACTOR** shall carry out preliminary tests (at outside NABL accredited laboratory without any cost to owner) for design mix on trial mixes proposed by him in design of mix to satisfy the **Engineer-in-Charge** that the characteristic strength is obtained. In this regard, CONTRACTOR may consult govt. approved/reputed institute to get design mix done as per IS 10262 at his own cost. The concrete mix to be actually used shall be approved by the **Engineer-in-Charge**.

4.5.3 Notwithstanding the above, the following shall be the maximum combined weight of coarse and fine aggregate per 50 kg of cement.

Grade of Concrete	Maximum weight of fine & coarse aggregates together per 50 kg of cement (for nominal mix only)
1. M - 10	480 kg
2. M - 15	350 kg
3. M - 20	250 kg

4.5.4 The workability of concrete produced shall be adequate, so that the concrete can be properly placed and compacted. The slump shall be as per IS 456.

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4.6 **Testing of Concrete**

4.6.1 Testing of concrete, sampling and acceptance criteria shall be in accordance with IS 456.

4.7 **Proportioning**

Mixes of cement concrete shall be as ordered. Where the concrete is specified by grade, it shall be prepared by mixing cement, sand and coarse aggregate by weight as per mix design. In case the concrete is specified as volumetric mix, then dry volume batching shall be done, making proper allowances for dampness in aggregates and bulking in sand. Equivalent volume batching for concrete specified by grade may however be allowed by the **Engineer-in-Charge** at his discretion.



4.8 **Pre Cast Concrete**

The specifications for pre cast concrete will be similar as for the cast in situ concrete. All pre cast work shall be carried out in a yard made for the purpose. This yard shall be dry, properly levelled and having a hard and even surface. If the ground is to be used as a soft former of the units, shall be paved with concrete or masonry and provided with a layer of plaster (1:2 proportion) with smooth neat cement finish or a layer of MS sheeting. The casting shall be over suitable vibrating tables or by using form vibrators as per directions of **Engineer-in-Charge**.

The yard, lifting equipment, curing tank, finished material storage space etc. shall be designed such that the units are not lifted from the mould before 7 (seven) days of curing and can be removed for erection after 28 (Twenty Eight) days of curing. The moulds shall preferably be of steel or of timber lined with G.I .sheet metal. The yard shall preferably be fenced.

Lifting hooks, wherever necessary or as directed by **Engineer-in-Charge** shall be embedded in correct position of the units to facilitate erection, even though they may not be shown on the drgs. and shall be burnt off and finished after erection.

Pre cast concrete units, when ready shall be transported to site by suitable means approved by **Engineer-in-Charge**. Care shall be taken to ensure that no damage occurs during transportation. All adjustments, levelling and plumbing shall be done as per the instructions of the **Engineer-in-Charge**. The CONTRACTOR shall render all help with

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instruments, materials and staff to the **Engineer-in-Charge** for checking the proper erection of the pre cast units.

After erection and alignment the joints shall be filled with grout or concrete as directed by **Engineer-in-Charge**. If shuttering has to be used for supporting the pre cast unit they shall not be removed until the joints has attained sufficient strength and in no case before 14 (fourteen) days. The joint between pre cast roof planks shall be pointed with 1:2 (1 cement : 2 sand) mortar.

5.0 STEEL REINFORCEMENT

5.1 Steel reinforcement shall comprise:

Cold twisted bars conforming to IS: 1786

CRS bars

TMT bars



Hard drawn steel wire fabric conforming to IS: 1566

5.2 All joints in reinforcement shall be lapped adequately to develop the full strength of the reinforcement as per provision of IS: 456 or as per instruction of **Engineer-in-Charge**.

6.0 FORM WORK

6.1 The shuttering or form work shall conform to the shape, lines and dimensions as shown on the drawings and be so constructed as to remain sufficiently rigid during placing and compacting of the concrete and shall be sufficiently tight to prevent loss of liquid from the concrete. The surface that becomes exposed on the removal of forms shall be examined by **Engineer-in-Charge** or his authorized representative before any defects are made good. Work that has sagged or bulged out, or contains honey combing, shall be rejected. All shuttering shall be steel shuttering.

6.2 The **CONTRACTOR** shall be responsible for sufficiency and adequacy of all form work. Centering and form work shall be designed & detailed in accordance with IS 14687 and approved by the **Engineer-in-Charge**, before placing of reinforcement and concreting.

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6.3 Stripping Time

Forms shall not be struck until the concrete has reached strength at least twice the stress to which the concrete may be subjected at the time of removal of form work. The strength referred to shall be that of concrete using the same cement and aggregates, with the same proportions and cured under conditions of temperature and moisture similar to those existing on the work. Where possible, the form work shall be left longer as it would assist the curing.

Note 1: In normal circumstances and where ordinary Portland Cement is used, forms may generally be removed after the expiry of the following periods:


1.	Walls, columns and vertical faces of all structural members	24 to 48 hours as may be decided by the Engineer-in-Charge
2.	Slabs (props left under)	3 days
3.	Beam soffits (Props left under)	7 days
4.	Removal of props under slabs 1. Spanning up to 4.5 m 2. Spanning over 4.5 m	7 days 14 days
5.	Removal of props under beams & arches: 1. Spanning up to 6 m 2. Spanning over 6m	14 days 21 days

For other types of cements, the stripping time recommended for ordinary Portland Cement may be suitably modified.

Note 2: The number of props left under, their sizes 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.

7.0 CEMENT CONCRETE BLOCK

Cement concrete block shall be machined made in the proportion of such that mix shall not be leaner than one cement to twelve combined aggregates (by volume) but having

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minimum strength of 7.5 MPa. Combined aggregate shall be graded as near as possible to IS: 383. The fineness modules of combined aggregate shall be between 3.6 and 4. The concrete block shall be properly cured as per IS-456. The surface of conc. block shall have even face without any honeycomb and free from cracks.

7.1 **Mortar**

Cement and water shall confirm to the requirements laid down for cement concrete work.

7.1.1 Sand for concrete block masonry mortars shall be coarse sand generally conforming to IS: 2116. Maximum quantities of clay, fine dust, shall not be more than 5% by weight. Organic impurities shall not exceed the limits laid down in IS: 2116.

7.1.2 Mix of mortar for building concrete block shall be as specified in the item of work.

7.1.3 Mixing of the mortar shall be done in a mechanical mixer. When quantity involved is small hand mixing may be permitted by **Engineer-in-Charge**. Any mortar remaining unused for more than 30 minutes after mixing shall be rejected.

7.2 **Concrete Block Masonry**


The thickness of joints shall be 10 mm +/- 3mm. Thickness of joints shall be kept uniform. In case of foundation and manholes etc. joints up to 15 mm may be accepted.

7.3 **Half Concrete Block**

All courses shall be laid with stretchers. Reinforcement comprising 2 nos. 6 mm dia MS bars shall be provided over the top of the first course and thereafter at every fourth course.

7.4 **Fixtures**

All iron fixtures, pipes spouts, hold fasts of doors and windows which are required to be built into the wall shall be embedded in cement concrete blocks 1:2:4 mix (1 cement :2 coarse sand :4 graded stone aggregate. 20 mm nominal size) of size indicated in the item.

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7.5 Curing

Concrete block masonry shall be protected from rain by suitable covering when mortar is green. Masonry work shall be kept constantly moist on all faces for a minimum period of seven days.

8.0 STRUCTURAL STEEL WORK

This specification covers the technical requirements for the preparation of shop drawings, supply, fabrication, protective coating, painting and erection of all structural steel rolled sections, built up sections, plates and miscellaneous steel required for the completion of the work.

Steel

All structural steel used in construction within the purview of this contract shall, comply with one of the following Bureau of Indian Standard Specifications, whichever, is appropriate or as specified.

IS – 2062 Hot rolled sections and plates


IS – 1079 Cold formed light gauge sections

IS – 1161 Tubular sections

IS – 4923 Hollow sections (rectangular or square)

Fabrication

Fabrication of steel structure shall be carried out in conformity with the best modern practices and with due regard to speed with economy in fabrication and erection and shall conform to IS-800. All members shall be so fabricated as to assemble the members accurately on site and erect them in correct positions. Before dispatch to site the components shall be assembled at shop and any defect found rectified. All members shall be free from kink, twist, buckle, bend, open joints etc. and shall be rectified before erecting in position. Failure in this respect will subject the defective members to rejection.

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Fabrication Drawings:

Development of Fabrication drawings shall be in contractor's scope. Connections, splices and other details shall be suitably designed based on good Engineering practice.

Electrodes:

Electrodes used for welding shall comply with IS-814 or IS - 815.

8.1 MS Black/High Strength Bolts and Nuts



M.S.Black or high strength bolts, nuts and washers etc. shall be as per IS-800, IS-1363 and IS-1367. Manufacturer's test certificate shall be made available to the **Engineer-in-Charge**. For bolted joints, shanks and threaded bolts are to be used to ensure that threaded length do not encroach within the thickness of connected members of dimension beyond the following limit:-

1. 1.5 mm for connected members of thickness below 12 mm and
2. 2.5 mm for connected member of thickness 12 mm and above and that adequate shearing and bearing values required as per design are achieved.

Every portion work shall have its erection mark or numbers stencilled on the member for guidance in erection and bear all necessary marks of erections as directed by the Owner / Consultant.

8.2 No part of the work is to be oiled, painted (except contact surfaces) packed, bundled, crated or dispatched until it has been finally inspected and approved by the Owner / Consultant or his authorized representative. The whole steel work before being dispatched from the Contractor's shop shall be dry and after being thoroughly cleaned from dust, mills scale, rust etc., and shall be given two coats of primer and one coat of final paint as per painting specification attached in this enquiry. Unless otherwise specified, all surfaces inaccessible after welding shall be given two coats of primer and two coats of paints as per painting specification attached in this enquiry.

8.3 The Owner / Consultant or his authorized representative shall have free access at all reasonable time to all places where the work is being carried out, and shall be provided by

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the Contractor at his own expenses all necessary facilities for inspection during fabrication and erection. The Owner / Consultant or his authorized representative shall be at liberty to reject the work in whole or in part if the workmanship or materials do not conform to the terms of the specifications mentioned herein. The Contractor shall remove, replace or alter any part of the work as ordered by the Owner / Consultant or his authorized representative.

9.0 PAINTING ON STRUCTURAL STEEL

The following specification shall be used for painting of structural steel work.

9.1 Scope

This specification covers the technical requirements for shop and site application of paint and protective coatings and includes; the surface preparation, priming, application, testing and quality assurance for protective coatings of structural steelwork, plate work, handrails and associated metal surfaces, which will be exposed to atmospheric for industrial plants.

9.2 Definitions

C.S	-	Carbon steel and low chrome (1-1/4 Cr through 9 Cr) alloys
S.S	-	Stainless steel, such as 304,316, 321, 347,
Non-ferrous	-	copper, aluminium and their alloys.
High Alloy	-	Monel, Inconel, Incoloy, Alloy 20, Hastelloy, etc.
DF	-	Dry Film thickness, the thickness of the dried or cured paint or coating film.

9.3 Safety Regulations

Protective coatings and their application shall comply with all national, state, and local codes and regulations on surface preparation, coating application, storage, handling, safety, and environmental recommendations.

Sand or other materials producing silica dust shall NOT be used for any open-air blasting operations.

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9.4 Material Safety Data Sheets

The latest issue of the coating manufacturer's product datasheet, application instructions, and material safety data Sheets shall be available prior to starting the work and shall be complied with during all preparation and painting / coating operations.

9.5 Materials

All paints and paint materials shall be obtained from the company's approved manufacturer's list. All materials shall be supplied in the manufacturer's containers, durably and legibly marked as follows.

Specification number

Colour reference number

Method of application

Batch number

Date of Manufacture

Shelf life expiry date

Manufacturer's name or recognised trade mark.

9.6 CODE AND STANDARDS:

Without prejudice to the provision of Clause 1.1 above and the detailed specifications of the contract, the following codes & standards shall be followed. Wherever reference to any code is made, it shall correspond to the latest edition of the code.

9.7 Indian Standards:

IS-5: 1994 Colors for ready mixed paints and enamels.

IS-2379: 1990 Color codes for identification of pipe lines.

IS-2629: 1985 Recommended practice for hot-dip galvanizing on iron and steel.

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IS-2633: 1986 Methods for testing uniformity of coating of zinc-coated articles.

IS-8629: 1977 Code of practice for protection of iron and steel structures from atmospheric corrosion.

IS: 110 Specification for Ready Mixed Paint, Brushing, Grey Filler, for Enamels, for Over Primers

IS: 101 Methods of test for ready mixed paints & enamels.

9.8 Other Standards:

9.8.1 Swedish Standard: SIS-05 5900-1967 / ISO-8501-1-1988

(Surface preparations standards for Painting Steel Surface).

This standard contains photographs of the various standards on four different degrees of rusted steel and as such is preferable for inspection purpose by the Engineer-in-charge.

9.8.2 DIN: 53151 Standards for Adhesion test.

9.9 The paint manufacturer's, instructions shall be followed as far as practicable at all times. Particular attention shall be paid to the following:

- a. Instructions for storage to avoid exposure as well as extremes of temperature.
- b. Surface preparation prior to painting.
- c. Mixing and thinning.
- d. Application of paints and the recommended limit on time intervals between coats.

9.10 Surface Preparation

9.10.1 Safety

All work in adjacent areas, which may negatively affect the quality of blast cleaning, and/or impose safety hazards, must be completed or stopped before the blasting operation starts.

9.10.2 Pre-Cleaning

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Prior to surface preparation all weld spatter shall be removed from the surface, all sharp edges ground down and all surfaces cleaned free of contaminants including chalked paint, dust, grease, oil, chemicals and salt. All shop primed surfaces shall be water washed by means of suitable solvent, by steam cleaning, with an alkaline cleaning agent if necessary or by high-pressure water, to remove contaminants prior to top-coating.

9.10.3 Surface decontamination

Surface decontamination shall be performed prior to paint application when uncoated surface is exposed to a corrosive environment or existing paint work is to be repaired. Existing coatings shall be removed by abrasive blast cleaning, and then high pressure potable water shall be used to clean steel surfaces. Prior to application of coatings, the surface shall be chemically checked for the presence of contaminants. A surface contamination analysis test kit shall be used to measure the levels of chlorides, iron salts and pH in accordance with the kit manufacturer's recommendations.

Swabs taken from the steel surface, using cotton wool test swabs soaked in distilled water shall not be less than one swab for every 25m² of surface area to be painted.

Maximum allowable contaminant levels and pH range is as follows:

Sodium chloride, less than 50 microgram / cm²;



Soluble iron salts, less than 7 microgram / cm²; and

pH between 6 – 8

If the results of the contamination test fall outside the acceptable limits, then the wash water process shall be repeated over the entire surface to be painted, until the contaminant test is within the specified levels.

9.10.4 Abrasive blasting

All C.S materials shall be abrasive blast cleaned in accordance with relevant IS Codes. To reduce the possibility of contaminating S.S., blasting is not usually specified. However, for coatings which require a blast-cleaned surface for proper adhesion, S.S. may be blast cleaned using clean aluminium oxide or garnet abrasives (Free from any

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chloride or Iron / Steel contamination).When hand or power tool cleaning is required on S.S., only S.S. wire-brushes (including 410 S.S.) which have not been previously used on C.S. surfaces may be used.

The surface profile of steel surfaces after blasting shall be of preparation grade Sa 2-1/2 of Swedish Standards SIS-05-5900 (Latest Revision) or better according to ISO 8501-1 and shall be measured using the replica tape method or the comparator method.

The roughness (profile) of blast-cleaned surfaces shall be Medium (G) according to ISO 8503-2: 1988 (appendix 1) unless otherwise specified. Medium defines a surface profile with a maximum peak-to-valley height of 60-100 microns, and G indicates that the surface profile is obtained by grit blasting. For the evaluation of surface roughness Comparator G shall be used.

Abrasive blast cleaning shall NOT be performed when the ambient or the substrate temperatures are less than 3 Degree Celsius above the dew point temperature. The relative humidity should preferably be below 50% during cold weather and shall never be higher than 60% in any case.



Abrasive blast cleaning shall be performed with a clean, sharp grade of abrasive. Grain size shall be suitable for producing the specified roughness. Abrasives shall be free from oil, grease, moisture and salts, and shall contain no more than 50ppm chloride. The use of silica sand, copper slag and other potentially silica containing materials shall not be allowed.

The blasting compressor shall be capable of maintaining a minimum air pressure of 7 kPa at the nozzle to obtain the acceptable surface cleanliness and profile.

The blast cleaning air compressor shall be equipped with adequately sized and properly maintained oil and water separators. The air supply shall be checked to ensure no oil and water contamination at the beginning of each work shift.

Blast cleaning abrasive shall be stored in a clean, dry environment at all times. Recycling of used abrasive is prohibited.

After blast cleaning, the surfaces shall be cleaned by washing with clean water (Pressure 7kg/cm² using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matter.

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Assessment of the blast cleaned surfaces shall be carried out in accordance with reference code.

Blast cleaned surfaces which show evidence of rust bloom or that have been left uncoated overnight shall be re-cleaned to the specified degree of cleanliness prior to coating.

All grit and dust shall be removed after blasting and before coating application. Removal shall be by a combination of blowing clean with compressed air, followed by a thorough vacuum cleaning with an industrial grade, heavy duty vacuum cleaner.

All cleaned surfaces shall have protection from atmospheric corrosion as per IS8629:1977

9.11 Painting system to be used is indicated below:

Epoxy Painting:

- 9.11.1 All the surfaces must be abrasive blasted and 1 coat of primer, 2 coats of intermediate and 1 coat of finish paint applied in the fabrication shop before the same are shifted to site for erection. All the members must be suitably match marked for facilitating proper assembly.

After erection is over all surfaces shall be washed up as follows:

Washing with clean water (pressure 7 kg/cm²) using suitable nozzles. During washing broom corn brushes shall be used to remove foreign matters.

Solvent washing if required to remove traces of oil grease etc.

After washing the surface as indicated above, the surfaces shall be suitably touched up to the extent required so that all the damages to the primed surfaces caused during erection are done up.



- a) The surfaces affected by welding and / or gas cutting during erection shall also be suitably touched up. Before touch up is taken up surfaces shall be prepared by mechanical means such as grinding, power brushing etc. to achieve surface finish to ST-3.

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- b) After touch up work is over as indicated above, all the surfaces shall be given one coat of finish paint to the required specification.

9.11.2 The following points must be observed for painting work:

1. Primer and paint shall be compatible to each other and should be from the same manufacturer.
 2. The recommendation of the paint manufacturer regarding mixing, matching and application must be followed meticulously.
 3. Technical representative of paint manufacturer should be available at site as and when required by **Engineer-in-Charge** for their expert advice as well as to ensure that the painting work is executed as per the instruction of paint manufactures.
- c) Paints and primers shall be supplied at site in original container with factory seal otherwise such paints and primers shall not be allowed to be used. Mode of application i.e. by spray, brush or roller shall be strictly as per recommendation of paint manufacturer.
- d) Painting materials must be used before the expiry date indicated on the containers.
- e) Number of coats and DFT per coat must be strictly followed as indicated above. If the desired DFT is not achieved for primer, intermediate and finish paints in two coats (each), **CONTRACTOR** shall be required to apply extra coat (s) to achieve the desired DFT without any extra cost to **Engineer-in-Charge**.
- f) Color shade for each coat of primer and finish paint must be different to identify the coats without any ambiguity.
- g) Shade for the final finish coat shall be decided by **Engineer-in-Charge** at site.
- h) All painting materials must be accompanied by manufacturers test certificates. However, Engineer-in-Charge has any doubt regarding quality of materials, he shall have the right to direct **CONTRACTOR** to get the doubtful material tested or and provided (by **CONTRACTOR**) testing agencies for which no extra payment shall be made to the **CONTRACTOR** and the charges shall deemed to be covered in the unit rates quoted for fabrication and erection of structural work.



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- i) DFT for paint shall be measured at least 20 points and mean DFT shall not vary by more than 10% than specified in DFT.
- j) Reliable and calibrated Instrument for measurement of DFT shall be arranged and provided by **CONTRACTOR** at his cost.
- k) Thickness of each coat shall also be checked regularly to ensure uniformity in DFT.

9.11.3 Abrasive blasting and painting works, being a specialized job must be carried out through the approved agencies only.

9.11.4 PAINTING ON STEEL STRUCTURES

SL.NO	DESCRIPTION	GENERIC COATING SYSTEM
1.	SURFACE PREPARATION	Blast clean to SA 2.5
2.	PRIMER	One coat of ethyl silicate zinc rich with solvent. Thickness 75 micron per coat
3.	INTERMEDIATE	Two coat of two pack high build aliphatic amine cured epoxy coating Thickness 100 micron per coat.
4.	FINISH COAT	One coat of two pack amine cured epoxy / Acrylic aliphatic polyurethane. Thickness 50 micron per coat
5.	Total DFT	325 Micron

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On Minor Structural Steel Sections/Structures such as fencing, concertina coil etc.

Painting on Structural Steel on minor structures shall be with synthetic enamel paint of approved brand and manufacture to give an even shade: Two or more coats on new work after necessary primer coat.

10.0 STEEL / ALUMINIUM DOORS, WINDOWS AND VENTILATORS

10.1 The Steel doors, windows and ventilators shall be of the size and type as per IS-1361 and IS-1038. Fixing and glazing shall be done as per IS-1081 and as per manufacturer's instructions. The putty of approved make such as special gold size or equivalent conforming to IS-419 shall be used.

10.2 Aluminium doors, windows and ventilators shall be manufactured from wrought aluminium and aluminium alloy extruded round tube and / or hollow rectangular / square sections conforming to IS: 1285 & IS : 6477 or equivalent as approved by **Engineer-in-Charge**.

11.0 ROOFING & CLADDING

For roofing & cladding Non-asbestos high impact Polypropylene reinforced cement 6mm thick corrugated sheets (as per IS:14871) roofing up to any pitch and fixing with polymer coated J or L hooks, bolts and nuts 8mm dia. G.I. plain and bitumen washers or with self drilling fastener and EPDM washer.

12.0 FLOORING AND PAVING

12.1 Sub Base of floor

12.1.1 The area to be paved shall be divided into suitable panels. Form work shall be provided. The boarding / battens shall be fixed in position with their toe at proper level, giving slope where required. Alternatively base concrete may be deposited in the whole area at a stretch.

12.1.2 Before placing the base concrete the sub-base shall be properly wetted and rammed. The concrete of the specified mix shall then be deposited between the forms where provided, thoroughly tamped and the surface finished level with the top edge of the forms. The surface of base concrete shall be spreader uniformly. The surface shall be

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finished rough to provide adequate bond for the topping. Two or three hours after concrete has been laid the surface shall be brushed with wire brush to remove any scum or Lattice and swept clean so that coarse aggregate is exposed.

12.2 Cement Concrete Floor Finishes

12.2.1 The surface of base concrete shall be thoroughly cleaned by scrubbing with coir or steel wire brush. Before laying the topping, the surface shall be soaked with water at least for 12 hours and surplus water mopped up immediately before the topping is laid.

12.2.2 The forms shall be fixed over the base concrete dividing into suitable panels. Where glass dividing strips are provided, thickness of glass dividing strips shall be 4 or as indicated. Before placing the concrete topping, neat cement slurry at the rate of 2 kg/sq.m shall be then thoroughly brushed into the base concrete just ahead of the finish. The topping shall then be laid, thoroughly compacted by using screed board/plate vibrator. The surface floated with a wooden float to a fair and even surface shall be left for some time till moisture disappears from it. Junctions with skirting / dado or wall surfaces shall be rounded off using cement mortar 1:2 curing shall be carried out for a minimum of 7 days.

13.0 PLASTERING

13.1 Sand for plastering shall be 50% fine sand and 50% coarse sand from approved sources.


13.2 Preparation of surface shall be done as per CPWD specifications.

13.3 Cement mortar shall be of the mix as indicated in the items and shall be mixed as specified in the CPWD specifications.

13.4 Joints in walls etc. shall be raked to a depth of 12 mm, brushed clean with wire brushes dusted and thoroughly washed before starting the plaster work.

13.5 The surface shall be thoroughly washed with water cleaned and kept wet to saturation point before plastering is commenced.

13.6 Cement mortar as indicated, shall be firmly applied to the masonry walls in a uniform layer to the thickness specified and will be pressed into the joints. On concrete surfaces


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rendering shall be dashed to the roughened surface to ensure adequate bond. The surface shall be finished even and smooth. Hectoring wherever required shall be done as per directions of **Engineer-in-Charge**. Nothing extra shall be paid on this account.

- 13.7 All plaster work shall be cured for at least 7 days.
- 13.8 Integral water proofing compound shall be mixed with cement in the proportion recommended by the manufacturer. Care shall be taken to ensure that the water proofing material gets well and integrally mixed with cement. All other operations are the same as for general plaster work.
- 13.9 For sand face plaster undercoat of cement plaster 1:4 (1 cement : 4 sand) of thickness not less than 12 mm shall be applied similar to one coat plaster work. Before the under coat hardens the surface shall be scared to provide for the top coat. The top coat also of cement mortar 1:4 shall be applied to a thickness not less than 8 mm and brought to an even surface with a wooden float. The surface shall then be tapped gently with a wooden float lined with cork to retain a coarse surface texture, care being taken that the tapping is even and uniform.

14.0 EXTERIOR PAINTING

- 14.1 Exterior painting shall be Acrylic smooth exterior.
- 14.2 Where shown on drawings for external surfaces of sand faced plaster, or any other surface, two coats of cement paint shall be applied of tint and shade as approved by the **Engineer-in-Charge**.
- 14.3 The surfaces shall be prepared as specified for white washing. Before applying cement paint the surface shall be thoroughly wetted to control surface suction. The surface shall be moist but not dripping wet, when the paint is applied. Not less than 24 hours shall be allowed between the two coats. In hot weather the first coat shall be slightly moistened before applying the second coat.
- 14.4 On external plastered surfaces (one coat primer + minimum 3 coat of paints), sand faced or plain plastered and concrete surfaces, apex weather proof paint shall be vigorously scrubbed on to work the paint into the voids and provide a continuous paint film free from pin holes and other openings

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15.0 GLAZING

15.1 Sheet glass glazing of doors, windows etc. shall be of selected quality glass conforming to IS: 2835. Toughened splinter proof industrial safety glass shall confirm to IS: 2553. No cracked chipped or disfigured glass shall be accepted Glass shall be in one piece for each pan.

15.2 Glazing shall be fixed with timber or steel / aluminium beading as called for. Glass shall be back puttied and fixed with beading for a water tight and rattle free installation. Sizes of timber/ steel / aluminium beading shall be as directed.

16. PROTECTIVE COATING AND LINING SYSTEM

16.1 EPOXY COATING

Characteristics of coated surfaces (after application)



- Compressive strength : min. 90 N/mm²
- Tensile strength : min. 10 N/mm²
- Abrasion resistance : as per Amsler 1.5 mm after 3000 revol.
- Bonding (joining) factor : 1
- Adhesion with concrete : min. 2.5 N/mm²
- Elongation : 15%

APPLICATION:

A) ON FLOOR

1. For Chemical resistant flooring

SL. NO	DESCRIPTION
1.	Surface preparation- in this case concrete columns, beams, soffitt slabs, floors & plastered brick masonry walls (for receiving IMPREGNATION, BOND COATS, COATINGS etc) with hand wire brushes or rotary wire brushes etc and removing all the dust , dirt etc complete.
2.	Impregnation with monomer (5 cps viscosity) to be applied by brush with a consumption of



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SL. NO	DESCRIPTION
	minimum 0.25 kg/m ²
3.	Providing and applying structural grade Epoxy Bonding agent, (with bond strength of 3 N/mm ²) over concrete prior to screed concrete. Bonding agent to be used as per application procedure of manufacturer.
4.	Self levelling cementitious screed avg. 25mm thick, using proportion 1:1:0.5 cement: sand : 8 mm down aggregates (by weight) with addition of suitable free flow and performance improving additives namely micro silica, shrinkage compensating admixtures, polymers, high range super plasticizers. W/C ratio not to exceed 0.4. Compressive strength of the screed to be 37.5 N/mm ² after 28 days over bonding agent.
5.	Providing and applying structural grade Epoxy Bonding agent, (with bond strength of 3 N/mm ²) over screed concrete. Bonding agent to be used as per application procedure of manufacturer.
6.	Self levelling epoxy phenolic IPN (inter penetrating polymer network) screed (min 3mm thick, solvent free resin in proportion of 1 resin hardener mix : 2 sharp silica sand 600 micron down) on dry and clean surface of the self levelling cementitious screed done earlier, using special fork type leveller tool and allowing the screed to cure for 48 hours.

2. For Anti-static epoxy flooring system in Substation –

The switch gear room in the substation shall be provided with electrostatic discharge flooring (ESD flooring- 2MM thick Anti-static epoxy flooring system)

Sr. No.	Specification
	Base Surface Requirement: Base floor substrate should be minimum M20 grade reinforced concrete surface, clean dry (moisture below 5%), sound and finished smooth and levelled.
1	Surface Preparation: Clean the surface thoroughly by mechanical means preferably using vacuum assisted mechanical grinders to remove loose particles, dust, dirt, laitance, etc. All the stickers on the floor shall be removed and the area cleaned thoroughly. Any cracks above 1mm should be groove cut, cold/construction joints to be given suitable treatment. (Expansion /Isolation

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	<p>joints to be provided with flexible PU sealant and will be in the scope of contractor)</p>
2	<p>Primer Application : Providing & Applying two component epoxy based penetrating primer, having a volumetric mixing ratio of resin and hardener as per manufacturer guidelines, to a thickness of 100 microns which has excellent bond with concrete substrate by Brush / Roller and broadcasting of chemically treated silica and allow for 5-6 hours curing.</p>
3	<p>Sealer Application Providing & applying two components epoxy mortar of homogeneous mix and levelled by trowel to form a monolithic layer to a thickness of 800 microns and allow curing for 4-5 hours.</p>
4	<p>Conductive Coat: The self adhesive copper grid shall be provided across the area with 10 mtr spacing. The copper stripe shall be taken out at few points to connect the same to earth pit. (Connecting to earthing strip and making earthing pit will be in the scope of contractor)</p>
5	<p>Conductive Base Coat: Providing & applying of epoxy ESD, at a specified ratio as per manufacturer guidelines to a thickness of 100 microns by Brush / Roller and broadcasting of chemically treated silica and allow for 12 hours curing. This layer forms the electrical plane through which static charges are dissipated.</p>
6	<p>Topcoat Application: Providing & applying of STAT GUARD ESD at a specified ratio and levelled by trowel to a thickness of 1000 microns and spike roller is applied for de-aeration. This can be given in any colour. The entire top coat has to be dried for 24 hours before loading. Final finished floor shall be levelled smooth surface, clean and dust free. The surface resistivity of the total system shall be in the range of 1×10^6 Ohms to 1×10^9 Ohms as per the ASTM F 150, EOS/ESD Standard 7.1 or NFPA 99 A guidelines.</p>

B) ON WALLS, SLAB, SOFFITS, BEAMS, COLUMN

SL. NO	DESCRIPTION
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SL. NO	DESCRIPTION
1.	Surface preparation- in this case concrete columns, beams, soffitt slabs, floors & plastered brick masonry walls (for receiving IMPREGNATION, BOND COATS, COATINGS etc) with hand wire brushes or rotary wire brushes etc and removing all the dust , dirt etc complete.
2.	Impregnation with monomer (5 cps viscosity) to be applied by brush with a consumption of minimum 0.25 kg/m ²
3.	Impregnation of prepared concrete surface (internal walls, slab, soffits, beams, column and cut outs) with polymethyl methacrylate monomer (viscosity 5cps), brush applied @ 0.25kg/m ² . Three coat epoxy phenolic IPN solvent containing protective coating with one non pigmented primer coat and two subsequent colour coats with approved shades giving total dry film thickness of 225 +/- 10 microns over impregnated and cleaned surface.

16.2 ACID PROOF TILES:

MATERIAL

1) TILES


These tiles shall be made of clays, feldspar, quartz, talc and vitrified at high temperature in ceramic kilns and kept unglazed so as to prevent from slipperiness. Tiles shall not absorb more than 2% of their own dry weight when soaked in water. Compression strength: 700 Kg/cm² Min. & Flexural strength: 200 Kg/cm² Min. It shall not lose more than 1.5% of it weight when soaked in acid.

Chemical compositions of tiles:

- Al₂O₃ : 22-24%
- SiO₂ : 60-65%
- Fe₂ O₃ : 1.0-2.0%
- Alkalise : 10-12%

2) K-BASED SILICATE MORTAR

Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid tile linings carried out with KSC cement are not subject to crystal formation in the pores of

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cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

- Colour : White
- Density (lbs/Cub. ft.) : 130
- Water Absorption : 2-5 %
- Tensile Strength (Psi) : 400
- Compressive strength (Psi) : 2800
- Bond Strength (Psi) : 180
- Coefficient of thermal expansion : 6.0×10^{-6}

3) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.

Characteristics of Bituminous compounds:

- Density (Kg/m^3) : 2200
- Water content by mass percent (max) : 0.5
- Flash point $^{\circ}\text{C}$, min. : 35

Consistency


- a) Before setting (test after 1 hr) min. : 100
- b) After setting (test after 24 hr) min. : 80

Mastic shall be heated to $150-300^{\circ}\text{C}$ and shall be applied in 5 mm layers after surface is cleaned and dried.

4) BITUMINOUS PAINT

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

The primer shall conform to the following requirements:

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- Viscosity by standard tar viscometer, 4mm orifice at 25°C: 4 to 24
- Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50
- Water content percent (max) : 0.2

APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
1.	Bituminous Paint (Primer)	Concrete surface
2.	10mm Bitumastic Laying in two layers each shall not be more than 5mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	10 mm thick Acid proof tiling	Over K-based Silicate

- Tiles should be fixed on bitumastic surface with the help of 5mm K-based silicate mortar.

16.3 ACID RESISTANT BRICK LINING

A. MATERIAL



These bricks are made of raw materials such as clay or shale of suitable composition with low lime and iron content, feldspar, flint or sand and vitrified at high temperature in ceramic kilns. Bricks shall not absorb more than 2% of their own wt. when soaked in water.

Compression strength: > 700 Kg/cm². Bricks shall not lose more than 1.5% at their own weight when tested for acid resistance.

Chemical compositions of bricks are

- a) Al₂O₃ 22-24%
- b) SiO₂ 60-65%
- c) Fe₂ O₃ 1.0-2.0%
- d) Alkalies 10-12%

1) K-BASED SILICATE MORTAR

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Acid Proof cement KSC is a potassium silicate based corrosion cement. Acid brick linings carried out with KSC cement are not subject to crystal formation in the pores of cement. Besides Bitumastic surface is joint-less, hence there is no danger of Acids percolating through the surface.

Characteristics of K-based Silicate mortar:

Colour	: White
Density (lbs/Cub. ft.)	: 130
Water Absorption	: 2-5 %
Tensile Strength (Psi)	: 400
Compressive strength (Psi)	: 2800
Bond Strength (Psi)	: 180
Coefficient of thermal expansion	: 6.0×10^{-6}

2) BITUMASTIC MORTAR

It shall consist of an acid proof inorganic filler and blended bitumen. It shall be trowelled to concrete having total thickness of 10 mm.


Characteristics of Bituminous compounds:

Density (Kg/m ³)	: 2200
Water content by mass percent (max)	: 0.5
Flash point °C ,min.	: 35
Consistency	
c) Before setting (test after 1 hr) min.	: 100
d) After setting (test after 24 hr) min.	: 80

Mastic shall be heated to 150-300°C and shall be applied in 5 mm layers after surface is cleaned & dried.

3) BITUMINOUS PAINT(PRIMER)

This is generally of heavy grade bituminous corrosion resisting paint. 2 coats of the paint shall be given, and drying time between the 2 coats shall not be less than 5 hours. Also, its drying time after second coat shall not be more than 8 hours. Its finish shall be smooth, glossy and elastic.

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The primer shall conform to the following requirements:

Viscosity by standard tar viscometer, 4mm orifice at 25°C : 4 to 24

Penetration at 25°C, 100g, 5sec in 1/100 cm : 20 to 50

Water content percent (max) : 0.2

APPLICATION

SL. NO.	DESCRIPTION	ITEM OR AREA
.	Bituminous Paint (Primer)	Concrete surface
.	10mm Bitumastic Laying in two layers each shall not be more than 5 mm thick	Over Bituminous Paint
3.	One layer, 5mm Acid, K-based Silicate Type mortar	#
4.	One layer, 40mm Acid resistant Brick lining	Over K-based Silicate

#:- K-based Silicate mortar should be buttered on all sides of acid-resistant brick except the side facing the surface to be exposed to corrosives


17. POLYURETHANE WATERPROOFING

17.1 MATERIALS

The two component Solvent free Polyurethane coat shall have the following properties –

1. Solid content ASTM D 2369- $\geq 90\%$
2. Mixing ratio - 8:1
3. Elongation ASTM D 638 - 700-900%
4. Tensile strength ASTM D 638- 1-2 MPa

The coating shall be applied to a minimum thickness of 600 microns (300 μ X2) thickness with separate wearing course (as per ASTM C 898 & 836) over application of 2 component, solvent free Epoxy Primer of 200 microns with tensile of 20-30 MPa and

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elongation of 4-5% for smooth surface and act as primer coat at all elevations in vertical and horizontal surface

It shall be perfectly smooth, dust free and shall retain glossy finish at least up to 3 years It shall be resistant to acid, alkalis and have a very low water absorption rate of 0.5% maximum at ambient temperature after 7 days.

The packs shall not be older than 9 months after the date of manufacture and packing.

17.2 Workmanship

17.2.1 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.

17.2.2 Primer Coat

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 minimum of 8 hours before the successive finishing coats of Polyurethane are applied.

17.2.3 Finishing coats

The finishing coats shall consist of three successive pigmented seating coats each of 2 pack polyurethane, mixed in the ratio as per manufacturer's specifications. Application shall be with brush, to a smooth and even finish. The overall dry film thickness shall be Ambient temperature at the time of application shall not be less than 5°C and not more than 40°C.

Each coat shall be allowed to dry for minimum 8 hours or as per manufacturer's specification 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 specification. (Maximum 60 minutes at 30°C.

Polyurethane coating shall be continued up the parapets/ walls for a minimum of

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150 mm over the finished roof surface. It shall be continued into rain water pipes by at least 100mm.

Treated surface should be allowed to cure for minimum 72 hours.

17.2.4 Cement Screed

The final coat of polyurethane, when tacky shall be sprinkled with 300 micron layer of clean sand. Plain cement concrete (1:2:4) of 25mm minimum thickness with 24 SWG chicken wire mesh shall be then laid to slope in panels not exceeding 6 M² area per panel The joints between panels shall be raked out neatly to a minimum 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 skoping of PCC as per drawing. 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.

17.3 Guarantee

The agency for waterproofing shall furnish a guarantee, which shall be agreed upon in the Contract to ensure the successful performance of the Contract. The guarantee shall be for a period of 10 years. Any work required to be carried out as a result of any defects in workmanship during the period of the guarantee shall be carried out by CONTRACTOR at his cost.



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ASH POND**

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1.0.0 PREPARATION OF WORK AREAS / CLEARING SITE / JUNGLE CLEARANCE

1.1.0 Scope

This section covers site preparation of the area as indicated in the drawings and as directed by the Engineer.

1.2.0 General Requirements

The Contractor shall furnish all labour, equipment and materials required for the complete performance of the work in accordance with the drawings and specifications herein and as directed by the Engineer.

1.3.0 Clearing Site



Clearing and grubbing operations shall be performed in excavation areas, embankment areas; (including a strip measured beyond and contiguous to the limit line of the areas) and borrow areas. The sites should be cleared of all vegetation, trees less than girth diameter 30 cm, stumps, roots, bush, rubbish and all other objectionable or organic matter as directed by the Engineer. All materials to be burnt shall be piled neatly and when in suitable condition shall be burnt completely. The burning shall be so thorough that the materials are reduced to ashes. Special precautions shall be taken to prevent fire from spreading and there shall be available, at all times, suitable equipment for preventing and suppressing fires. Trees of specified girth and/or any other cleared materials shall be stock piled and handed over to the Engineer, without being burnt, if Engineer so directs.

2.0.0 EXCAVATION, FILLING & BACKFILLING WORK

2.1.0 Scope

2.1.1 This section of the specification covers the technical requirements for excavation of cut-off trench, trenches for embedding pipes, trench for replacing foundation soil of dyke embankment, foundation of water escape structures, brick masonry panel walls for slope protection, slope drains, toe drain, discharge channel, dowel bank/kerb wall on dyke top, steps on dyke slope etc. and filling/backfilling the gaps around masonry/ RCC structures (except impervious soil filling of cut-off trench, pipe trench, forming impervious core of dyke, etc) and conveyance and disposal of surplus spoils and/or stacking them properly as directed by the Engineer.

2.1.2 The Contractor shall be fully responsible for proper setting out of works, profiling in excavation, stacking, etc., taking adequate safety measures, etc. The Contractor shall carry out all works meant within the intent of this specification even if not explicitly mentioned herein. All works shall be executed to the satisfaction of the Engineer and as per the construction drawings.

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2.1.3 Existing trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, drains, sewers, or other surface or sub-surface systems/drains/facilities within or adjacent to the works being carried out which are not to be disturbed shall be protected from damage by the Contractor. The Contractor shall provide and install suitable safeguards approved by the Engineer for this purpose.

2.1.4 During excavation, the contractor shall take all necessary precautions against soil erosion, water and environmental pollution, and where required undertake, additional works to achieve this objective. Before start of operations, the Contractor shall submit to the Engineer for approval, his work plan and the procedure he intends to follow for disposal of waste materials etc., and the schedule for carrying out temporary and permanent control works. However, the approval of the Engineer to such plans and procedures shall not absolve the Contractor of his responsibility for safe and sound work.

2.2.0 General requirements



2.2.1 The Contractor shall furnish all skilled and unskilled labour, plant, tools, tackle, equipment, men, materials, required for complete execution of the work in accordance with the drawings and as described herein and/or as directed by the Engineer.

2.2.2 The Contractor shall control the grade in the vicinity of all excavations so that the surface of the ground will be properly sloped or dyked to prevent surface water from running into the excavated areas during construction.

2.2.3 All materials obtained from excavation shall remain owner's property. All salvaged materials of archaeological importance or of value (in the opinion of the Engineer) shall be segregated from the other materials and both stacked separately and in a regular manner at locations indicated by the Engineer.

2.2.4 Excavation shall include removal of trees including roots & organic remains, vegetation, grass, bushes, shrubs, plants, poles, fences, etc. that are in the area to be excavated as well as beyond the excavation line so as to ensure safety of the excavated side slopes, and of men and equipment operating in the area. Before start of excavation work, joint measurements of ground level shall be taken after cleaning all grass, vegetation, etc.

2.2.5 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance as decided by the Engineer or defined by payment line to permit the placing and setting of forms, inspection and completion of all works to the satisfaction of the Engineer for which the excavation was done.

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2.3.0 Classification of materials excavated / filled

For purposes of work to be executed in accordance with this specification, the following classification only shall apply. In case of any dispute regarding classification of materials excavated/filled, the decision of the Engineer shall be final and binding on the contractor.

Soil



- (a) This shall include all types of soils which can be excavated by pick axes or spades or earth moving equipment such as dozer, poclains, shovels, draglines, etc.
- (b) It shall include, but not be limited to, vegetative or organic soil, turf, sand, silt, mud, moorum, shingle, clay, gravel, cobbles, talus, loam, macadam, peat, ash, marsh, brick bats, tar / bitumen surfaces, etc.

Rock

- (a) Rock shall include materials, which are not classified under soil above.
- (b) Rock not requiring blasting – rock / boulder / PCC which can be excavated by earth moving equipment, (i.e. without blasting, wedging) such as poclain, shovels, draglines, grafting tools, etc. In case, contractor decides to use blasting for excavation of rock types considered by Owner as 'rock not requiring blasting', the payment for such works shall also be made under the item rock not requiring blasting and nothing extra shall be paid for the blasting.
- (c) Rock requiring blasting - any rock / boulder / RCC for the excavation of which blasting is required (i.e, without blasting excavation can not be carried out)

Rock level

After complete removal of soil overburden, the Contractor shall inform the Engineer about the rock level. The excavation in rock by mechanical means shall proceed only after establishing the rock level by Engineer and complete removal of soil over burden by Contractor. The blasting in rock (requiring blasting) shall proceed only after establishing the level of such rock by Engineer and complete removal of upper rock by mechanical means by Contractor.

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2.4.0 Excavation in soil

2.4.1 Sides and bottoms of excavation shall be cut sharp and true to line and level. Undercutting shall not be permitted. When machines are used for excavation, the last 300 mm before the required level shall be excavated such a manner that soil at the required final level will be left in its natural condition. Suitability of strata (at the bottom of excavations) for laying the foundation thereon shall be determined by the Engineer.

2.4.2 Excavation for foundations shall be to the bottom of lean concrete or as shown on drawings for the cut off trench and drains or as directed by the Engineer. The bottom of all excavations shall be trimmed to required levels and when excavation is carried below such levels, by error, it shall be brought back to specified level by filling with concrete of nominal mix 1:4:8 (cement : coarse sand : 20 mm down aggregates) as directed by the Engineer.

2.4.3 The Contractor shall ascertain for himself the nature of materials to be excavated and the difficulties, if any, likely to be encountered in executing this work. Cofferdams, sheeting, shoring, bracing, maintaining suitable slopes, draining, etc. shall be provided and installed by the contractor, to the satisfaction of the Engineer.



2.4.4 When excavation requires bracing, sheeting or shoring, etc. the Contractor shall submit drawings to the Engineer, showing arrangements and details of proposed installation. The Contractor shall also furnish all supporting calculations as called for and shall not proceed until he has received written approval from the Engineer. However, the responsibility for adequacy of such bracing, sheeting, shoring, etc. will rest with the Contractor, irrespective of any approval of the Engineer.

2.4.5 The Contractor shall have to constantly pump out any water collected in excavated pits and other areas due to rain water, springs, etc. to atleast 0.5 meter below bottom of the working level. The contractor shall remove all slush/muck from excavated areas. Sludge pumps, if required, shall be employed by the Contractor for this purpose.

2.4.6 The Contractor shall remove all materials arising from excavations from the vicinity to the work either for direct filling, stacking and subsequent filling or for ultimate disposal as directed by the Engineer. In no case shall the excavated soil be stacked within a distance of 1.5 m from the edge of excavation or one-third the depth the excavation whichever is more, Material to be used for filling shall be kept separately.

2.5.0 Filling

2.5.1 Excavated selected materials to be used for filling purposes shall have the prior written approval of the Engineer.



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2.5.2 Materials

- a) Materials to be used for filling purpose shall be stone, sand or other inorganic materials and they shall be clean and free from shingle, salts, organic, large roots and excessive amount of sod, lumps, concrete or any other foreign substances which could harm or impair the strength of the substructure in any manner. All clods shall be suitably broken to small pieces. When the material is mostly rock boulders, these shall be broken into pieces not larger than 150 mm size. Sand used for filling shall be clean, medium grained and free from impurities. Fines less than 75 microns shall not be more than 20%. In any case, the materials to be used for filling purpose shall have the prior written approval of the Engineer.
- b) If excavated materials are to be used for filling, then the contractor shall select the materials from the stockpile, load and transport this material and execute the filling. These shall include excavation of earth which may become hard due to lying in stock yard for a long period of time.

2.5.3 Filling (/backfilling) Procedure



- a) After completion of foundation, footings, walls and other construction below the elevation of the final grades, and prior to filling, all temporary shoring, timber etc. shall be sequentially removed and excavation cleaned of all trash, debris, and perishable materials. Filling shall begin only with the written approval of the Engineer. Also, areas identified for filling shall be cleared of all soft pockets, vegetation, bushes, slush, etc. In case of plinth and similar filling, the ground shall be dressed and consolidated by ramming and light rolling.
- b) Filling materials shall not be dropped directly upon or against any structure or facility where there is danger of displacement or damage. Filling shall be started after the concrete/masonry has set and shall be carried out in such a manner so as not to cause any undue lateral thrust on any part of the structure.
- c) All space between foundation (concrete or masonry) and the sides of excavation shall be filled to the original surface after making allowance for settlement.
- d) Fill shall be placed in horizontal layers not exceeding 300 mm compacted thickness. Each layer shall be watered and compacted with proper moisture content and with such equipment as may be required to obtain a compaction/density as specified.

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- e) Trucks or heavy equipment for deposition or compacting fill shall not be used within 1.5 meters of building walls, piers, or other facilities which may be damaged by their weight or operation. The methods of compaction shall be with plate compactors subject to the approval of the Engineer.
- f) Fill adjacent to pipes shall be free of stones, concretes etc. and shall be hand placed and compacted uniformly on both sides of the pipe and where practicable up to a minimum depth of 300 mm over the top of pipes. While tamping around the pipes, care should be taken to avoid unequal pressure.
- g) Filling shall be accurately finished to line, slope, cross section and grade as shown on the drawings. Finished surfaced shall be free of irregularities and depressions and shall be within 20 mm of the specified level.
- h) Where filling with stone from excavated materials is specified, it shall be from broken pieces of boulders. At first a 75 mm thick cushion of selected earth shall be laid over which 200 mm thick graded stones shall be laid to loose layers of 200 mm and then the interstices filled with properly graded fine materials consisting of selected earth brought from within ash pond or from borrow areas. Each layer shall be watered and compacted to the specified density before the next layer is laid. However, no cushion shall be required where filling is over non-rocky surface.
- i) Where filling with 65 mm down graded stone obtained from excavated materials/ borrow areas/ quarries is specified, it shall be selected stone laid over an initial 50 mm thick cushion layer of selected earth and then stone laid in 200 mm loose thick layers, interstices filled with properly graded fine material consisting of selected earth brought from borrow areas. Each layer shall be watered and compacted to the specified density before the next layer is laid. However, no cushion shall be required where filling is over non-rocky surface.
- j) Where clean stone fill is specified, it shall consist of clean selected stone metal of 40 mm nominal size. It shall be laid in layers not exceeding 150 mm (loose) and lightly tamped before the next layer is laid. No compaction shall be required for this type of stone filling.

2.5.4 Compaction

- a) Where compaction to 85% of Standard Proctor Density is called for such compaction shall be by mechanical means but the Contractor may be permitted to adopt manual means only if the Engineer finds that the desired compaction is achievable in the field.

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- b) Where compaction to 95% of Standard Proctor Density is called for, it shall be by mechanical means only by with minimum 10 tonne vibratory rollers. Each layer shall be watered, rammed and compacted to the density as specified in the Schedule of Items.
- c) For compacting each sand layer, water shall be sprayed over it to flood it and it shall be kept flooded for 24 hours to ensure maximum compaction. Vibro-compactors shall also be used if necessary to obtain the required degree of compaction. Any temporary works required to contain sand under flooded condition shall also be undertaken. The surface of the consolidated sand shall be dressed to required levels or slope.
- d) After the compacted fill has reached the desired level, the surface shall be flooded with water for 24 hours, allowed to dry and then rammed and consolidated to avoid any settlement, at a later date. The compacted surface shall be properly shaped, trimmed and consolidated to an even gradient or level. All soft spots shall be excavated, filled and consolidated.
- e) The degree of compaction of compacted fill in place will be subjected to tests by the Engineer as the work progresses, and the contractor shall provide the necessary facilities to make such tests. If any test indicates that the compaction achieved is less than the specified degree of compaction, the engineer may require all fill placed subsequent to the last successful test to be removed and re-compacted by the contractor. Compaction procedure shall be amended as necessary to obtain satisfactory results.

3.0.0 STRIPPING

3.1.0 Scope

This section of the specification covers stripping of foundation for embankment as shown in the drawings and as described herein.

3.2.0 General Requirements

The Contractor shall furnish all labour , equipment and materials required for complete performance of the work in accordance with the drawings and as described herein.

3.3.0 Stripping of Foundations

The entire area of embankment including some area beyond and contiguous with the area of embankment proper shall be stripped to minimum 300-500 mm depth (or more as per design) on soil/ash respectively as directed by the Engineer, to remove all unsuitable materials and to provide for benching. In the portion of the dyke where

ground slope is steep, the stripping shall be done in a fashion as directed by the Engineer to provide for benching. The unsuitable material shall include all debris, vegetable matter including roots, weathered and disintegrated rocks, organic silts, swamps material, that are unsuitable for use in permanent construction or that might interfere with the proper binding of the embankment with the foundation, or the proper compaction of the materials in the embankment or that may be otherwise objectionable.

The stripping shall be kept far enough in advance of other items of works to ensure that no undesirable material will get mixed with approved embankment material and to allow for inspection and measurement.

Materials from stripping operations shall be deposited on either side of the embankment away from the heel and toe of the embankment and unsuitable material shall be disposed off upto a lead as per schedule of items or as directed by Engineer.

The stripping shall be carried to the required level and to provide benching wherever required as indicated in the drawing. Should the excavation be done deeper by error, the same shall be made good by filling the same with approved earth and properly compacted so that the required formation level is obtained at the Contractor's cost.

4.0.0 IMPERVIOUS LINER

SCOPE

This section of specification covers the item of providing & laying the Impervious Liner to the surface of ash storage pond as indicated in the drawings and below mentioned specifications:

Providing Bituminous Geo-membrane (BGM) having average thickness of 3.2 mm (minimum thickness 3.0 mm) of as per following specifications:

Physical Properties	Unit	Standards	BGM Value (min value-average value)
Thickness	mm	ASTM D 5199	3.0-3.2
Width	m		5.01-5.1
Geotextile. weight	g/m ²		200
Unit weight	Kg/m ²	ASTM D 3776	3.5-3.9
Friction angle	°		34°
Water Permeability	m/s	(ASTM E 96)	6x10 ⁻¹⁴
Air Permeability	m ³ / m ² /day	ASTM D 1434-82	2x10 ⁻⁴

Mechanical Properties	Standards	BGM Value
Max. tensile strength, kN/m:		-
- Longitudinal	ASTM D 7275	15-18
- Cross direction		13-15
Elongation, %:		30-35
- Longitudinal	ASTM D 7275	
- Cross direction		30-35
Static puncture resistance, N	ASTM D 4833	420-480

4.1.0 REQUIREMENTS OF PROVIDING BGM LINER

The Bituminous Geo-membrane lining is to be provided in the Ash pond as hydraulic barrier and for water proofing.

4.1.1 LAYING OF BITUMINOUS GEOMEMBRANE



At the first stage preparation works shall be provided. The grass and shrubs, if any, on the crown of embankment shall be trimmed. The excavation of the anchoring trench shall be started at this period as well.

After cleaning, cutting of grass, leveling and proper compaction of Ash Pond base, BGM sheet as per specification given in 4.0.0 is to be laid on the ground with proper 200mm lapping between lining sheets and welded jointing.

Then, the BGM panels shall be installed along the direction of width of pond. On the top the panels shall be laid into the anchoring trench, temporary fixed by the earth anchors, staples made of reinforcing steel bars of 12 mm of diameter, every 1.5 m.

Overlaps of 20 cm should be welded together within gas torch and pressed with the steel roller to ensure the safe seem. All workers must use personal safety measures such as gloves, working shoes etc.

After the installation of geomembrane the anchoring trench shall be backfilled and the upper part of embankment shall be reshaped again into the required slope.

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The laying of BGM should be carried out with the terphane (clear plastic film) downwards and the sanded face upward. The sanded face helps in stable movement of construction personals and the terphane film is anti-rooting film, which protects the penetration of vegetation from subgrade to BGM.



Procedure for welding of BGM Joints

- Remove any sharp stones that may still lie under the membrane, as their presence would hinder the proper rolling of the seam.
- Carefully brush the seam area to remove loose sand.
- Clean mud traces with a sponge.
- Remove the PE silicone film after the seam area has been cleaned.
- Carefully burn in advance the terphane film where present, after turning the membrane upside down.
- First, weld a 50cm long area, and roll the roller on it carefully to join the two strips together.
- While moving at a continuous steady pace with one hand or a hook, lift the upper membrane about 10cm and insert the torch between the two strips, while keeping the flame aligned with the edge in order to heat the 20cm width in one single run.
- Carry out the rolling 1.5 or 2.0 meters behind the burner, about 1.0 meter behind the flame.
- The torch must be tilted so as to simultaneously melt the bitumen on both surfaces.
- The welder heats the overlapping surfaces until the bitumen begins to melt (stop before the bitumen melts completely or begins smoking).
- The entire width of the overlap must be welded.
- The welder lowers the top geomembrane onto the bottom geomembrane, which may leave a few wrinkles in the overlap.

Procedure for application of BGM on Structures

The connection between the bituminous geomembrane to concrete shall be carried out according to the following general procedure:

- Ensure concrete is dry before placing primer.
- Apply Bituminous Primer with a brush over the dry concrete where the liner is previewed to be placed.
- After the primer is dry (usually after 60 minutes at 25°C), put the liner in place.
- With a flame torch, heat the primer and the liner at the same time and roll with a small roller applying high pressure to ensure that they

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are both sticking together. Bitumen will leak and fill the small voids on the surface of the concrete.

- Spread excess bitumen with a trowel.
- Compress the corner to where the liner is bent on the connection of the wall to the ground to make sure the liner is well attached.
- Place 150mm wide x 3mm thick steel batten bars on the edge if where the liner is placed (Required if vertical height of BGM application is >4m)
- Drill holes in the batten bars to locate where the 6mm anchor bolts will be placed at 250mm spacing c/c. (Required if vertical height of BGM application is >4m)
- Install and tighten anchors with a nut.
- Apply mastic at the edge of the batten bar and the concrete to ensure attachment.

4.1.2 Storage of BGM

BGM Rolls each having minimum 5.0m width and length as per the requirement should be wrapped over a steel mandrel.



The rolls should not be stored directly on the ground. They should be laid on specific supports, taking into account the distance between the bottom of the roll and that of the mandrel, which is approximately 35 cm. At site, two rows of concrete blocks or steel stands are required for storage of BGM.

4.1.3 Sub-grade Preparation

The surface upon which the Impervious Liner is to be provided shall be graded & prepared to provide adequate support for compaction and to be free from mass movements.

The subgrade surface should be prepared by minimum 300 mm stripping, grading, watering wherever required, and removing all vegetation, rocks, and other matter which could penetrate the Impervious Liner or decrease the uniformity of the mixture. The largest allowable rock shall have no dimension greater than one-third the finished thickness of the Impervious Liner. The prepared surface shall be compacted by at least 2 passes of 8 Ton – 10 Ton roller.

In case earth for formation of dyke is borrowed from inside the lagoon where impervious liner is to be provided, after borrowing fill material from the ash pond, the excavated surface shall be prepared with compaction by two passes of 8 Ton – 10 Ton roller and slope shall be maintained to 1V:4H.

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Impermeable geo membrane shall be installed at the base and embankments of the ash pond to create a barrier against slurry water. The installation of BGM layer forms an impermeable barrier all around the inner surface of pond and bund and along the top width of bund. This layer prevents the seepage of pond water to enter into the bund fill and at the same time during rains, the rainwater is also prevented to percolate into the bund.

Bituminous geo membrane can be laid directly over compacted earth and does not require any other protective membrane/layer.

5.0.0 BORROW AREAS

5.1.0 Borrow earth

5.1.1 All materials required for the embankment which are not available from cut-off trench excavation or from other excavations or within the lagoon shall be obtained from designated borrow areas. The impervious material required for filling cut-off trench and pipe trench and core of the dyke shall be approved clayey soil like CI-CH, CH etc. brought from elsewhere or manufactured soil prepared by blending the soil.



5.1.2 The depths of cut in all parts of the borrow areas will be determined by the Engineer and the cuts shall be made to such depths only. The type of equipment used and the operation in the excavation of materials in borrow areas shall be of such type that will produce the required uniformity of mixture of materials for embankment.

5.1.3 Borrow area shall be opened so as not to impair the usefulness or mar the appearance of any part of the work or any other property. The excavation surfaces and surface of dumped waste materials shall be left in a reasonably smooth and even condition. When the borrow area is located contiguous to the dyke alignment then it must be ensured that the borrow area shall not be opened within a distance of five times the height of embankment contiguous to the heel or the toe of the embankment or 25 metre whichever is more.

5.1.4 For acceptance criteria for fill material refer Part - A of this specification.

5.2.0 Preparation of Borrow Areas (site clearance)

All areas required for borrowing earth for embankment shall be cleared of all rank vegetation and stumps roots, bush, rubbish, and other objectionable material. Particular care shall be taken to exclude all organic matter from the material to be placed in the dyke embankment. All unsuitable materials including rank vegetation, stumps shall be disposed off as specified elsewhere in this specification. The cleared areas shall be maintained free of vegetation growth during the progress of the work. The

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unsuitable materials will be filled back, after borrowing earth for earth embankment construction, as directed by the Engineer.

5.3.0 Stripping of Borrow Areas

Borrow areas shall be stripped of top soil, sod and any other matter which is unsuitable for the embankment construction. Materials from stripping shall be disposed off upto a lead as per schedule of items or as directed by Engineer. The depth of stripping shall be decided by the Engineer depending upon the nature of top soil and the vegetation present.

5.4.0 Borrow Area Watering/ Dewatering

The natural moisture content of material in the borrow areas as well as the optimum moisture content corresponding to the Proctor's maximum dry density for the material in the particular borrow area shall be obtained from laboratory tests. Additional moisture if required shall be introduced into the borrow area by watering well in advance of excavation, to ensure uniformity of moisture content. If in any borrow area before or during excavation there is excess moisture, steps shall be taken to reduce the moisture by the selective excavation to secure the materials of required moisture by excavating drainage ditches, by allowing adequate time for drying or by other means. To avoid formation of pools in the borrow areas during excavation operation, drainage ditches from borrow areas to the nearest outlets shall be excavated.

6.0.0 PREPARATION OF FOUNDATION SURFACE

6.1.0 Scope

This section covers the preparation / compaction of foundation of the dyke as indicated in the drawings and described herein.

6.2.0 General Requirements

6.2.1 Foundation preparation shall be performed as per drawings and as described herein subsequent to stripping of foundation and excavation, if any, No material shall be placed in any section of the fill portion of the embankment until the foundation for the section of the fill portion of the embankment has been dewatered, suitably prepared and has been approved by the Engineer. All excavations made for test pits or other sub-surface investigations and all other existing cavities, found within the zone below the established lines of excavation for embankment foundation, shall be filled with earth/ash of the corresponding zone and properly compacted. The foundation should be free from all organic materials, vegetable sods, and weak layers of compressive materials such as clays or low density silts. The top soil of foundation should be stripped properly such that vegetable sods and top layers are removed to ensure proper bond between embankment and foundation.

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6.2.2 Masonry / concrete surfaces of the back of retaining walls, wing walls, concrete pipes, box culverts, etc. against which the fill is to be placed, shall be cleaned and moistened prior to placing the earth/ash. The foundation immediately adjacent to the masonry / concrete structures shall be thoroughly cleaned of loose materials and moistened and compacted using hand held plate compactors Pools of water shall not be permitted in the foundation and shall be drained and cleaned prior to placing the first layer of embankment material. In case wet patches/marshy area of nallah/pond is encountered along the proposed foundation of dyke embankment, shall be thoroughly cleaned/removed by box cutting and shall be built up in layers.

6.2.3 The area of rock surface which is to be in contact with earth/ash fill of the dyke shall be exposed with rough excavation. Hard rock promontories and overhangs shall be removed by suitable means wherever required, care being taken to avoid objectionable shocks to foundation rock. As far as possible, the whole contact area of foundation rock after rough excavation shall be exposed at one time to enable examination of the rock surface characteristics and planning the method of treatment. Suitable benching shall be provided in the foundation rock where the rock surfaces are steeper than 2 H : 1 V.

The rock surface shall be thoroughly cleaned. Pockets of sand and gravel and other soil shall be removed and soft erodable seams and localised decomposition cleaned out. Loose rock shall be removed by hand picking and wedging. Finally the hand cleaned surface shall be thoroughly washed with powerful water jets to remove the fines which would have worked into the seams of the rock and to obtain a clean surface.



6.2.4 Wherever specified in the Schedule of Items or Drawings, the earth/ash surface shall be compacted by rolling, to achieve the specified degree of compaction using appropriate rollers, in a manner specified for formation of embankment in layers, elsewhere in this specification.

7.0.0 Impervious Soil Fills



7.1.0 Scope

This section of specification covers the item of filling the cut-off trench, filling around pipe/ RCC encased pipe laid in trench (for water escape pipes, ash water recirculation pipes, emergency escape water pipes, etc) and formation of impervious core as indicated in the drawings with naturally existing impervious clayey soils or manufactured impervious soil by blending available soil/earth with bentonite.

7.2.0 General Requirements

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- 7.2.1 The Contractor shall furnish all materials labour, equipment and material required for complete performance of the work in accordance with the drawings, schedule of items and as described herein.
- 7.2.2 The cut-off trench shall be filled up in layers not exceeding 300 mm in compacted thickness and in the manner described under placing the earth fill in **Clause 8.5.0** using impervious soils CL or CI type having permeability less than 1×10^{-6} cm/sec, to be obtained by the Contractor from his borrowed area as approved by the Engineer or from the pond area. The suitability or otherwise of the material shall be determined by laboratory tests. In case clayey soil of the specified quality is not available, alternatively manufactured impervious soil by blending required quantity bentonite (not less than 4 percent) to available soil to achieve the specified permeability also can be used with the same specified procedure for laying and compaction. Blending of bentonite with earth shall be done in dry form in a concrete mixer or mixed by suitable means on a platform. Each layer of earth deposited shall be compacted to have a dry density not less than 98% of the maximum dry density (standard proctor) for the soil with suitable tractor drawn heavy sheep foot tamping rollers of minimum 10 tones capacity or by any other method approved by the Engineer. The compaction shall have to be uniform throughout the length and breadth of each layer. The roller should be made to travel over the entire section of each layer so that the earth is fully compacted and the roller leaves no visible marks on the surface.
- 7.2.3 Before placing the water escape pipes within the embankment, construction of dyke upto 600 mm above the RCC lining for pipes shall be carried out without actually placing the pipes. Later on, trenches shall be excavated for pipes and lining work, pits for cut-off collars and diaphragm filters. These trenches shall then be filled using naturally available CL-ML type soil (plasticity index 7-20). or with manufactured soil by blending with bentonite to achieve specified plasticity. Earth layer deposited in these trenches shall be compacted with suitable compactors to have a dry density not less than 100 percent of the maximum dry density (standard proctor).
- 7.2.4 The spreading of the next layer shall be carried out only after the underlying layer has been approved by the Engineer or his authorised representative.
- 7.2.5 The impervious core of the dyke shall be made with approved clayey soil brought from elsewhere and / or with manufactured soil by blending the available soil with bentonite (not less than 4 per cent by volume) to achieve the permeability not more than 1×10^{-6} cm/ sec. The procedure for laying and compaction shall be the same as specified for the dyke or shells of dyke.
- 7.3.0 Water for cut-off trench and embankment works**

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The Contractor has to make his own arrangements for the supply of water for embankment works. It shall be the responsibility of the Contractor to identify and develop water source or sources, running a pipe line / pipe lines laid at a distance not less 10 metre away from the toe / heel of the dyke for conveying the water required for the work from the supply sources, tapping water from manifolds provided at suitable intervals along the pipe line with the aid of water hoses and sprinkling jets for sprinkling water uniformly over the entire area (and not poured in patches) for bringing up the layers to the required moisture content. Alternately he may employ sufficient number of water tankers also. No separate payment for the above shall be made and entire cost on account of the same shall be included in the rates for relevant items of schedule.

8.0.0 EARTHEN / ASH /SLAG DYKE AND EARTHEN / ASH /SLAG DYKE SHELL/CORE

8.1.0 Scope

This section of specification covers the earth work involved in the dyke/ dyke shell/core formation.

8.2.0 General Requirement

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with drawings schedule of items and as described herein.

8.3.0 Earthen Embankment

The shell/core embankment shall be constructed to the lines and grades shown on the drawings. Placement of fill shall be performed in an orderly way and in an efficient and workman like manner, so as to produce fills having such quantities of density, strength and permeability as will ensure the highest practicable degree of stability and performance of the embankment.

No bushes, roots, sods or other perishable or unsuitable materials shall be placed in the embankment. The suitability of each part of the foundation for placing embankment materials thereon and of all materials for use in embankment construction shall be determined by the Engineer. The dyke may be constructed in separate portions or reaches, provided that:

- i) The slopes of the bonding surfaces between the previously completed portions of the embankment and materials to be placed in each zone shall not be steeper than 2.5 horizontal to 1 vertical in case of earth and 3.0 H : 1 V in the case of ash.
- ii) The embankment is constructed right across the whole section in each portion or reach.

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8.4.0 Fill materials

The materials for dyke shell/core embankment shall be obtained from the designated borrow areas and available excavated material to the extent possible considering fill material as specified elsewhere in the specification. Some earth material available from the excavation of cut-off trench, etc., if found suitable, shall also be used for the embankment construction.

8.5.0 Placing the fill material

8.5.1 Before placing the fill, the foundation shall be prepared and compacted as per **Clause 6.0.0**. The distribution and gradation of materials throughout the fill shall be as shown in the drawings or as directed by the Engineer. The combined excavation and placing operations shall be such that the materials when compacted in the fill will be blended sufficiently to produce the specified degree of compaction and stability. The fill material obtained from a particular borrow area, as far as possible, shall be used in forming the complete cross-section of the fill, as per drawing, for a particular stretch. Sequences of the placing of fill material shall be such that it shall be possible to identify at all stages of construction which borrow area material is/was used in which stretch of the fill/embankment.

8.5.2 No stones, cobbles or rock fragments, having maximum dimensions of more than 10 cm shall be placed in the fill. Such stones and cobbles shall be removed either at the borrow pit or after being transported to the fill but before the materials in the fill are rolled and compacted. Such stones or cobbles shall be placed in other portions of embankment if found suitable or rejected as directed. The materials shall be placed in the fill in continuous horizontal layers, stretching right across the whole section, not more than 30 cm in compacted thickness and rolled as here in specified. During construction a small transverse slope from centre towards the edges should be given to avoid pools of water forming due to rains. The surface of materials to be placed thereon, shall be moistened and/or worked with harrow, scarifier or other suitable equipment, in an approved manner to a sufficient depth to provide a satisfactory bonding surface before the next layer of fill material is placed. If the rolled surface of any fill is found to be too wet for proper compaction, it shall be raked up, allowed to dry, or shall be worked with a harrow or any other approved equipment to reduce the moisture content to the required amount and then it shall be re-compacted before the next layer is placed.

8.5.3 When compacting the fill material against steep rock abutment or walls or masonry or concrete structure the construction surface of embankment shall be sloped away from rock or masonry or concrete structures for a distance of 3 m to 4 m at an inclination not steeper than 6 horizontal to 1 vertical. If the foundation surface is too irregular to allow the use of a large roller directly against a structure/rock out crop, the roller shall be used to compact the fill material as close to the structure or the out crop as possible and the portion of the embankment directly abutting against the rock or the

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structure shall be compacted with pneumatic hand compactors/tampers in thin layers. The moisture content of the fill material placed against the rock or the structure shall be high enough to allow it to be compacted into all irregularities of the rock or the structure. Care shall be taken in placing the first layer of the fill so that no damage is caused by the hauling machinery to the base grade as this may get concealed by the spread layer or fill. Sheep foot roller shall not be employed for compacting till the thickness of the layers already compacted by other means is greater by 30 cm than the depth of the feet on the roller drum. The material for the first layer shall be at moisture content sufficient to enable bonding of the fill with the rock surface.

8.6.0 Weather Conditions

Embankment materials shall be placed only when the weather conditions are satisfactory to permit accurate control of the moisture content in the embankment materials.

8.7.0 Moisture Control

Prior to and during compacting operations, the materials in each layer of fill shall have moisture content about 2% less than the optimum moisture content, in the case of cohesive soil. In the case of cohesionless material, including ash, the placement moisture content may have only little effect on the compaction behaviour of the fill, and hence, appropriate moisture content required from other site considerations such as dust suppression, etc, may be adopted. The Contractor shall make his own arrangements for supply of water in the manner described under "Water for cut-off trench and embankment" under the Clause 7.3.0. If the moisture content is greater than required, the material shall be spread and allowed to dry before starting rolling. The moisture content shall be uniform throughout the layer of materials and ploughing, discing, harrowing or other methods of mixing may be required to obtain uniform distribution. If the moisture content is more or less than the range of the required practicable moisture content, or if it is not uniformly distributed throughout the layer, rolling shall be stopped and shall be started again only when the above conditions are satisfied.

8.8.0 Degree of Compaction

8.8.1 While the specification provides that equipment of a particular type is to be deployed and used, compaction shall be done to achieve 95% standard Proctor density by mechanical means. Compacted layer thickness shall be maximum 300 mm. Tamping (sheep foot) rollers or pneumatic rollers shall be used for compacting cohesive materials and pneumatic rollers and vibratory rollers shall be used for compacting cohesionless materials including ash. Any other suitable type of compaction equipment also can be employed after necessary field trials about their effectiveness and with approval of the Engineer.

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8.9.0 Rolling and Tamping

8.9.1 Rolling

When each layer of material has been conditioned so as to have the proper moisture content uniformly distributed throughout the material, it shall be compacted by passing the roller. The exact number of passes shall be decided after necessary field tests. The layers shall be compacted in strips overlapping not less than 0.6 m. The rollers or loaded vehicles shall travel in a direction parallel to the axis of the dyke.

Density tests shall be made after rolling and the dry density attained shall be not less than 95% of maximum dry density (Standard Proctor) obtained in the Laboratory for the type of material used unless otherwise specified elsewhere.

8.9.2 Tamping

Rollers will not be permitted to operate within 1.0(one) m of concrete and masonry structures. In locations where compaction of the fill material by means of the roller is impracticable or undesirable the material shall be specially compacted as specified here in at following locations:



- a) Portions of the dyke embankment adjacent to masonry structures.
- b) Earth / ash in dyke embankment adjacent to steep abutments,
- c) Earth / ash fill at locations specially designated by the Engineer.

Fill shall be spread in layers not more than 30 cm. in compacted thickness and shall be moistened to have the required moisture content. When each layer of material has been conditioned to have the required moisture content it shall be compacted to achieve the dry density of not less than 95% of maximum dry density (Standard Proctor) by special rollers, mechanical tampers, hand held vibratory tampers or by other approved methods, and all equipment and methods used shall be subject to approval based on evidence of actual performance.

8.10.0 Inspection Test

Control tests shall be carried out as per approved quality plan of Part C of this specification. The Contractor shall provide all facilities such as labour, conveyance, equipment, etc. required for collection of samples and to conduct tests in-situ or at laboratory. Relevant tests to be conducted at the borrow area, on embankment and at laboratory as the work progresses.

8.11.0 Dressing and Trimming of the Slopes

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The outer slopes of the embankments shall be neatly dressed to line as the placing of the fill progresses. Compaction shall extend over the full width of the embankment and the material in the slopes shall be compacted as for the rest of structure. To ensure proper compaction at the outer edge, either slope compactor may be used or the fill shall be constructed for a minimum of 0.5 m extra width on either edges and the outer edge trimmed to specified width and slope, as per construction drawings, after completion of the dyke section upto top, in different stretches of the alignment. No slope shall be left without trimming to design slope. The trimmed slope surface shall be checked for adequate compaction as specified in the Quality Assurance check list as given in Part C and under compaction, if any, shall be corrected. Slopes shall be maintained until final completion and acceptance. Any material that is lost by weathering or due to any other cause shall be replaced. The trimmed materials are permitted for reuse in the embankment. No separate payment shall however, be made for forming extra width, offsets or trimming the slopes and the unit rates for the embankment work shall, therefore, provide for the same.

8.12.0 Provision for Settlement

While forming the embankment, due allowance of 1 per cent of the vertical height or as appropriate shall be made to allow for settlement so as to maintain the top of dyke at designed elevation.

9.0.0 FORMATION OF SAND BLANKET AND CHIMNEY

9.1.0 Scope

The section of the specification covers supplying and forming of sand blanket on the foundation of embankment, sand chimney if any in the bund and sand filters between toe drain, rock-toe, rip rap and foundation and along the slope as indicated in the drawings.

9.2.0 General Requirements

The Contractor shall furnish all labour and material required for the complete performance of the work in accordance with the drawings, schedule of item and as described herein.

9.3.0 Sand Blanket/Sand Chimney/sand filter

Thickness of graded sand shall be provided as indicated in the drawings or as specified or as directed by the Engineer.

9.4.0 Material

The material for blanket, chimney and sand filters shall consist of clean sound and well graded coarse sand. The materials shall be free from

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debris, wood, vegetable matter and other deleterious matter. The gradation of sand material shall meet the requirements as specified below (Refer Table 2 Criteria for Filters IS 9429 – 1999):

- a) $D_{15} (F) \geq 5D_{15} (B)$ or 0.1mm whichever is higher
 where, suffix "F" denotes filter material and "B" base material
 (common to all 4 types of base material)
- b)

<u>Base Soil Type</u>	<u>Filter criteria</u>
1	$D_{15} (F) \leq 9D_{85} (B)$ or 0.2mm, which ever is higher
2	$D_{15} (F) \leq 0.7\text{mm}$
3	$D_{15} (F) \leq (40-A)$ $\frac{\text{-----}}{(40-15)} \times (4 \times D_{85}(B) - 0.7) + 0.7\text{mm}$, where A = % passing 75 micron
4	$D_{15} (F) \leq 4D_{85} (B)$
- c) Max size of filter shall not exceed 75 mm.
- d) Material passing 75 micron shall not exceed 5%
- e) Filter material should be non-cohesive
- f) Limits of $D_{10} (F)$ and $D_{90} (F)$ for preventing seggregation should be as under :

$D_{10} (F)$ Min. (mm)	$D_{90} (F)$ Max. (mm)
<0.5	20
0.5 to 1.0	25
1.0 to 2.0	30
2.0 to 5.0	40
5.0 to 10	50

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10 to 50

60

9.4.1 Degree of compaction

The filter material shall be suitably compacted to a firm condition to achieve a relative density of 70%.

9.5.0 Placing

9.5.1 Sand Blanket

Sand blanket shall be laid subsequent to site clearance, stripping and excavation, if any. The foundation area shall be cleared before laying the bottom layer of blanket material. Filter material shall be laid in layers not exceeding 30 cm. Care shall be taken to ensure that materials of different layers do not get mixed, both at the time of placing and during compaction. After the layers of filter blanket material have been laid and compacted as directed by the Engineer earth/ash fill material shall be laid.

9.5.2 Sand Chimney

Sand chimney of specified thickness shall be laid at the specified location by excavating and removing the already compacted bund material, exposing sand chimney in the lower layers earlier laid, and refilling the trench with sand in layers. The layer of sand shall be well rammed. The depth of each layer of chimney to be laid shall not be more than 30 cm or as directed by the Engineer. The excavated material can be reused in the dyke construction While excavating the earth for filling sand for chimney drain, the top layer of sand which has been mixed with earth/ash, shall also be removed.

Alternatively, the sand chimney can also be laid in layers simultaneously with the laying of each layer of fill. In such case, the top level of sand layer shall always be kept at about 100 mm above earth/ash level on both sides. Each layer of sand shall be compacted. Care shall be taken to avoid mixing of earth/ash and sand.

9.5.3 Sand filter

The sand filter around the rock-toe and below rip-rap shall closely follow the levels of the embankment in the area. Sand filter shall be laid subsequent to stripping of foundation and / or trimming of slope of compacted bund. The excavated earth/ash shall be removed from the working area and stockpiled at a place directed by the Engineer. The surface to receive the sand filter shall be cleaned by suitable means before laying of filter material. The sand filter shall be laid in layers. The thickness of the layers shall not be more than 30 cm or as directed by the Engineer. The sand layer shall be well compacted. Care shall be taken that materials

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of different layers do not get mixed, both at the time of placing and during compaction.

10.0.0 GRADED COARSE RAINED AGGREGATE FILTERS

10.1.0 Scope

The section of the specification covers supply and placement of the graded aggregate filters at the bottom and on the slope of toe drain, rock-toe and below rip-rap protection layers on embankment slopes and at any other place as indicated in the drawings released for construction or as directed by the Engineer.

10.2.0 General Requirements

The Contractor shall furnish all labour, equipment and materials required for the complete performance of the work in accordance with the drawings and as described herein.

10.3.0 Material

The coarse aggregate material shall consist of durable well graded broken rock of hard stone variety from the specified quarries and shall be approved prior to being transported to the area of deposition. The materials shall range in the size from 10 mm to 75 mm and shall satisfy the filter criteria.

The rock material used in the aggregate filters shall satisfy the following condition:

- a) Specific gravity shall not be less than 2.50. (As per IS: 1122)
- b) Sulphate soundness less than 10% loss of weight after 5(Five) cycles (As per IS: 1126)
- c) Aggregate Impact value shall not exceed 30% (As per IS: 2386)
- d) Water absorption shall not exceed 2.5%. (As per IS: 2386)
- e) In slake durability test (as per IS: 10050), the percentage retained after ten (10) minutes cycles shall be more than 85%.

10.4.0 Placing

Graded aggregate filters shall be constructed over the trimmed surface of the embankment slope, as indicated in the drawings. The aggregate filters shall be placed in layers of uniform thickness as shown in the drawings and

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care shall be taken to avoid segregation of coarse and fine materials and formation of pockets.

11.0.0 ROCK TOE

11.1.0 Scope

This section of the specification covers the supply and forming toe drain & rock toe as shown in the drawings.

11.2.0 General Requirements

The Contractor shall furnish all labour, equipment and materials required for the complete performance of the work in accordance with the drawings, schedule of item and as described herein.

11.3.0 Material

The rock material used for the toe drain & rock toe shall satisfy the quality requirements specified under Clause 10.3.0. The materials shall range in size from 10 to 45 cm. All brush, roots or other perishable materials shall be removed from rock-fill during spreading and shall be transported to a disposal area as decided by Engineer.

The rock available from the excavation of water escape structure/ stripping / drain channel / within the land acquired for construction of earthen dyke etc. which satisfy the quality requirements specified under Clause 10.3.0 and found suitable for construction of toe drain & rock toe by Engineer shall be used. These shall be washed, cleared, and broken into required size and stacked separately, at a place as directed by the Engineer.

11.4.0 Placing

The stone pieces shall be hand placed to obtain a stable, well graded and free draining fill. The toe drain & rock toe shall be constructed in layers so that the smaller rock fragments shall be placed adjacent to the filter of embankment and the large rock fragments near the outer edge of the rock toe. The rock fill shall be hand placed, spread and roughly levelled in layers not greater than 30 cm. in thickness in order to maintain a reasonably uniform surface and ensure that the completed fill will be stable and do not contain any voids having least dimension larger than 50 mm.

Contamination of the rock with finer materials from any other zones shall be avoided. Accumulations of soil caused by contamination shall be removed.

Separate record shall be kept for the rock toe constructed using the rock obtained from quarries, from within the acquired land, from the excavation of cut-off trench, water escape structure etc. if separate rates are quoted in the Schedule of Items.

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12.0.0 RIP-RAP ON THE SLOPE OF EMBANKMENT

12.1.0 Scope

The section of the specification covers the supply and forming rip-rap protection on the slope of the embankment as shown in the drawing.

12.2.0 General Requirements

The Contractor shall furnish all labour, equipment and material required for the complete performance of the work in accordance with the drawings, schedule of item and as described herein.

12.3.0 Material and Placing

Rip-rap shall be hand placed on the slopes of the dyke embankment as per **IS: 8237 - "Code of practice for Protection of slope for reservoir embankments"**. The thickness of rip-rap layer shall be as indicated in the drawings. The thickness shall be measured normal to slope of the embankment.

The rock materials used for rip-rap shall satisfy the quality requirements specified under Clause 10.3.0.

The quality of individual rock fragments shall be dense, sound and resistant to abrasion, and shall be free from cracks, seams, shale partings, conglomerate bands and other defects that would tend to increase unduly their susceptibility to destruction by water and weathering action. The shape of the individual rock fragment shall be angular. Fragments having thickness less than 50% of their maximum dimensions shall not be used as rip-rap. The stones shall be evenly distributed over the paved area. The average weight of stones shall be 15 kg. for 300 thick rip-rap and 50 kg. for 600 thick rip-rap. These stones shall be placed on the edge with longer dimension normal to the slope. Rock fragments and spells shall be tightly driven into the interstices to wedge the rip-rap in place and close direct opening to underlying slope. The wedging shall be done with the largest chip practicable, each chip being well driven home with a hammer so that no chip can be removed by hand. Stones shall be laid in a compact manner beginning at the bottom of the slope.



Rip-rap shall be placed along with the fill so that a minimum of break down will occur during placing and spreading.

The rock, if any, available from the excavation of water escape structure / stripping / drain channel, etc, which satisfies the quality requirements specified under **Clause 10.3.0** and found suitable for construction of rip-rap by Engineer shall be used. These shall be washed, cleared, and broken into required size and stacked separately, at a place as directed by the Engineer.

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Similarly, rock materials which satisfy the quality requirements specified under **Clause 10.3.0** can also be obtained from rock if any available within the land acquired for construction of earthen dyke, if it is found suitable. The location from where the material will be obtained shall be approved by the Engineer. The rock shall be broken to required size and shape and shall be cleaned before use.



Separate record shall be kept for the rip-rap constructed using the rock obtained from quarries, from within the acquired land, from the excavation of cut-off trench, water escape structure, etc. if separate rates are quoted in the Schedule of Items.

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SECTION – 7.3



DESIGN PHILOSOPHY

(CIVIL & STRUCTURAL)



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1.0 GENERAL

1.1 Scope

This engineering design basis defines the minimum design criteria that shall form the basis for carrying out detailed structural design and engineering of all plant and non-plant structures and buildings. All data required in this regard shall be taken into consideration for acceptable, satisfactory and trouble-free engineering of the structures.

Compliance with this design basis and / or review of any of CONTRACTOR documents shall in no case relieve the CONTRACTOR at the contractual obligations. All structures shall be designed for the satisfactory performance of the functions for which they are being constructed.

1.2 Units of Measurement

Units of measurement in design shall be in metric system.

1.3 Definitions

1. CCE Chief Controller of Explosives
2. TAC Tariff Advisory Committee
3. NFPA National Fire Protection Association
4. IS Indian Standards

1.4 Codes and Standards

The design shall be in accordance with established codes, sound engineering practices and shall conform to the statutory regulations and MOEF guidelines as applicable to the country.

The main codes and standards and statutory regulations considered as minimum requirements are as follows Latest revision of these shall be followed:

IS 3873- Laying Cement Concrete/Stone Slab Lining On Canals

IS 10430- Criteria For Design Of Lined Canals and Guidance For Selection Of Type Of Lining

IS 4558- Under-Drainage of lined canals

IS:456 Code of practice for plain & reinforced concrete



SP:34 Handbook on concrete reinforcement and detailing

IS:800 Code of practice for general construction in steel



IS 801 Code of practice for use of cold formed light gauge steel structural members in general building construction.

IS:802 Code of practice for use of structural steel in overhead transmission line towers

IS:806 Code of practice for use of steel tubes in general building construction

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- IS:816 Code of practice for use of metal arc welding for general construction
- IS:875 Code of practice for design loads
- IS:1080 Code of practice for design & construction of shallow foundations on soil
- IS:1161 Specification for steel tubes for structural purpose
- IS:1597 Code of practice for construction of stone masonry
- IS:1838 Filters for expansion joints
- IS:1893 Criteria for earth quake resistant design of structures
- IS:1904 Code of practice for design and construction of foundations in soils, General requirements
- IS:1905 Code of practice for structural use of un-reinforced masonry
- IS:2185 Concrete masonry units
- IS:2629 Recommended practice for hot dip galvanizing of iron and steel
- IS:2633 Methods for testing uniformity of coating of zinc coated articles
- IS:2911 Code of practice for design and construction of pile foundations
- IS:2950 Code of practice for design & construction of raft foundations
- IS:2974 Code of practice for design & construction of machine foundations
- IS:3370 Code of practice for concrete structures for storage of liquids
- IS:4091 Code of practice for design and construction of foundation for transmission line tower and poles
- IS:4326 Code of practice for earthquake resistant design and construction of buildings
- IS:4925 Specification for Concrete Batching and Mixing Plant
- IS:4991 Criteria for blast resistant design of structures for explosions above ground
- IS:5249 Determination of dynamic properties of soil
- IS:6403 Code of practice for determination of bearing capacity of shallow foundations
- IS:6745 Method for determination of mass of zinc coating
- IS:8009 Code practice for calculation of settlements of foundations
- IS:9595 Recommendations for metal arc welding of carbon and carbon manganese steel
- IS:11089 Code of practice for design and construction of ring foundation
- IS:12118 Two parts polysulphide based sealant
- IS:13920 Code of practice for ductile detailing of reinforced concrete structures subjected to seismic forces.

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National Building Code
Factory Rules

In case of any difference between Codal provision and this design basis, the stringent one should govern the design.

In case of any conflict / deviations amongst various documents, the order of precedence shall be as follows:

2.0 Design Loads

The following design loadings shall be considered:

1. Dead loads including self weight
2. Live load
3. Wind load
4. Seismic load
5. Equipment load
6. Dynamic load
7. Load from lifting appliances
8. Erection loads / maintenance loads
9. Thermal load
10. Earth pressure / Hydrostatic Loads
11. Any other load not mentioned above, but applicable

These loadings shall be applicable to all structures irrespective of the material employed for construction.

2.1 Dead Loads

Dead load shall comprise of the weight of all permanent construction including walls, fire proofing, floors, roofs, partitions, stairways and fixed services.



2.2 Equipment Loads

The empty / operating / test weight of process equipment including all fixtures, platforms, ladders and attached piping but excluding contents, shall be considered. If piping weight is not indicated separately or not included in the weight of the equipment, the same shall be taken as 10% of the weight of the equipment.

1. Bundle Pull

Bundle pull forces for different types of exchangers shall be taken as under:

- | | | |
|--------------------|---|---|
| a. Fixed type | - | Nil |
| b. Kettle type | - | 0.30 × Bundle weight |
| c. All other types | - | 0.86 × Bundle weight or 30 N/mm of diameter
Whichever is greater |

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Total Bundles Pull shall be considered on fixed pedestal alone

2. Thermal Expansion

Horizontal force due to thermal expansion of horizontal vessels / exchangers shall be relieved by using slotted holes and slide plates and remaining force derived from the product of the sliding saddle 'gravity load' and the coefficient of friction shall be applied to each support. the coefficient of friction shall be taken as under:

a. teflon to teflon	:	0.08
b. stainless steel to teflon	:	0.10
c. steel to steel	:	0.30
d. steel to concrete	:	0.45

3. Non-Static Loading

Foundations and structures supporting vessels subject to surge loading, such as Deaerators shall be designed with sufficient stiffness and rigidity to resist a notional horizontal forces of 10% of those derived from the Vessel's operating weight or the given surge load whichever is greater. The forces shall be applied at the vessel's centre of gravity and act longitudinally or transversely. Consideration shall be given to bracing these structures.

The design of foundations and structures supporting agitated vessels, centrifuges, reactors and other variable load equipment shall take full account of all the loading data provided by the equipment vendors. Where no loads are available, consideration shall be given to applying force at 10% of operating weight. In addition, for dynamic effect loads will be increased by 50% of steam agitated equipment and 25% for mechanical agitated vessels.

Where two or more similar items of such equipment are supported on a common foundation or structure, the design must be based on the assumption that these items will resonate in phase.

4. Rotating Equipment



Comprehensive loading data of mechanical equipment, such as, fans, blowers, pumps, compressors, D.G. Sets, turbines, motors engines etc., as furnished by the equipment vendor shall be considered.

2.3 Live Loads

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.

1. Process Building / Technological Structure (Open / Enclosed type)

Operating area	-	5.0 kN/m ²
Maintenance area	-	7.5 kN/m ²
Ground floor	-	10.0 kN/m ²



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2. Compressor House/TG House		
Operating area	-	7.5 kN/m ²
Maintenance area	-	7.5 kN/m ²
Ground floor	-	10.0 kN/m ²
3. Service Platform		
Vessel / Tower	-	3.0 kN/m ²
Isolated platform (for valve operation)	-	2.5 kN/m ²
Access way	-	2.5 kN/m ²
Cross over	-	2.0 kN/m ²
Piperack walkways	-	2.5 kN/m ²
Gantry girder walkway	-	3.0 kN/m ²
4. Substation / Control Room		
Panel floor	-	10.0 kN/m ²
Miscellaneous partition	-	1.0 kN/m ²
Other areas	-	5.0 kN/m ²
5. Office building		
Office area	-	3.0 kN/m ²
Entrance lobby	-	5.0 kN/m ²
Exit way	-	5.0 kN/m ²
Miscellaneous partition	-	1.0 kN/m ²
Document Storage area	-	10.0 kN/m ²
6. Laboratory		
Upper floors	-	4.0 kN/m ²
Ground floor	-	5.0 kN/m ²
7. Cooling Tower		
Operating platform /cover	-	3.0 kN/m ²
Slab of hot water basin & Sump	-	
8. GT Building / DM Plant /ETP		
Operating platforms	-	3.0 kN/m ²
Ground floor	-	5.0 kN/m ²
9. Staircase		
Process Building	-	5.0 kN/m ²
Technological structure	-	5.0 kN/m ²
Office	-	5.0 kN/m ²
Substation/Control Room	-	3.0 kN/m ²
Laboratory	-	4.0 kN/m ²
Service platform	-	2.5 kN/m ²

Loads on account of equipment and incidental loads shall be taken over and above the loads indicated in the table.

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

1 kN/m² allowance shall be made for services supported from below the floor.

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

2.4 **Wind Loads**

Wind loads for structural design shall 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 50 m/s. Definition of basic wind speed shall be peak gust velocity averaged over 3 second time interval at 10 m height above mean ground level with 50 years mean return period. The design life span of all structures, except temporary structures, and boundary wall shall be taken as 50 years. Life span of temporary structures and boundary wall can be lesser and shall be as per IS:875.

To account for surface area of piping, platforms and other attachments fixed to the equipment, the surface area of the equipment (vessel/column) exposed to wind shall be increased by 20% or as specified in the mechanical data sheets of the equipment.

2.5 **Seismic Loads**

The site falls in Seismic zone-III. Seismic loads shall be as per IS: 1893 (Latest Revision).

2.6 **Impact and Vibratory Loads**

Structures subjected to impact or vibratory loads shall be designed as per the provision of IS: 875 & IS: 2974. Requirements for monorails and overhead cranes shall be as per IS: 800, IS: 875 or manufacturer's data, whichever is more stringent.

2.7 **Contingency Loads**

2.7.1 **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.

2.7.2 **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:

- | | |
|-----------------------------|-------|
| 1. Platform Walkways | 3 kN |
| 2. Secondary Floor Trimmers | 5 kN |
| 3. Primary / Grid beams | 10 kN |

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2.8 Miscellaneous Loads

Apart from the specified live loads, possible overloading during construction / hydro-test maintenance / erection shall also be considered in the design Job specifications and shall also be referred to, for any specific loading.

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).

2.9 Load Combinations

Structure & its member shall be designed for worst combination of the above loads.

3.0 DESIGN CRITERIA FOR FOUNDATIONS

3.1 General

Foundation sizing shall be based on working loads without any factor.

3.2 Shallow Foundations

3.2.1 For gravity loading, allowable net bearing capacity of soil shall be based on the following settlement criteria:



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

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

3.2.3 For load combinations including wind/Earthquake, the Safe Soil Bearing Pressure may be increased by 25%.

3.2.4 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.

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%

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	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

3.2.5 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.

3.2.6 Stability of foundations

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

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	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
Flare supporting Structures	1.5	-	1.5	-	50**

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** 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 into account in investigating stability against uplift.

3.3 **Piled Foundations**

Piles shall be designed as per IS: 2911 . However, pile capacity shall be proven by a sufficient number of initial load tests before preparing piling plans.

The increase in Safe Working Load permitted as per codal provisions, under load combinations including wind / earthquake shall apply equally to uplift and shear conditions, subject to confirmations by the piling CONTRACTOR with respect to the particular piling system. Pile capacity may be similarly increased in blast condition to 1.5 times the permissible capacity under compression, tension and shear modes.

When any major machinery is to be supported on piles, behaviour of the piles under dynamic, loading conditions, as established by necessary field test, shall be considered.



The capacity of pile groups shall be obtained by applying appropriate group efficiency factors. Where piles pass through filed ground, the available pile safe working load shall be suitably reduced to account for negative skin friction caused by settlement of fill. Where suitable, consideration shall be given to reducing drawdown effects by slip coating the piles.

While computing horizontal capacity, piles shall be treated as fixed head or free head depending on the degree of fixity at the top.

3.4 **Machine Foundations**

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

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 are 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.

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When dynamic analysis is called for, the combined centre of gravity of the machine and foundation system shall, as far as possible, pass through the centre of area of the foundation raft or centroid of the pile group. Wherever unavoidable, eccentricity shall be less than 5% for block foundations and 3% for frame foundations. However, in highly compressible soils, no eccentricity shall be permitted.

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)

It shall be ensured that there is no transfer of vibrations from machine foundations to any part of the adjoining structures. In case such machine are sitting on building floors, approved damping pads shall be used with prior approval of OWNER / CONSULTANT.

Where deviations (resulting from inaccuracies in soil parameter measurements, approximations in design method, etc.) from calculated natural frequencies, leading to amplitudes in excess of specified limits are foreseen, provision for increasing the foundation mass without removal of the machine and without affecting surrounding space availability or connected piping shall be made, if possible.

3.5 **Concrete Grade**

Grade of concrete to be used in foundation shall in general be as per the philosophy adopted for the entire structure. However, minimum cement content, type of cement and any remedial actions, if required for foundations due to aggressiveness of subsoil water, shall be as stated elsewhere in this document. Minimum grade of reinforced concrete shall be M25. For underground & water retaining structures, such as, manholes, cooling tower etc. M 30 grade reinforced concrete shall be used.

3.6 **Foundation Bolts**

3.6.1 **Minimum cover to Foundation Bolts**

Minimum distance from the center line of foundation anchor bolt to edge of pedestal shall be as per standard drawings.

3.6.2 All equipment foundation bolts / templates shall be designed and supplied by equipment vendor.



Foundation bolts for steel structures shall be designed and supplied by CONTRACTOR as per standard drawings or approved equivalent.

3.7 **Pedestal Heights**

Building plinth : 450 mm above finished ground level

Pedestals for structural columns:

Open paved area : 300 mm (min.) OR as indicated in

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	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
Stair Pedestals	: 300 mm (min.) OR as indicated in equipment Layout drawing.
Ladder pedestals	: 300 mm



3.8 **Design Criteria for Reinforced Concrete Structures**

3.9 **General**

- 1) All buildings, structures retaining storage structures, trenches, pits etc. shall be of RCC and designed based on the following IS codes (latest revision with all amendments, issued there to) in general, and other relevant IS codes applicable : IS:456, 875, 1893, 1904, 2911, 2950, 2974, 3370, 4326, 4991, 4998, 5249, 6403, 8009, 13920.
- 2) Only limit state method as per IS:456 shall be followed for the design unless otherwise specified elsewhere in this document for special structures.
- 3) All skeletal structures shall be of frame type construction, and detailing shall be as per provision of IS:13920.
- 4) 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.

3.10 **Liquid Retaining R.C.C. Structures and Basements**

- 3.10.1 All liquid retaining / storage R.C.C. structures shall be leakproof and designed as uncracked section in working stress method as per IS:3370. However, the parts of such structures not coming in contact with the liquid, shall be designed according to IS:456 except ribs of beams of suspended floor slabs and counterforts of walls (located on the side remote from liquid) and roof of liquid retaining structures which shall be designed as uncracked section. Hot/cold water basin, and other primary framing members of Cooling Towers and similar liquid retaining structures, which remain constantly in contact with water (stored / sprayed) shall be designed as uncracked sections. No increase in permissible stresses in concrete and reinforcement shall be made under wind or seismic conditions for such structures.
- 3.10.2 All liquid retaining / storage structures shall be designed assuming liquid up to the full height of wall, irrespective of provision of any overflow arrangement. Pressure relief valves or similar pressure relieving devices shall not be considered in underground water retaining RCC structures. Hot water basin in cooling tower shall be designed for the weight of water up to top of parapet wall.
- 3.10.3 The walls and base slabs of liquid retaining storage structures shall be provided with reinforcement on both faces for thicknesses greater than 150 mm.

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- 3.10.4 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 150/230 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.

4.0 Concrete Grade

The **minimum M25** grade of reinforced cement concrete shall be used for all structures and foundations except for grade slabs / paving for which M20 may be used. From durability consideration the minimum cement content and maximum water-cement ratio shall be as follows :

Type of Cement	Plain concrete		Reinforced concrete		Remarks Exposure Condition
	Minimum cement content (kg/m ³)	Maximum water-cement ratio	Minimum cement content (kg/m ³)	Maximum water-cement ratio	
43 Grade-OPC	240	0.55	330 (for shallow fdns) -400 (for piles)	0.45	Moderate

Maximum cement content shall not exceed 450 kg/m³. If soil investigation report recommends high cement content and / or specified type of cement, the same shall have precedence.

75 mm thick lean concrete of grade M10 (nominal mix) shall be provided under all RCC foundations except under base slab of liquid retaining structures where 100 thick concrete of mix M10 (nominal mix) shall be used. The lean concrete shall extend 75 mm beyond the foundation for normal foundations and 100 mm under liquid retaining structures.



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 damp proof course, at plinth level of all masonry walls and to be coated with 3 mm thick bitumen emulsion.

4.1 Reinforcement Bars

High yield strength deformed TMT steel bars of grade Fe500D conforming to IS:1786 shall be used.

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4.2 **Minimum Cover to Reinforcement**

Minimum clear cover shall be provided to all steel reinforcement as per IS:456 & IS:3370.

4.3 **Expansion Joints**

Concrete structures

Expansion points in concrete structures shall be provided at 30-35 m centers. The expansion joint shall be provided preferably by way of twin columns on a common foundation. Sliding joints shall be avoided as far as possible.

4.4 **Deflections**

4.4.1 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 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
- Total horizontal deflection between two floors : Storey height/200

4.5 **Miscellaneous Applications**

4.5.1 **Admixtures**

Admixtures shall conform to IS:9103 and to be mixed with concrete (if required) strictly as per manufacturer's recommendations.

4.5.2 **Plinth protection**



Each building shall be provided with 1.0 m wide concrete M15, 100 thick laid on 75 mm thick M7.5 concrete with 8 Tor @ 250 c/c both ways Reinforcement bars all round as plinth protection. A surface drain to be provided along-with plinth protection which shall be connected to the drainage system.

4.5.3 **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.

4.5.4 **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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4.5.5 **Masonry Wall**

- a) 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.
- b) All brick masonry (M 7.5 grade) walls shall be considered as 230mm thick, except for partition walls which will be 115 mm thick. However, for fire barrier walls minimum thickness shall be considered as 350 mm.
- c) All in-filled brick (M7.5 grade) panels shall be designed to transfer horizontal loads from wind and seismic to the structural frameworks without damage and the extent of brick panel dimensions shall be as per the recommendations in IS. All half masonry wall shall be provided with reinforcement consisting of 2 Nos. of 8mm diameter bars at every fourth layer.

4.5.6 **CRITERIA FOR MASONRY WORKS**

4.5.6.1 **General**

All masonry works shall be designed in accordance with IS:1905, IS:1597, IS:2185, IS:4326 and other relevant IS Codes as applicable. All external brick, stone and hollow concrete block masonry walls shall be of minimum 230, 350 and 250 mm thickness respectively. ES 2516, enclosed with the tender may be referred for details. Masonry shall be plastered with CM 1:6, 12 mm thick on inside surfaces and 20 mm thick on outside surfaces.

4.5.6.2 **Cement Mortar**



All masonry work shall be constructed in 1:6 cement sand mortar except half brick partition walls which shall be constructed in 1:4 cement sand mortar with 2 nos.8mm dia. M.S bars provided at every fourth course properly anchored with cross walls or pillars.

5.0 **DESIGN CRITERIA FOR STEEL STRUCTURES**

5.1 **General / Design Methods**

- 5.1.1 Design, fabrication and erection of the above work shall be carried out in accordance with the following IS Codes as applicable to the specific structures, viz, IS:800, 801, 802, 806, 814, 816, 875, 1893, 6533, 9595, etc. Basic consideration of structural frame work shall primarily be stability, ease of fabrication/erection and overall economy, satisfying relevant Indian Standard Codes of Practice. 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. Flare stack supporting structure shall be adequately braced on all four faces.

Structural elements, continuously exposed to temperatures above 200° C, shall be designed for reduced stress as per Table-4 of IS:6533 (Part-2). The expected temperature of steel components shall not be allowed to exceed 400 ° C. The

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structures connected to column, heater vessels working at high temperatures shall not be rigidly connected with staircase and adjoining structures, which are on ambient temperatures.

- 5.1.2 Crane gantry girders shall generally be of welded construction and of single span length. Chequered plate shall be used for gantry girder walkway flooring.
- 5.1.3 Steel staircases shall have channels provided as stringers with minimum clear width of 1000 mm. The vertical height between successive landings shall not exceed 4.0 meters. Treads shall be minimum 250 mm wide made of grating (with curved chequered plate nosing) spaced equally so as to restrict the rise to maximum 150 mm. If relevant local by-laws or applicable Factory Act Rules stipulates more stringent requirements in this regard, the same shall be adhered to.
- 5.1.4 Electro-forged galvanized MS gratings grating shall be minimum 30 mm deep. The maximum size of voids in the grating shall be limited to 34 mm x 65 mm. The minimum thickness of galvanizing shall be 86 microns. Gratings shall be suitable for the operation and maintenance loads for the floors.
- 5.1.5 Bolted connections shall be adopted as far as practicable, except for cases where welded connections are required viz. (Galvanized) electrical switchyard structures and transmission towers. Structural connections shall have minimum two bolts of 16 mm dia. unless otherwise limited by the size of members
- 5.1.6 Lock nuts shall be provided for anchor bolts of tall structures, tall process columns, vibrating equipment, etc.
- 5.1.7 Minimum two nuts shall used for all anchor bolts except for ladder, stair and hand rail.

5.2 **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.

5.3 **Steel Grade**

Structural steel shall be of yield stress of 250 Mpa conforming to grade B of IS:2062. Tubular steel shall conform to Yst 310 of IS:1161 & 4 IS: 4923.



5.4 **Limiting Permissible Stresses**

Permissible stresses in structural members shall be as specified in various codes.

- IS:800 - Hot rolled sections (excluding transmission towers and Switchyard structures).
- IS:801 - Cold formed light gauge sections
- IS:802 - Transmission towers & switchyard structures
- IS:806 - Tubular Structures

Permissible stresses in bolts shall be as specified in:

- IS:800 - Hot rolled sections
- IS:801 - Cold formed light gauge sections

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- IS:802 - Transmission towers & switchyard structures
IS:806 - Tubular Structures
Permissible stresses in welds shall be as specified in:
IS:801 - Cold formed light gauge sections
IS:806 - Metal Arc Welding

5.5 Limiting Deflection

- a) The limiting permissible vertical deflection for structural steel members shall be as specified below :-

- Gantry girder for electric overhead crane (Capacity up to 50T)	:	L/750
- Gantry girder for electric overhead crane (Capacity over 50T)	:	L/1000
- Gantry girder for manually operated crane	:	L/500
- Girder beam for supporting dynamic equipment/hoist	:	L/450
- Grating / Chequered plate	:	L/200 or 6mm Whichever is less
- Purlins supporting any type of roofing material	:	L/200
- Under (dead load + live load) or (dead load + wind Load) conditions	:	
- Other structural components	:	As specified in relevant IS, Where “L” represents the span
- The limiting permissible horizontal deflection for multistoried steel structure/ building including flare stack	:	Height/325



5.6 Minimum Thickness

5.6.1 Structural Components

The minimum thickness of various structural components (Hot rolled sections) shall be as given:

a. General Construction

- Trusses, Purlins, Side Girts, Bracings : 6 mm
- Columns, beams : 7 mm
- Gussets in trusses & girders

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|---------------------------------|-------------------|
| i. Upto and including 12 m span | : 8 mm |
| ii. Above 12 m span | : 10 mm |
| • Flare Trestles, Stiffeners | : 8 mm |
| • Base plates | : 10 mm |
| • Chequered plate | : 6 mm (on plain) |
| • Grating | : 3 mm. |

6.0 DESIGN REQUIREMENTS FOR SPECIFIC APPLICATIONS

6.1 Pipe rack/Cable rack

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

6.1.1 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. Insulation density shall be taken as 2600 N/m³ minimum. In case of gas / steam carrying pipes, the material content shall be taken as one-third volume of pipe filled with water. The total actual weight thus calculated, shall then be divided by the actual extent of the span covered by the pipes to get the uniformly distributed load per unit length of the span. 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 piperack shall not be less than 1.25 kN/m². In case, the calculated loading is higher than 1.25 kN/m², this shall be rounded off to the nearest multiple of 0.25 (i.e., 1.50, 1.75 kN/m²)

Vertical loads of flare pipe shall be taken as one third full of water for piping within units & one sixth full for outside unit battery line. All flare line independent support shall be of four legged braced open lower type construction.

In addition to piping load, gravity loads due to encasement, if any, shall be considered.

6.1.2 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. 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.

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For two-phase fluid flow/transfer lines frictional force shall be minimum 50% of the weight of pipe including contents & insulation, acting simultaneously in transverse & longitudinal direction.

6.1.3 Anchor and Guide Force (Thermal Load)

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

6.1.4 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.

6.1.5 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 into account in the design of the longitudinal beam. Friction & anchor forces, if specifically given by the Piping Specialist, shall also be catered for in the design. Loads from monorails, when supported from these beams, shall also be considered to be acting simultaneously along with all other loads mentioned above.



6.1.6 Cable Tray and Walkway Loads

The estimated actual load from electrical, instrumentation trays shall be considered at the specified locations, together with walkways, platforms for valve operation, wherever provided.

6.1.7 Wind Force

Transverse wind loading shall be calculated depending on the width of the piperack as per the following table. This force shall be considered irrespective of the height between two tiers.

Width of Piperack	Wind Force at each Tier level(N)
– Upto 4 m	1.25 x p x s
– Above 4 m but upto 6 m	1.50 x p x s
– Above 6 m but upto 10 m	2.00 x p x s
– Above 10 m	projected height x p x s
Where p = Horizontal wind pressure as per IS:875 (N/m ²)	
s = Spacing of portals (m)	

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For pipe racks of width greater than 10 m, the projected height shall be lesser of the following two:

1. $0.8 X$ (diameter of largest pipe including insulation (m) + $\tan 10^\circ \times$ (width of rack (m)).
2. Height between consecutive tiers

6.1.8 For flare header or any other line supported on extended leg of piperack, the wind force shall be considered separately.

6.1.9 **Seismic Loads**

Seismic loads shall be as per IS:1893(Latest Revision) .

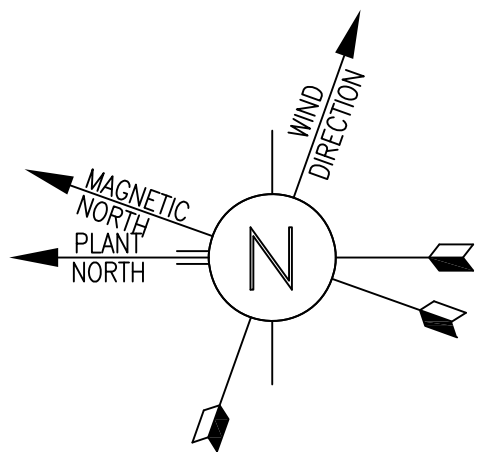
6.1.10 Pipe racks should be adequately braced in all possible directions, consistent with function requirements.

6.1.11 Limiting permissible horizontal deflection for piperack shall be height / 325.

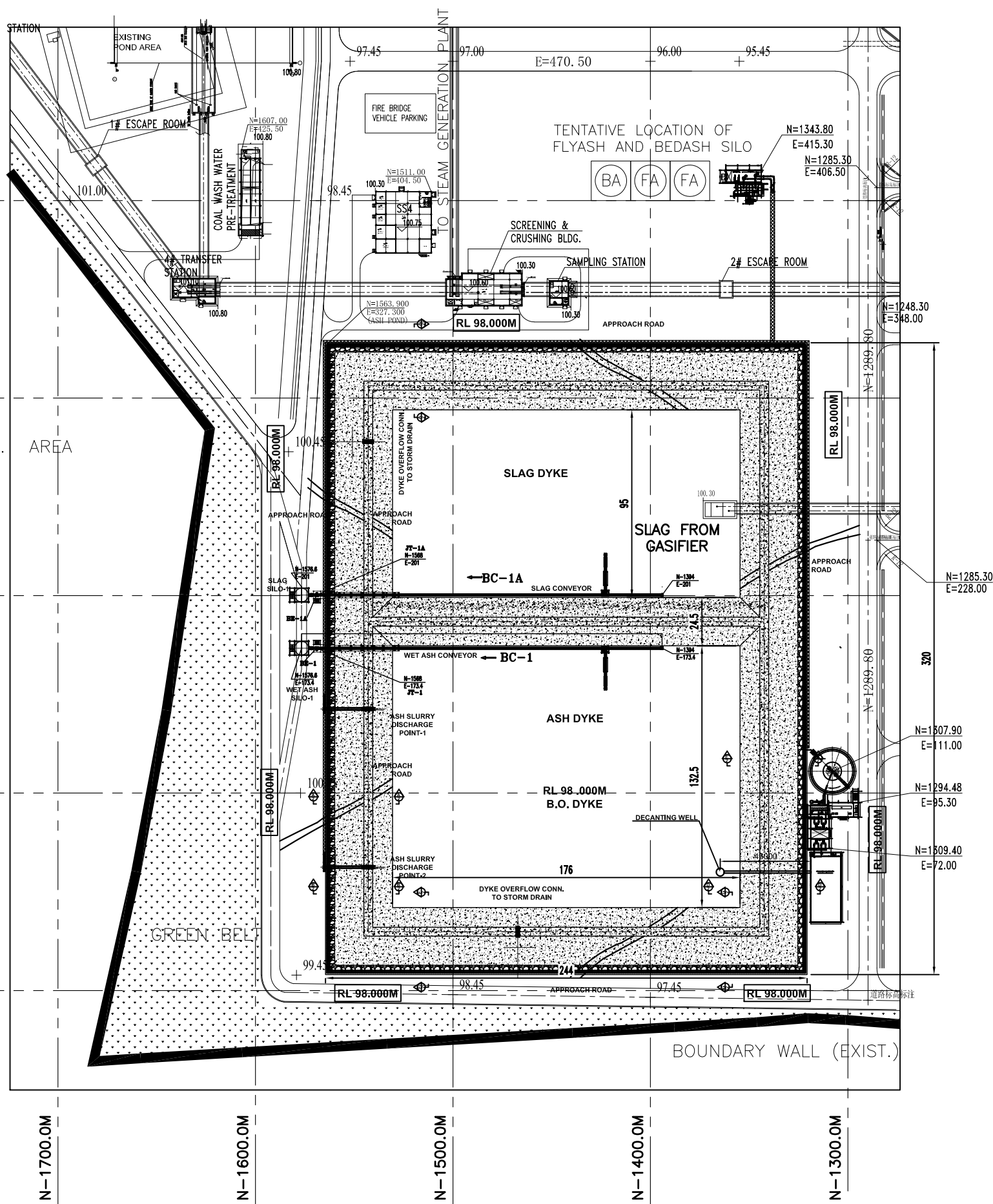
6.2 **Culverts**

Culverts shall be designed as per the following IRC codes of practices and manual. Where crane access is specified, the culverts shall be designed for the crane loads.

1. Standard specifications and code of practice for Road Bridges (Section – I - General features of design)	IRC 5
2. Standard specifications and code of practice for Road Bridges (Section-II – Load and Stresses)	IRC 6
3. Guidelines for Evaluation of Load Carrying Capacity of Bridges	SP 37



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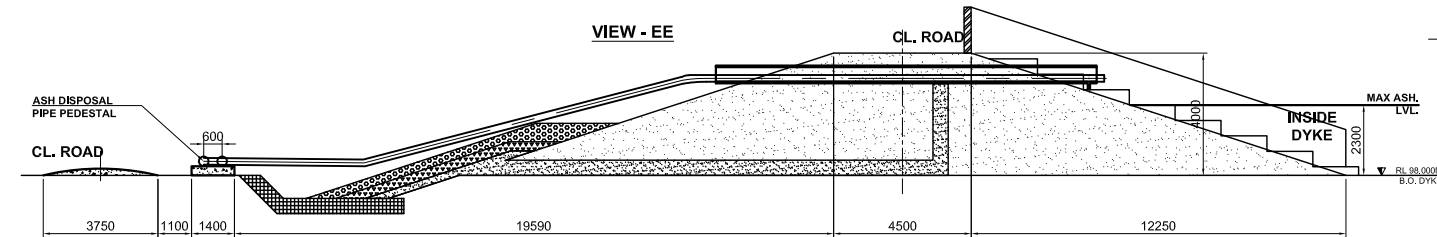
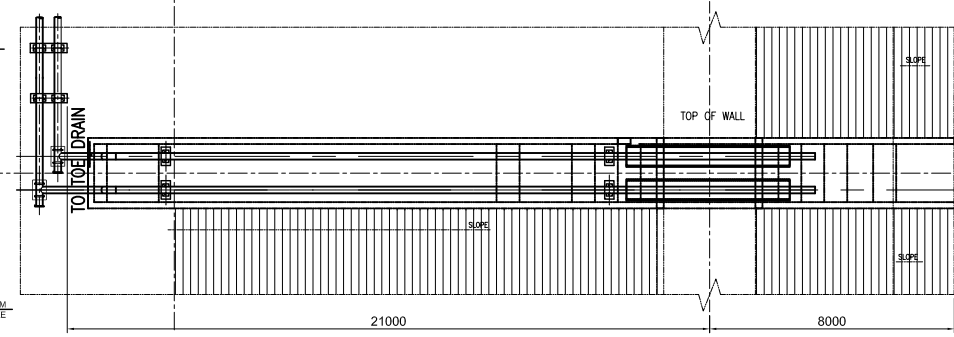
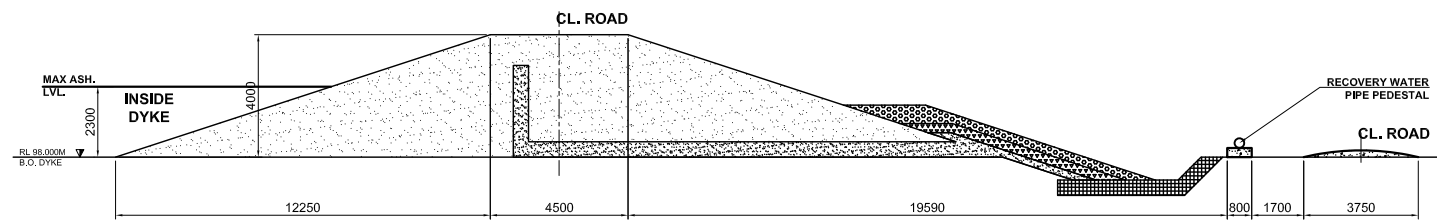
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FGL - FINISHED GROUND LEVEL
 FFL - FINISHED FLOOR LEVEL
 HPL - HIGHEST PAVED LEVEL
 TOG - TOP OF GROUT

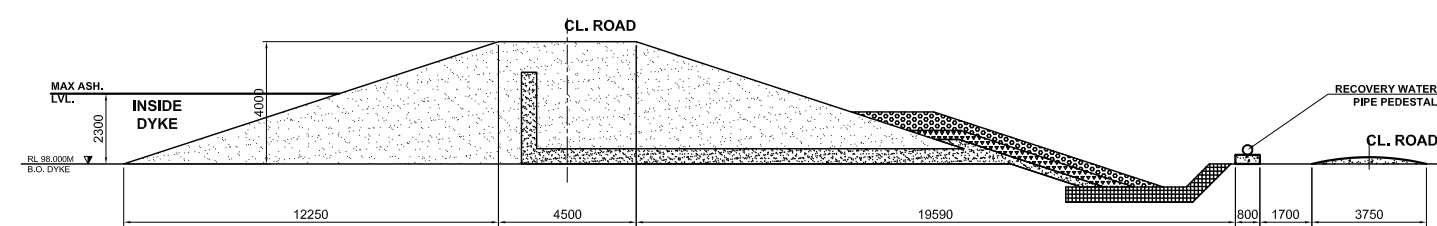
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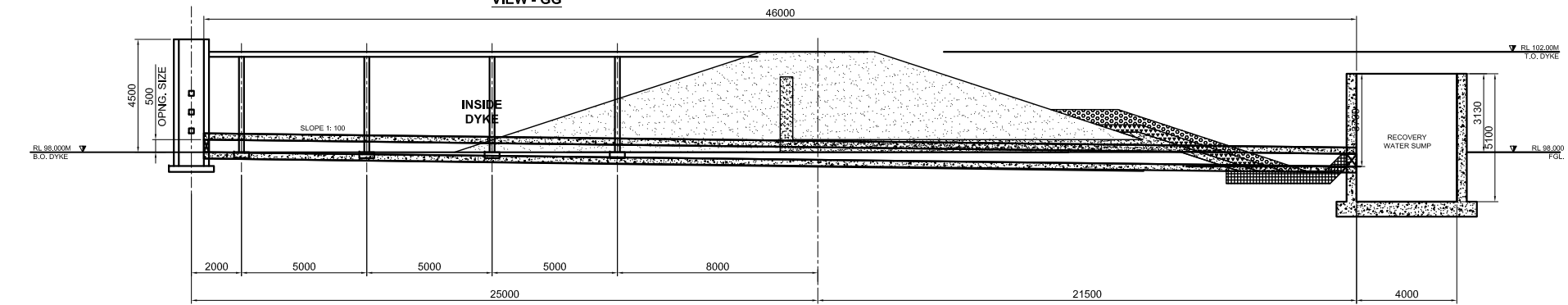
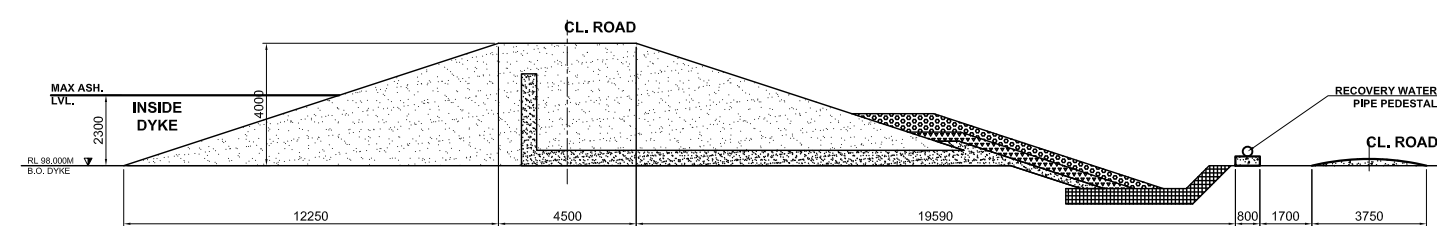
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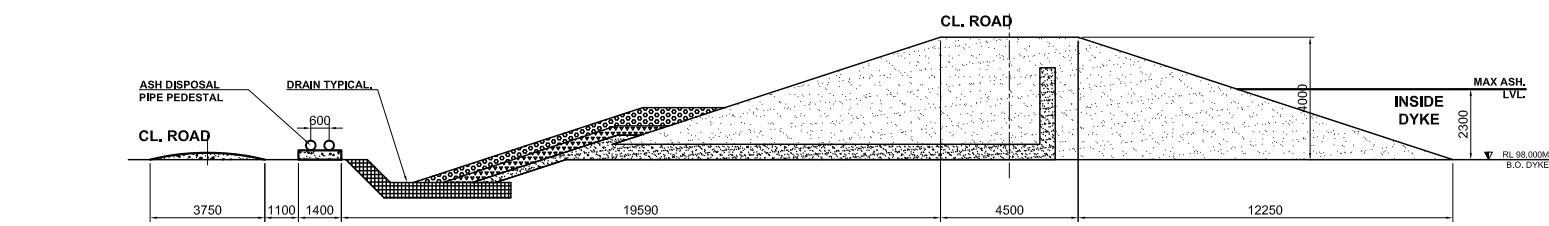
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(TYP. PIPE RAISING OVER DYKE)**



VIEW - GG



**VIEW - DD
(PIPING FROM DECANTING WELL
TO RECOVERY WATER SUMP)**



VIEW - AA

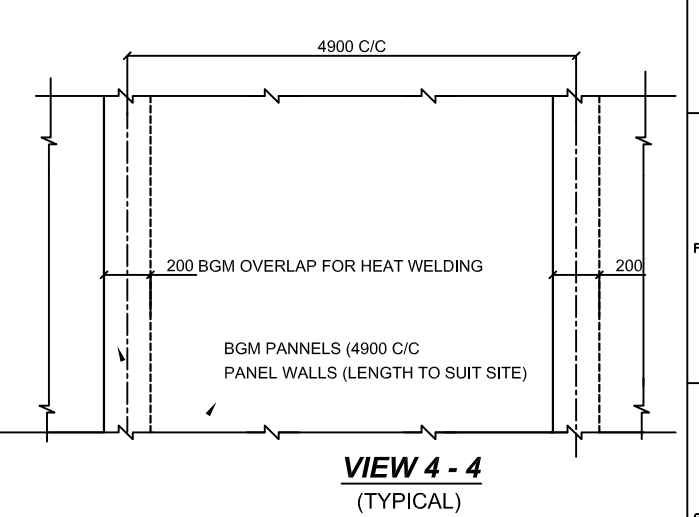
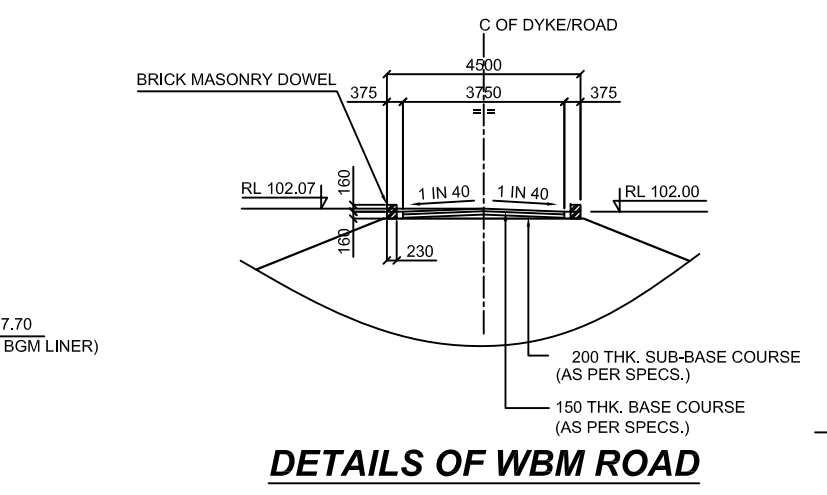
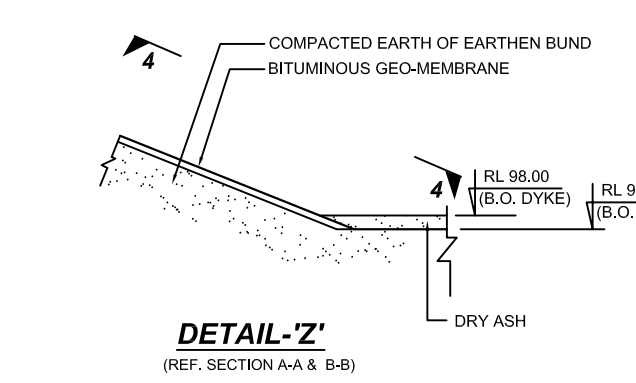
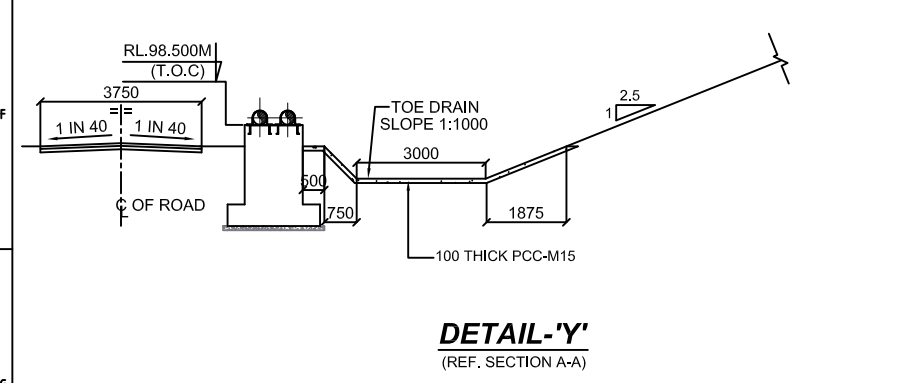
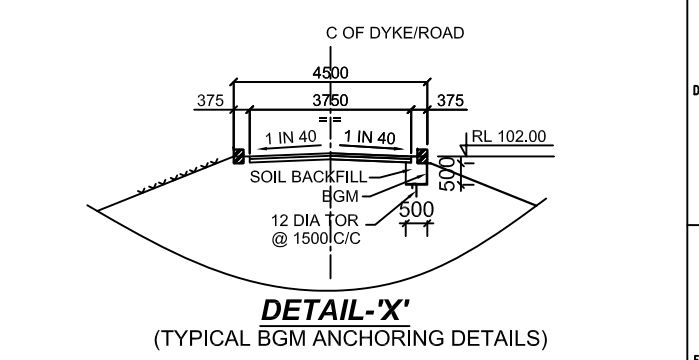
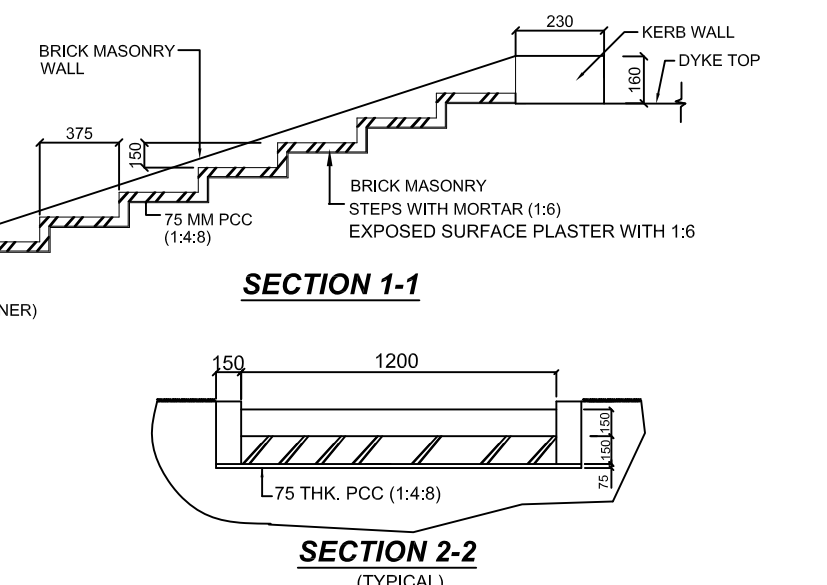
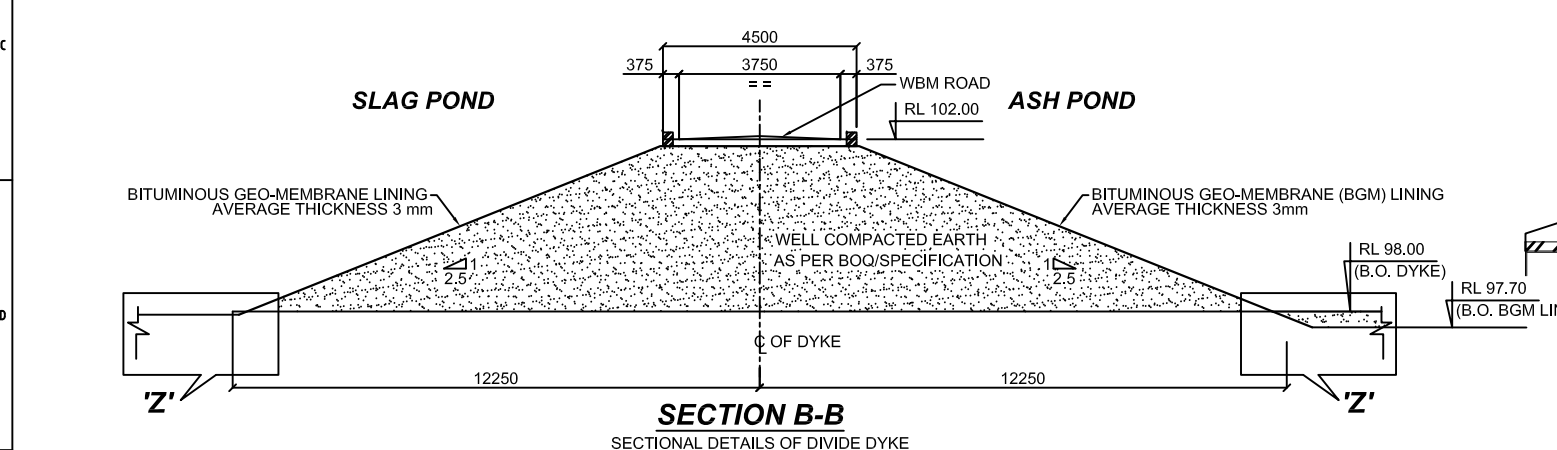
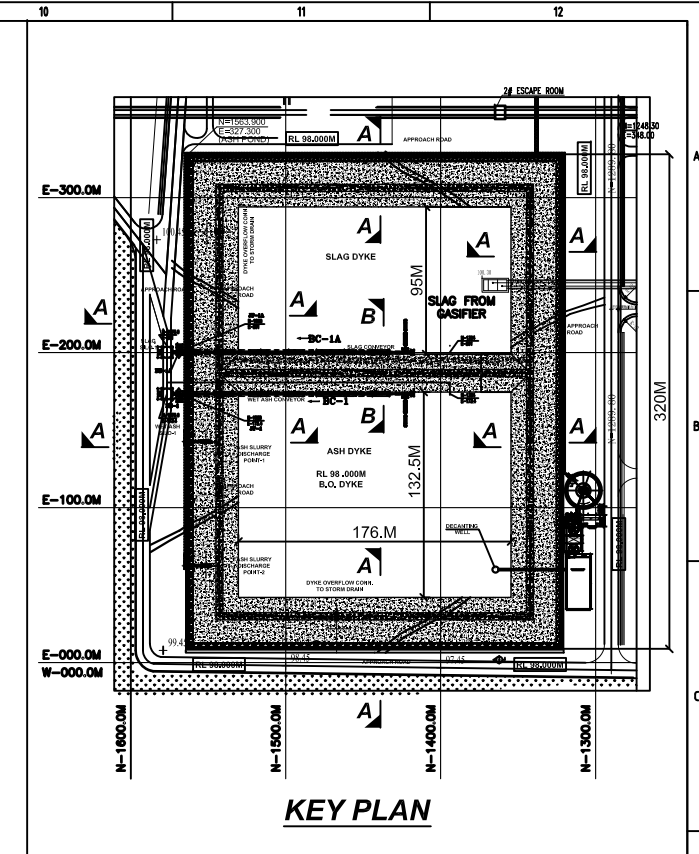
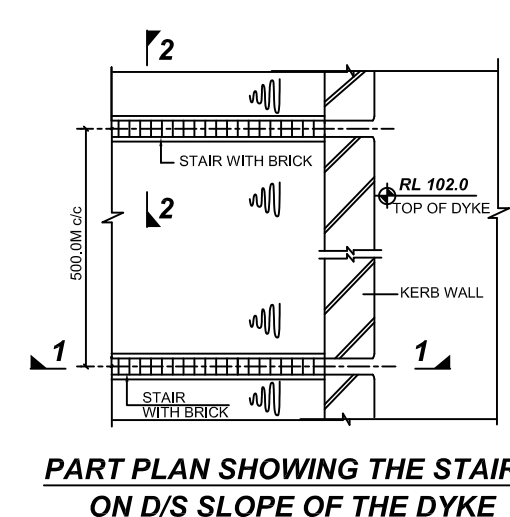
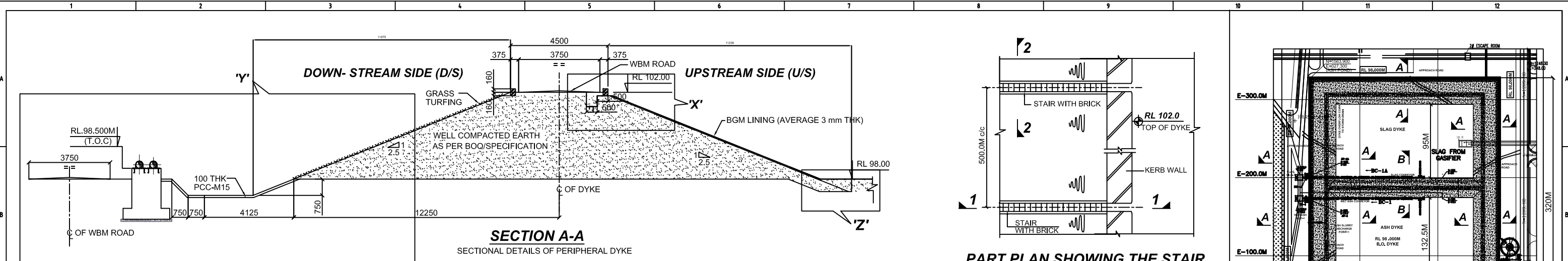
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 HPL - HIGHEST PAVED LEVEL
 TOG - TOP OF GROUT

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 - EL (+)0.000M BELONGS TO RL 98.000M
 - BGM MEAN BITUMINOUS GEOMEMBRANE OF AVERAGE THICKNESS OF 3 MM HAVING MINIMUM WIDTH OF 5m
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