SECTION –"C"

SPECIFIC TECHNICAL REQUIREMENTS FOR GENERAL CIVIL WORKS AS PER CUSTOMER TENDER

NOTE:-
RELEVENT CLAUSE TO BE ADHERED

(PEC TENDER NO.: 12/2008)

VOLUME V

SECTION - 10

CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

(PEC TENDER NO.: 12/2008)
VOLUME – V

SECTION – 10 – CIVIL, STRUCTURAL & ARCHITECTURAL WORKS

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10.0 CIVIL WORKS

10.1 Description of Civil Works and Design Requirements

10.1.1 General

This section covers all civil works and related technical services required for the construction of Simple Cycle Power Plant.

The work comprises of supply, construction and commissioning of fully functional buildings and structures to meet the requirements connected with arrangement, erection and operation of the equipment installed.

All Civil engineering and building works for every structure and item of plant required for complete power station shall be designed and detailed by the Contractor subject to the provisions of this specification and in accordance with American Standards and Codes of Practice or other European Codes as approved by the Engineer. Special attention must be paid not only to the design and construction but also to the specific local conditions.

The Contractor shall assume full responsibility for the use of :

- the most suitable materials
- appropriate design
- competent workmanship
- full serviceability in unrestricted continuous operation
- observance of relevant specifications - standards - rules and regulations

The dimensions of the buildings and structures if indicated in the bid documents are not final. The final dimensions shall be determined by the Contractor according to the approved design and requirements.

The Bidder will be deemed to have visited the site before preparing his offer, to familiarise himself with the local conditions under which the works have to be carried out and also to have an understanding about availability of access roads, labour, equipment, materials, water, electricity etc. necessary for the execution of works and for compliance with the completion date and the time schedule of the Contract.

10.1.2 Scope of Supply and Services

10.1.2.1 Scope

The works to be provided comprises of design, planning, supply of materials and equipment as well as construction and erection work for the faultless operation and easy maintenance of the power station components, which may not be explicitly stated in this specification but implied and necessarily required for the complete installation. The scope will cover but not limited to the following structures / buildings / facilities

a. GT Bay - Foundations for GT and auxiliaries and paving

b. Stack Foundation

c. Equipment and machine foundations

d. Switchgear & Control Building for Phase -II and any modifications in Phase-1 to accommodate extension of 6.6 kV switch gear and other related equipment.The work shall include the following buildings as minimum in addition to those specified elsewhere in this specification. The Switchgear & Control Building to house control consoles, MV / LV switchgears & DBs complete with offices, toilets etc. The general arrangement, equipment specification, layout, fixtures and fittings, furnishing specification, for the building / room shall be compatible with acceptable standard for power generation facilities. This building shall also house control panel, relay panel, DC system, power distribution boards, power line carrier communication equipment, RTUs etc. for the 400 kV Marib substation to be implemented in separate contract. The Bidder shall be required to coordinate with the Marib substation contractor during design of the building.The building shall be designed to meet the requirement of Phase – II as well as future requirement of Phase – III.

AC plant room shall be housed in this building

e. Foundations for transformers / busducts and Lightning arrestors. etc.

f. Masonry boundary wall for outer perimeter of paint area and internal chain link fencing for transformer areas. Temporary chain link fencing shall be provided between Phase – I work and Phase – II works. The temporary fencing shall be removed after completion of Phase – II work.

g. Civil & foundation works for treated water system, compressed air system, fire fighting system, fuel gas, fuel oil system.

h. Outdoor / indoor cable and pipe trenches or cable duct banks

i. Outdoor pipe / HVAC duct / cable racks / bridges

j. Plant area roads, drainage and sewerage with necessary treatment system.

k. Hosing complex buildings.

It is the responsibility of the Contractor to supply all labour, materials, facilities and equipment of either temporary or permanent nature, for the completion of all works.

The civil works shall comprise all necessary works for foundations buildings and structures as required to accommodate the Mechanical / Electrical equipment and other installations including requirement of hooking up with existing Phase-I wherever required and modifications but not limited to:

- Structural, civil and architectural design of all buildings, structures and foundations including also the complete structural analysis, execution and workshop drawings.
- Survey work
- Soil investigation work
- Site preparatory works
- Site installation and site offices
- Earthworks

- Foundations
- Underground structures
- Concrete works
- Earthing and lightning protection
- Roads and paving
- Storm water drainage and sewage system
- Masonry works
- Steelwork
- Doors & Windows
- Finishing works
- Sanitary installation

The Contractor may employ Sub-Contractors but in that case the Bidder must include in his offer complete details and information about the proposed Sub-Contractor.

The scope of work shall also include construction of residential apartments within the existing housing complex adjoining the power plant as part of the Project. The proposed arrangement of the apartments is shown in tender drawings.

Based on the estimate of manpower requirement and categories of personnel, different types of living quarters shall be furnished, as described below:

i. Management Residential Building

Management personnel and senior staff members are proposed to be housed in two identical two story buildings, each having eight apartments. Each apartment shall have a gross floor area of 175 sq. meters and shall have the following facilities:

- Master bed room with bath room and walk-in closet
- Two (2) bed rooms with closet
- Main bath room
- Laundry & Storage
- Dining Room
- Kitchen
- Living Room
- Family Room
- Entrance Hallway & Closet

The building shall be provided with oriental sitting room and toilet which implies the first room when entering the main door of the apartment will have a small toilet independent from family toilet.

ii. Staff Residential Unit – Family Type

For housing the staffing, two two-story buildings each having twelve apartments, have been planned. Each apartment shall have a gross floor area of 140 sq. meters and is intended for family accommodation. Each shall have the following facilities:

- Master bed room with closet
- One bed room with closet
- Main Bathroom
- Living Room
- Family Room
- Kitchen
- Dining Room
- Laundry & storage
- Entrance Hallway
- Hallway Closet

The apartment shall be provided with oriental sitting room and toilet which implies the first room when entering the main door of the apartment will have a small toilet independent from family toilet.

10.1.2.2 Exclusion

The following buildings/structure are excluded from Phase-II work as the same of Phase-I work are deemed to be sufficient for both phases of work..

a. Canteen Building

b. DG Building

c. Warehouse

d. Workshop

e. Fuel Oil Storage Area (However foundations for Fuel forwarding pump skid & metering skid are included.)

10.1.3 Site Development

The site is generally graded and is more or less flat. The proposed area of the site will be prepared so that the finished ground level of this site will match with the adjacent plant grade level. Ungraded virgin land shall be given to the Contractor by the Owner in "as it is" condition. The Contractor shall visit the site immediately after award of the contract and shall undertake all necessary surface survey and leveling works necessary for layout and

level of all structure etc., at his own cost from the general grid of the plant and benchmarks given by the Owner.

All site cleaning and grubbing within all areas where excavation filling or other construction is planned shall be done by the Contractor. The Bidder shall be responsible for furnishing all supervision, labour, tools, materials and equipment, performing all operations in connection with excavation of all materials, regardless of nature of materials, obtaining fill and backfill materials, installing and compacting of fill and back fill materials; and producing final grade line, keeping in view the surface drainage, their disposal and adjacent topography.

All necessary arrangements for stripping of surface vegetation, sods, debris, removing organic top soil and providing suitable top soil from borrow pits with necessary compaction and stabilization shall be the responsibility of the Contractor. All combustible and other waste materials shall be removed from the construction areas and disposed of by and at the expense of the Contractor. The necessary infrastructural facility & off-site development including improvement of access road condition, construction of site offices, testing facilities with necessary arrangements for lighting, water supply, sanitation etc. shall be done by the Contractor without any obligation of the Owner.

10.1.4 Boundary Wall and Fencing

The outer perimeter of entire plant shall be provided with masonry boundary wall with barbed wire at top. The minimum height or masonry wall shall be 3.0 m and the barbed wire for 0.6 m height, steel entry gate shall be provided at entry points. Fencing for transformer area shall be in the form of chain link with barbed wire at top. Minimum height of fencing shall be 2.5 M height above adjacent ground/grade level. Minimum three (3) Barbed wires shall be provided above this with suitable arrangement for anchoring.

Fencing shall comprise of 2.0M high PVC coated galvanised chain link fencing of minimum 8 gauge (including PVC coating) of mesh size 75mm and galvanised barbed wire up to a height of 0.5 M above chain link fencing excluding PVC coating shall not be less than 12 gauge. Steel entry gate shall be provided for all fenced areas.

10.1.5 Soil Investigation

Detail soil investigation shall be carried out by the Contractor for his design. If required the Soil Investigation Report of Phase-I work would be furnished during Pre-Tender meeting. (PEC to confirm)

The Contractor shall carry out his own geo-technical investigation in all works (before he commences detailed design and working drawings) for finding out the allowable bearing pressures, expected settlements, type of foundations, etc. Soil investigation by the Contractor shall be done along with laboratory testing, in sufficient depth and numbers as necessary, for complete determination of sub-soil condition as approved by the Owner before the execution of work. The Contractor shall get the approval for the field and laboratory testing scheme proposed by him from the Owner before undertaking geo-technical investigation work. The soil investigation shall be submitted to the Owner for approval and the approved report shall become the basis for design of sub-structure. Approval of the Owner shall in no way relieve the Contractor of his sole responsibility in regard to stability and safety of his design.

A comprehensive soil report shall be prepared by the Contractor through any capable geo-technical firm which covers all information regarding field, laboratory tests & recommendations, which shall include but not limited to the following items.

i. Geological information of the region.

ii. Past observations and historical data, if available, for the area or for other areas with similar profile or for similar structures in the nearby area.

iii. Procedure of investigations employed.

iv. Net safe bearing capacity and settlement computation for different types of foundations for various widths & depths.

v. Recommendation regarding roads & pavements.

vi. Recommendations regarding stability of slopes and method of compaction for filling.

vii. Aggressiveness of percolating water through sub-soil/rock fissures to reinforced concrete foundation/sub-structures and also recommended protective measures, if required.

viii. Bore hole & trial pit logs on standard proforma showing the depths, extent of various soil strata etc.

ix. A set of longitudinal & transverse profiles connecting various boreholes shall be presented in order to give a clear picture of the site, how the soil/rock strata are varying vertically and horizontally.

x. Modules of sub grade reaction from plate load test for pressure ranging up to 6 kg/cm². The recommended values shall include the effect of size, shape and depth of foundations.

xi. Deformation modules from plate load test.

xii. Coefficient of earth pressure at rest and stress strain modules of soil from Menard pressure meter test.

xiii. Recommendations regarding method and slope of deep excavations.

xiv. Potential of rock slides and methods of stabilisation for slides for very steep cut if applicable.

xv. Evaluation of deign parameters for design and analysis based on dynamic parameters of soil like amplitude vs. frequency curves, co-efficient of elastic uniform compression and elastic uniform shear, elastic modulus, value of damping co-efficient, shear modulus and poison's ratio of soils.

xvi. Recommendations for the type of cement to be used and any treatment to the underground concrete structures based on the chemical composition of soil and sub-soil water.

xvii. Soil resistivity tests and its recommendation.

xviii. Yield test to determine ground water potential for water treatment plant requirements.

Foundations

a. All building, major equipments and structures shall be founded on RCC foundation of suitable type depending upon the findings of soil investigation.

b. The minimum depth of foundation shall be 1000mm from existing ground level.

c. The minimum thickness for pile cap shall be 500mm and for spread footings it shall be 150mm.

d. The foundation for circular steel tank resting on ground, when permissible from allowable bearing pressure and settlement, shall be reinforced concrete ring type and the earth inside the ring shall be removed upto 1.0m minimum or more from original ground if suitable bearing soil is not encountered and then backfilled with sand in a 200 mm layer and compacted to 95% proctor density. The top of the foundation shall be covered with 100mm thick (minimum) bituminous conglomerate material.

10.1.6 Construction Water

The contractor shall make his own arrangement for construction water so that uninterrupted supply of construction water is ensured.

10.1.7 Structural Design Criteria

10.1.7.1 Codes & Standards

The design & engineering work shall be carried out as per American Standards. However where specific American Standards are not listed then other relevant international standards as applicable shall be followed.

10.1.7.2 List of Standards Bodies

AASHTO	-	American Association of State Highway and Transportation Officials
ACI	-	American Concrete Institute
AISC	-	American Institute of Steel Construction
ANSI	-	American National Standards Institute
ASCE	-	American Society of Civil Engineering
ASTM	-	American Society for Testing and Materials
AWS	-	American Welding Society
API	-	American Petroleum Institute
DIN	-	Deutsches Institut fÜr Normung e.v. (German Standards)

ANY OTHER INTERNATIONALLY AUTHORIZED STANDARD OR EQUIVALENT MAY BE SUBSTITUTED FOR THE ABOVE. ALSO THE MANUFACTURER'S STANDARD AND/OR PRACTICE WILL BE APPLIED UNDER THE ENGINEER'S APPROVAL.

10.1.7.3 List of Codes for Design & Construction.

General

UBC 1997	Uniform Building Code (USA)
UBC Chapter 7	Fire-resistant Materials and Construction
ASCE 7 – 02	Minimum Design Loads for Buildings and other Structures (2002)
DIN 4024	Machine Foundations Part 1 & 2 for the dynamic analysis of gas turbine and generator foundation

AASHTO	Standard Specifications for Highway Bridges, 16th Edition 1996
TRRL	Design Note 87 Structural Design of New Road Pavements
TRRL	Report 1332 Road Pavement Design

Structural Steel

AISC	Code of Standard Practice for Steel Buildings and Bridges, March 7, 2000
AISC	Manual of Steel Construction ASD (Allowable Steel Design) 9th Edition
AISC	Specification for Structural Steel Buildings, ASD and Plastic Design June 1, 1989
AISC	Supplement No. 1 December 17, 2001 to the Specification for Structural Steel Buildings ASD and Plastic Design, June 1, 1989
AISC	LRFD Specification for Structural Steel Buildings. December 27, 1999
AISC	LRFD Specification for Steel Hollow Structural Sections. November 10, 2000
AISC	Specification for ASD of Single – Angle Members. June 1, 1989
AISC	LRFD Specification for Single – Angle Members. November 10, 2000
AISC	Specification for Structural Joints Using ASTM A325 or A490 Bolts. June 23, 2000
AISC	Seismic Provisions for Structural Steel Buildings. May 21, 2002
AWS D1.1-94	Structural Welding Code - Steel

Reinforced Concrete Structures

ACI 117 – 90	Standard Tolerances for Concrete Construction & Materials
ACI 121 R – 98	Quality Management Systems for Concrete Construction
ACI 201.2 R-01	Guide to Durable Concrete
ACI 207.1R-96	Mass Concrete
ACI 211.1-91	Selecting Proportions for Normal, Heavy-Weight and Mass Concrete
ACI 211.5R-01	Guide for Submittal of Concrete Proportions
ACI 212.3R-91	Chemical Admixtures for Concrete
ACI 214-89	Practice for Evaluation of Strength Test Results of Concrete
ACI 222 R-01	Corrosion of Metals in Concrete
ACI 224-3R-95	Joints in Concrete Construction
ACI 232.1 R-94	Use of Natural Pozzuolana in Concrete
ACI 234R-96	Guide for use of Silica Fumes in Concrete
ACI 301-99	Specifications for Structural Concrete
ACI 302.1R-96	Guide for Concrete Floor & Slab Construction
ACI 304.2R-96	Placing Concrete by Pumping Methods
ACI 304R-00	Guide for Measuring, Mixing, Transporting and Placing Concrete
ACI 305 R-99	Hot Weather Concreting
ACI 308-01	Standard Practice for Curing Concrete
ACI 309 R-96	Guide for Consolidation of Concrete
ACI 315-92	SP-066(94) ACI Detailing Manual
ACI 318 M-99	Building Code Requirements for Structural Concrete (Metric)
ACI 325.9R-91	Construction of Concrete Pavements and Bases
ACI 330 R-01	Design & Construction of Concrete Parking Lots
ACI 347R-01	Guide to Formwork for Concrete
ACI 349-01	Nuclear Safety Related Concrete Structures (Part related for Design of anchor bolts holding down the Gas Turbine Generator, Exhaust Stack and other equipment
ACI 349 R-01	Commentary Appendix B – Steel Embedments

ACI 350.03-01	Liquid-Containing Concrete Structures
ACI 350R-01	Environmental Engineering Concrete Structures
ACI 351.1R-93	Grouting for Support of Equipment and Machinery
ACI 360R-97	Design of Slabs on Grade
ACI 408.1R-90	Hook Provisions for Deformed Bars in Tension
ACI 408.2R-92	Bond under Cyclic load
ACI 439.3R-91	Mechanical Connections of Reinforcing Bars
ACI 504R-93	Joint Sealants for Concrete Structures
ACI 515-IR	Water Proofing
ACI 515.1R-79	Decorative Barrier Systems for concrete
ACI 530-02	Masonry Structures
ACI 530.1-02	Masonry Structures
ACI SP-299	ACI Manual of Concrete Inspection

10.1.7.4 List of Standard Specifications for Materials

Steel Structures

ASTM A6/AM-01	Rolled Structural Steel Bars, Plates, Shapes and Sheet Piling
ASTM A36/A36M-00	Carbon Structural Steel
ASTM A53/AM53-01	Pipe, Steel, Black & Hot-Dipped, Zinc-Coated Welded and Seamless Steel Pipe
ASTM A242/A242M-00	High-Strength Low Alloy Structural Steel
ASTM A307-00	Carbon Steel Bolts & Studs
ASTM A325/A325M-00	Structural Bolts, Steel, Heat Treated 120/105 KSI Minimum Tensile Strength
ASTM A490/A490M-00	Heat-Treated Steel Structural Bolts, 150 KSI Minimum Tensile Strength
ASTM A500-01	Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds & Shapes
ASTM A501-01	Hot-Formed Welded and Seamless Carbon Steel Structural Tubing
ASTM A563/A563M-00	Carbon and Alloy Steel Nuts
ASTM F436-93(2000)	Hardened Steel Washers
ASTM A992/A992M	Steel for Structural Shapes for Use in Building Framing
ASTM A6/A6M	Standard Profiles (American)
Euro Norm 53-62/ DIN 1025/3	Standard Profiles (European)

Concrete Structures

ACI SP-071	ASTM Standards in ACI 318 N.B. This publication is a compilation of all the ASTM standards cited in ACI 318. It contains all 48 ASTM Standards.

10.1.8 Design Conditions

10.1.8.1 Site Conditions

Site Locations

The project is a Phase-II work of Marib Power Project, Republic of Yemen. The site is located near Yemen Hunt Oil fields and Refinery. It is close to the town of Marib,

approximately 15 KM to the north. The site elevation is about 1100 meters above the mean sea level.

Geological Characteristics

The geology is predominantly ballistic with periodic outcroppings of lime stone. The proposed plant site is generally graded and is more or less flat. Piling foundations are not envisaged for this site. Normal spread footing or mat foundation may be adopted. Minimum depth of footings, safe bearing capacity shall be finalized after receipt of Soil Investigation Report from the Contractor after award of work.

Datum Level

All levels are based on Datum as +0.000m, which correspond to finished grade slab level of Phase-I GT area.

EL+0.00 m (FINISHED GROUND FLOOR LEVEL)

EL-0.300 m (FINISHED GRADE LEVEL)

In all drawing Levels shall be indicated by EL only.

Climatic Conditions

Ambient Temperature

Min.	-	0°C
Max.	-	50°C

Relative Humidity

Min.	-	2%
Max.	-	98%
Design condition	-	60%

Rain fall

Average annual rainfall	-	less than 100 mm

Wind Speed

Basic wind speed of 34 m/s. (120 KM/hr). Occasional sand storm.

Seismic

Seismic zone 2A as per UBC and shall have a seismic acceleration of 0.15 g.

Ground Water Level for Design

Water level for design purpose shall be considered as per Soil Investigation Report

10.1.9 Material

Materials will conform to the Codes and Standards listed under clause 10.1.7.4 in this Section. As for the materials other than specified therein such as coarse and fine aggregate, brick, concrete block, architectural finish materials, etc., first choice shall be locally available materials conforming to the relevant sections of the Project Technical

Specifications Volume III (Civil). Gradation of course and fine aggregate shall comply with ASTM C-31.

10.1.9.1 Concrete

Cement

Sulphate resisting Cement conforming to ASTM C150 Type-V and Type-I shall be used for all substructures and superstructure concrete works respectively.

Concrete Grade

The minimum grade based on cube test at 28 day age will be as follows:

LOCATION	CONCRETE GRADE	CUBE STRENGTH fc N/mm²
Gas Turbine Generator Foundation and all other Under Ground Concrete works.	Grade 35	35
General R.C Structures	Grade 25	25
Plain, Levelling, Blinding concrete under Foundations, Grade Beams and Slabs on Grade. Plain concrete used for miscellaneous levelling and filling.	Grade 20	20

Reinforcing Bar

Reinforcement bars will conform to ASTM A-615, grade 60.

Yield strength of Fy = 414 MPa. All reinforcing bars shall be have fusion bonded epoxy coatings

Cover to Reinforcement

Cover to reinforcement bars shall be as follows.

Section	Top (mm)	Bottom (mm)	Sides (mm)
Foundation & Pedestal	75	75	75
Wall in Contact with Soil	50	75	50

Grade Beams	50	50	50
Grade Slab	40	40	40
External Columns & Beams	50	50	50
Internal Columns & Beams	40	40	40
Slab & Staircase	35	35	35

10.1.9.2 Structural Steel

Material shall conform the following:-

Structures

Main Structural Elements	ASTM A36
Crane rail	ASTM A730-81 or Equivalent

Bolts

a. High strength friction grip bolt (HSFG)	ASTM A325 Type - 1 or equivalent
b. Ordinary bolt	ASTM A307 Grade - A or equivalent
Electrodes for welding (Low Hydrogen type)	AWS (E7016)
Anchor Bolt, embedded metal	ASTM A307 & A36 or equivalent

Other Materials

a. Grating	Galvanized ASTM A569 or equivalent.
b. Checkered Plate	ASTM A36 or equivalent
c. Handrail	ASTM A53 or equivalent.
d. Kick Plates	ASTM A36 or equivalent.
e. Stairs and Ladders	ASTM A36 or equivalent
f. Window Glass	Insulated glass consisting of 2 panes of 6mm thick, separated by 12mm dehydrated air space.

10.1.10 Structural Design

10.1.10.1 General

The structural design for steel structures shall be in accordance with the Allowable Stress Design method as per AISC manual and that for concrete structures shall be in accordance with Strength Design Method specified in ACI codes. Type, size and weight of all foundations will be determined by structural analysis in consideration of actual soil condition, design codes and standards.

10.1.10.2 Loads

Dead Loads (DL)

Dead load shall be calculated from unit weights of materials.

Typical values are shown below:

Steel	:	78.50 kN / m³
Concrete (reinforced)	:	25.00 kN/ m³
Concrete (plain)	:	24.00 kN/m³
Block work/Brick Work	:	20.00 kN/m³
Double skinned metal sheet	:	0.2 kN/m²
Single skinned metal sheet	:	0.1 kN/m²

Piping & Cable tray loads

Loading in accordance with Mechanical / Electrical requirement would be considered in the design.

Live Loads (LL)

Roof	:	1.50 kN/m²
Roof without access	:	0.75 kN/m²
Precast R.C covers for Mechanical / Electrical trenches	:	15.00 kN/m² UDL + 70kN Point Load
Checkered Plate Steel covers for Electrical Room	:	15.00 kN/m²
Out door precast R.C covers for Mechanical / Electrical trenches	:	20.00 kN/m² UDL + 70kN Point Load
Switchgear & Control Building	:	15.00 kN/m² UDL
Corridors, platforms & stairways	:	5 kN/m²
Surcharge on backfills for Underground Water Tank design	:	20.00 kN/m²

Loads due to equipment like HVAC, Ducts, Light Fixtures, Cable trays etc. would be considered in the design in accordance with Mechanical/Electrical requirements.

Crane loads will be considered under this load case.

Equipment Loads (ML)

i. Loadings both static (and dynamic) of major equipments, supported, on structural floors shall be obtained from the manufacturer's drawings of the specific equipment.

ii. All equipment, tank and piping design loads will include hydraulic testing loads.

iii. Crane girders and columns will be designed for vertical and horizontal forces (including impact forces) as developed from crane weights and wheel loads.

iv. Weight of equipments, ducts, tanks, pipes conduits etc. supported by structure shall include maximum possible loading conditions i.e. flooded material contents and associated impacts, test loadings, anchorage on restraint effects.

v. Suitable hung loads for piping, electrical ventilation and air conditioning shall be assumed.

Impact and Dynamic Loads

The following impact loads will be applied unless the manufacturer of equipment specifies these loads.

a. Gas Turbine Generator : As per manufacturer data
b. Cranes : As below

The lateral force on crane runways to provide for the effect of moving crane trolleys shall be not less than 20% of the sum of weights of the lifted load and of the crane trolley, but exclusive of other parts of the crane. The force shall be assumed to be applied at the top of the rails.

The longitudinal tractive force shall be not less than 10% of the maximum wheel loads of the crane applied at the top of the rail.

When the manufacturer of equipment specifies the loads, such loads shall be considered in the design instead of the above.

Wind Loads (WL)

The wind loads will be calculated based on UBC.

Basic wind speed	V	=	34 m/s
Exposure Factor		=	C
Occupancy Category		=	1

Seismic Load (EL)

The seismic loads will be calculated based on UBC.

Seismic Zone Factor		=	2A
Soil Profile		=	Sd
Occupancy Category		=	1
Source Factor	Na	=	1.0
Source Factor	Nv	=	1.0

Sand Deposition Load(SD)

Suitable sand load shall be considered for wind swept desert sand accumulation.

Temparature Load(TL)

The structures shall be designed to withstand stress due to fifty (50) percent of the total temperature variation. The total temperature variation for temperature loading should be taken as two-third (2/3) of the average maximum annual variation for this purpose which will be taken as the difference between the mean daily temperature during the coldest month of the year and the mean daily maximum temperature during the hottest month of the year.

10.1.10.2 Load Combinations

The structures and all parts thereof shall be capable of withstanding the permissible settlement, deflection and stress limits arising out of the worst practicable combination of dead and live loads, wind / seismic loads, erection forces, secondary stresses impact, temperature and shrinkage effects, except that wind and seismic forces shall not be assumed to act together.

Design load factors applicable (for foundation design, member design, stability, etc.) as per relevant codes shall be applied to the basic loads.

10.1.10.3 Deflections

Structural steel

The maximum allowable deflections are specified as follows :

1. Vertical deflection of beams due to imposed load

a.	Cantilevers	:	L / 180
b.	Beams carrying plaster	:	L / 360
c.	Other Beams	:	L / 200
d.	Girts	:	L / 180

2. Horizontal deflection of columns due to imposed load and wind load

a.	Top of columns (single storey)	:	H / 300
b.	Top of columns in each storey	:	H / 300

3. Crane girders

As per crane Manufacturer requirements or specified as follows :

a.	Overhead traveling crane girder of Turbine Hall Building Vertical deflection due to static vertical wheel loads from overhead travelling cranes	:	L / 600 without impact

Horizontal deflection (calculated on the top flange properties alone) due to horizontal crane loads : L / 600 without impact

b. Crane and hoist support beam rail & monorail support
Vertical : L / 600 without impact
Horizontal : L / 600 without impact
where L: span; H: Height

Concrete Structures

The maximum allowable deflections are specified as follows as per Table 9.5(b) ACI 318

Type of member	Deflection to be considered	Deflection Limitation
Flat roofs not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to live load LL	L / 180
Floors not supporting or attached to nonstructural elements likely to be damaged by large deflections	Immediate deflection due to live load LL	L / 360
Roof or floor construction supporting or attached to nonstructural elements likely to be damaged by large deflections	That part of the total deflection occurring after attachment of nonstructural elements (Sum of the long-time deflection due to all sustained loads and the immediate deflection due to any additional live load)	L / 480
Roof or floor construction supporting or attached to nonstructural elements not likely to be damaged by large deflections		L / 240

Where L = Span

10.1.10.4 Design Criteria for GTG Foundation

Design of Gas Turbine foundation shall be as per manufacturer's recommendation generally.

Machine Data

Foundation outline and loading data drawing of manufacturer.

Modelling

The following points shall be considered while constructing the model for analysis.

1. The GTG foundation shall be modelled as plate elements and founding media is idealised as springs in all three directions.
2. Nodes are specified at all supports and load points.
3. Lumped mass approach is used for computing nodal masses for dynamic analysis.
4. Long term modulus of elasticity of concrete is used in analysis

Loads and Load combinations

The following loads shall be considered for analysis and design of foundation

a. Dead Load
Dead Load of the foundation block is mainly the self weight of the GT foundation.

b. Equipment Load
Static equipment loads are mainly due to weight of the stator & rotor of the gas turbine and generator as provided by the manufacturer.

c. Dynamic Loads
Dynamic loads are mainly due to unbalanced loads of the Gas Turbine & Generator as provided by the manufacturer.

d. Loads due to operating nominal torque

e. Loads due to Exhaust Gas Back Pressure

f. Loads due to Thermal Expansion

g. Loads due to Bolt tightening and erection or maintenance force

h. Loads due to sudden failure of buckets and blades

i. Loads due to electrical short circuit

j. Seismic Loads

k. Wind load

Load Combinations

The following load combinations shall be considered for analysis and design of gas turbine foundation.

Combination of loads at the Serviceability limit state:

a. **Checking of the Bearing Pressure**

[Dead Load] + [Resultant of Normal Torque] + [Expansion] + 3 x λ_1 [Static Loads due to Unbalanced Forces] + [Exhaust Gas Back Pressure]

b. **Checking of the uplift condition**

[Dead Load] - [Resultant of Normal Torque] - [Expansion] - λ_1 [Static Loads due to Unbalanced Forces] - [Exhaust Gas Back Pressure]

c. **Checking of the static rigidity of the foundation**
[Dead Loads] ± [Resultant of Normal Torque] ± [Expansion] ± λ_1 [Static Loads due to Unbalanced Forces] ±[Exhaust Gas Back Pressure]

Combination of loads at the Ultimate Limit State

a. Checking of the Bearing Pressure

[Dead Load] + [Expansion] + λ_2 [static load due to blade breaking from the turbine rotor] + [Exhaust Gas Back Pressure]

[Dead Load] + [Expansion] + λ_2 [static load due the maximum force of false - coupling on the generator] + [Exhaust Gas Back Pressure]

[Dead Load] + [Expansion] + λ_2 [static load due to the blade breaking of the generator fan] + [Exhaust Gas Back Pressure]

b. Checking of the Condition of Lateral overturning

[Dead Load] - [Expansion] - λ_2 [static load due to blade breaking from the turbine rotor] - [Exhaust Gas Back Pressure]

[Dead Load] - [Expansion] - λ_2 [static load due to the breaking of a blade of the generator fan] - [Exhaust Gas Back Pressure]

[Dead Load - [Expansion] - λ_2 [static load due to the breaking of a blade of the generator fan] - [Exhaust Gas Back Pressure]

[Dead Load] - [Expansion] - [Resultant of Normal Torque] - [transversal seismic load]
Where : λ_1 and λ_2 - Dynamic Magnification Factors

Analysis

General

Linear elastic analysis at 3D model shall be performed with STAADPro package.

Static Analysis

Static analysis is performed for checking of bearing pressure and uplift condition in both serviceability limit state ultimate limit sate and checking of state rigidity of the foundation.

Dynamic Analysis

Frequency Calculation :

Lumped mass approach shall be used for evaluating the natural frequency of foundation.

Amplitude Calculations:

Time history analysis shall be used for computation of amplitudes.

Mass of Foundation

The total weight of the Foundation shall be at least 3 times the weight of the rotating parts of the GTG equipment including; Gas Turbine and generator rotors, load and accessory couplings and any other rotating parts in the Accessory Module

Acceptance Criteria

Natural Frequency

The foundation natural frequencies shall be atleast 20% away from the machine operating frequency and critical speed of machine.

Amplitude of Vibration

The amplitude shall be limited to prescribed value for specified loading by the manufacturer.

Displacement

Displacement of the foundation shall be limited to the value specified by the manufacturer.

Requirements of DIN 4024 will be considered for aspects not covered in manufacturer specification.

10.1.10.5 Design criteria for Other Equipment Foundation.

- Foundations supporting rotating and vibration devices shall be designed so as to prevent any transmission of harmful vibration to adjacent structures.
- The weight of the foundation block for a rotating machine shall not be less than 3 times the weight of the rotating machine and its driver. (for small Pump foundations where dynamic analysis is not necessary.)
- Foundation for inter connected machinery shall be designed so as to avoid differential settlement.
- The maximum allowable total settlement and the differential settlement as per codes and standards.

10.1.10.6 Anchor Bolt Embedment Design

Appendix B of ACI-349 defines the design requirements for steel embedment in concrete elements. The under lying philosophy is to assure ductile failure mode. This philosophy leads to the requirement that the concrete pull-out strength must be greater than the tensile strength of the embedded anchor bolt. As per Appendix B of ACI-349.

Anchor Bolt Tensile Strength

Anchor bolts shall be A307 bolts. This is an ASTM designation A36 grade steel and for treaded round stock f_u = 58 Ksi. (Kips per square inch)

For A307 bolts with Basic Major Nominal Diameters (D) the following table provides the tensile stress areas as and the tensile strength F.

D (in)	5/8	¾	7/8	1	1 1/8	1 ¼
As (in^2)	.226	.334	.462	.606	.763	.969
F (Kips)	13.11	19.37	26.80	35.15	44.25	56.2
F (KN)	58.34	86.20	119.26	156.42	196.91	250.09

Concrete Pullout Force

The anchor bolt installation detail shall be followed to be in compliance with the minimum requirements of ACI 349.

Minimum Side Distance / Lateral Bursting

The code specifies a minimum side cover distance at the anchor head to confine the lateral thrust generated by the full load transfer from steel to concrete and prevent failure due to lateral bursting forces at anchor heads.

10.1.10.7 BUILDING/STRUCTURE FOUNDATIONS

All buildings, Structures / equipments shall be supported on shallow foundations. All foundation surfaces in contact with soil will be protected using protective impervious membranes.

Bearing capacity of soil, depth of foundations, soil parameters, etc. shall as per Soil Investigation report.

Stability of foundations

Stability against Overturning

The minimum safety factor against overturning during construction or erection shall be 1.5. For normal operating load conditions, it shall be 2.0 and for cases of transient loads, such as earthquake or wind it shall be 1.5.

Stability against Sliding

The minimum safety factor against sliding shall be 1.5. The coefficient of friction used in computing the safety factor against sliding for cast-in-place foundations shall be 0.50, unless specified otherwise in a detailed soil investigation. Passive earth pressure from backfill shall not be considered in computing these safety factors.

Stability against flotation

All foundations subject to buoyant forces shall be designed to resist a uniformly distributed uplift equal to the full hydrostatic pressure. The minimum safety factor against flotation shall be 1.10, considering the highest anticipated water level.

Increase in Allowable Bearing Pressures

Allowable bearing pressures under foundations shall be increased by one third for load cases considering extreme load like wind or seismic forces, either acting alone or when combined with vertical loads.

10.1.11 Description of Major Civil Works

10.1.11.1 Buildings

The outlines of the buildings are shown in the Tables below. The buildings shall be analysed by applying all the primary loads like dead loads, live loads, equipment loads, wind loads and seismic loads. Appropriate load combinations shall be considered for the analysis and design.

Switchgear & Control Building

ITEM		SPECIFICATION
Building Scale	Building Size (W x L x H) Story	To be decided by the Bidder Two Story with basement
Foundation	Foundation Type	Mat foundation
Superstructure	Structure	Reinforced Concrete
	Exterior Wall	Cavity wall
	Floor & Roof	Reinforced Concrete slab
Exterior Finish	Exterior Wall	Plaster and Paint
	Roof	Built-up roofing

10.1.11.2 Housing Complex

3-bed Room, 2-bed room,.

ITEM		SPECIFICATION
Building Scale	Building Size (W x L x H) Story	Refer attached drawings Two Story
Foundation	Foundation Type	Isolated spread footings
Superstructure	Structure	Reinforced Concrete
	Exterior Wall	Cavity wall
	Floor & Roof	Reinforced Concrete slab
Exterior Finish	Exterior Wall	Plaster and Paint
	Roof	Built-up roofing

10.1.11.3 GTG Associated Equipment Foundations and Structures

GTG Foundations

Gas Turbine Foundation design/construction is already covered under Clause 10.1.9.4 above.

PEECC (Packaged electrical and electronics cubicle centre) Foundations

PEECC foundations will be of reinforced concrete Pit construction. Loads as per manufacturer data and soil lateral pressure shall be considered for the design.

Exhaust Duct & Exhaust Stack Foundations

Exhaust Duct & Exhaust Stack Foundations will be of reinforced concrete construction. Loads as per vendor data shall be considered for the design. Load data shall be verified for taking care of site wind conditions.

GT Auxiliaries Compartment Foundations

GT Auxiliaries Compartment foundations will be of reinforced concrete construction. Loads as per manufacturer data and soil lateral pressure shall be considered for the design.

Bus Duct Support Foundations

Bus Duct Support foundations will be of reinforced concrete construction. Loads as per manufacturer data shall be considered for the design.

GT Drain Oil Tank and G T Wash Water Drain Tank

Gas Turbine Drain Oil tank shall be housed in an underground reinforced concrete tank covered with precast concrete panels spaning the short direction of the open-vault type tank with width of panels not exceeding 600 mm . GT Wash Water Drain Tank shall be a monolithic underground reinforced concrete tank with a manhole for access.

10.1.11.4 B.O.P. Electrical & Mechanical Equipment Foundations.

Generator Transformer Foundation.

Generator Transformers will be supported on steel channels on concrete foundations with oil containment wall of concrete. Concrete Fire barrier walls will be provided between this transformer and adjacent transformer.

Other Transformer Foundations

Other Transformers will be supported on steel channels on concrete foundations with oil containment wall of concrete.

Common Oil Collection Tank for Transformers

Common Oil Collection Tank for Transformers shall be a monolithic underground reinforced concrete tank with a manhole for access.

10.1.11.5 Mechanical & Electrical Trenches, duct banks & Manholes

Cast-in-Situ Trenches and Precast Concrete Trench Covers

Utility trenches shall be of concrete walls on concrete slabs with precast concrete covers.

Cast-in-Situ Manholes

Cast-in-Situ Manholes shall be of concrete construction with a steel cover for access.

Duct Banks

Reinforced concrete duct banks shall be provided for running electrical cables. Cast-in-Situ Manholes shall be provided at every change of direction and junctions.

10.1.12 Site Development Works

10.1.12.1 Site Grading

Site grading shall be done by removing top loose sand not less than 150mm thick and replacing with compacted course grained soil, proof loaded and giving adequate slope for the drainage of storm water towards gully chambers.

10.1.12.2 Surface Roads

Access roads to the new areas shall be constructed in continuation of the existing road network. The minimum turning radius from the inside edge of the road shall be 10.5 m for 8.0 m wide road and 9 m for 6 m wide roads.

Surface drainage of roads shall be provided by giving proper longitudinal slopes and cross falls.

Desirable gradient of road should be 1 in 12.5 with maximum 1 in 10.

The roads and car park shall be constructed with the following as minimum.

Sub grade	:	Compacted to get minimum CBR value of 12.
Sub base course	:	100mm thick crushed aggregate.
Base course	:	100mm thick asphalt concrete as binder course.
Finish course	:	50 mm thick asphalt concrete as wearing course.

Precast concrete edging block of 75mm thick by 350mm deep shall be provided in all roads and pavements.

10.1.12.3 Storm Water Drainage System

Storm water drainage system consisting of catch basins and underground piping shall be provided for the new power plant units and shall be connected to the drainage network of existing plant.

The plant and storm water drainage shall take into account the topography of the plant area, area drainage pattern, intensity of rainfall. All storm water drains shall be designed for the maximum hourly rainfall intensity of the area.

The maximum velocity for pipe drains and open drains shall be limited to 2.5M/sec. and 1.5M/sec. respectively. However, minimum velocity for self cleansing of 0.6 M/sec. shall be ensured.

10.1.12.4 GTG Area

Gas Turbine Generator (GTG) will be located outdoor and no building is envisaged for the same. The area around the foundation will be paved in RCC with minimum thickness of 100 mm. The paved areas earmarked for vehicle movement shall be of higher thickness and suitably designed for wheel loads. The area shall be sloped towards catch pits / drains to facilitate surface drainage.

10.1.13 Architectural – Design Criteria

Generally the architectural design shall blend with the existing buildings/structures of Phase-I development.

Hollow Concrete Block for Masonry Work

i. External Walls - Air Conditioned area - Double hollow concrete block wall (100+50+100) 250 thick with 50 mm polystyrene block insulation.

ii. Other areas - 200 thick hollow concrete block wall.

iii. Internal Walls - 100/150/200 thick hollow concrete block wall as required as per the span and height of the wall.

Plaster over Masonry Work

iv. Internal Walls - In general 15 mm thick plaster in 2 coats with cement sand mortar.

v. External Walls - 20 mm thick cement sand plaster in two coats.

vi. Ceiling - 6 mm thick cement sand plaster.

10.1.14 Construction Features

Certain minimum requirements related to civil, structural and architectural works of various plant & non plant building and other facilities are described below:

General

Finished ground floor level (plinth level) of all buildings shall be minimum 300mm above formation/grade level.

Each building shall be provided with minimum 1.2m wide reinforced concrete paving all round. Paving shall be slopped to provide a rapid run off of rain water away from building.

50mm thick DPC shall be provided at plinth level before starting the masonry work.

Doors & windows on external walls of building (other than areas provided with insulated metal cladding) shall be provided with R.C.C. sun-shed besides the opening with 300 mm projection on either side. Projection of R.C.C. sun shed from walls shall be minimum 450 mm over window & 750 mm over doors.

All stairs shall have a maximum riser height of 175mm and a minimum tread width of 250mm. Minimum width of stairs in all buildings shall be 1200 mm.

Stairway in a single run shall have the same slope. The vertical rise of the stairways shall not exceed 3.0 M for a single flight.

Hand railing minimum 1000 mm high shall be provided around all floors/ roof openings, projections, balconies, walkways, platforms, stairs etc., All hand rails and ladder pipes shall be 32mm nominal bores M.S. pipe and shall be galvanised. All rungs for ladder shall also be galvanised.

For RCC stairs, hand railing with 20mm square MS bar balustrades with suitable MS flats & aluminium/wood handrails shall be provided.

Aluminium nosing shall be provided for edge protection in all RCC stairs.

All steel platforms above grade shall be constructed with kick plates at edge of platform to prevent tools or materials from falling off platform.

All cables & pipes in outdoor area shall run above ground over steel trestle or other supporting structures for easy inspection and maintenance except in transformer yard area and some other area where the same can run in RCC trenches. In case of trestles with overhead racks and bridges minimum 6.0M head clearance shall be provided over grades and roads.

Top of ungrounded pipe/ducts shall be minimum 1.0 M below grade level.

All steel section and fabricated structures which are required to be transported on Sea shall be provided with anti-corrosive paint and packing for Sea worthiness.

Apartments inside housing complex shall be developed, designed & constructed on the basis of sketches appended with this specification.

All roofs shall be provided with access ladder/stair for inspection and maintenance access.

Architectural

Roof Insulation Water Proofing

Roof insulation and water proofing shall consist of the following as minimum:

i. Rigid insulation board

ii. Four layer of Hessian based tar felt with five layers of bitumen top finished with white stone aggregates.

Wall & Cladding

iii. External walls of all buildings shall be with 200 mm thick hollow concrete block masonry except Air Conditioned Space. External wall of all air conditioned space shall be of Double Wall with insulation inside.

iv. 100/150/200 mm thick concrete block masonry with cement mortar as per span and height of wall.

v. All masonry work shall comply with UBC as appropriate or other equivalent approved standards.

False Ceiling

vi. Mineral board with fissured design fixed to M.S. framework (snap grid system) and suspended from steel/R.C. beams shall be provided for all air-conditioned spaces. The illumination and duct grills in these areas shall match the overall aesthetics.

Doors, Windows and Louvers

vii. Generally hollow metal (steel) flush doors with pressed steel frame shall be provided for plant and utility areas. Glazed aluminium doors/partition shall be provided at main entrance & lobby areas & air conditioned areas.

viii. Wooden flush doors with plastic lamination on both sides shall be used for offices of non-plant facility buildings, toilet areas on Residential Buildings

ix. MS/Rolling door shall be used where frequent use is not envisaged and large openings are required for handling & transportation of equipments.

x. Special areas like control rooms shall be provided with aluminium glazed partitions and double doors with air lock space.

xi. Fire proof doors shall be provided in cable spreader rooms and other areas having fire hazard. These shall be as per relevant Codes & Standards. Fire rating of the doors shall be as per Code requirements. However minimum fire-rating shall be for 1½ hrs.

xii. Doors shall be provided at appropriate location to prevent dust ingress from outside.

xiii. All windows shall be of Aluminium frame glazed windows.

Glazing

xii. Glazing partition wall shall be provided in control building & other facility buildings as necessary for a clear view of the operating equipments/control panels.

xiii. All external glazing in control room area and area between A/C and non A/C room shall be with double toughened glass of minimum 6 mm thickness and hermetically sealed for effective thermal insulation.

xiv. Windows & ventilators located on external walls above 3 m from ground floors levels and those located in fire prone areas shall be provided with clear wired glass of minimum 6 mm thickness. Windows in other areas shall be finished with 4 mm thick clear glass.

xv. Ground glass of minimum 4 mm thickness shall be used in toilets.

Floor

xvi. The nominal total thickness of floor finish shall be 50 mm.

xvii. Control room and all other Air-conditioned area shall have minimum 3mm thick vinyl tile floor covering.

xviii. Control room and its equipment room shall have access false flooring of minimum 600mm high.

xix. Floors of battery room and any other floor coming in contact with acid/alkali shall have acid and caustic resistance coating & dado shall also have the same coating upto 2200mm high.

xx. All toilet areas shall have unglazed ceramic tiles flooring and dado shall have ceramic tiles of minimum 6mm thickness up to 2200mm height.

xxi. Skirting shall match with floor finish.

xxii. Special areas, lobbies, risers & treads of main concrete stair case shall be provided with epoxy terrazzo finish.

xxiii. In general other plane building floors shall have concrete floor with harden or finish and as required and approved by the Owner.

Finish to Walls & Cladding

xxiv. Outside surface of buildings when masonry is used, shall have minimum 20 mm cement plaster (1:6).

xxv. Inside face of walls shall have minimum 15 mm, thick cement plaster (1:6) in two coats with top finished smooth.

xxvi. All RCC ceilings shall be provided with 6 mm thick cement sand plaster (1:4).

xxvii. Outside face of all buildings shall have Acrylic exterior grade spray textured paint of approved manufacturer.

xxviii. Acrylic emulsion paint of approved manufacturer shall be provided over internal walls and ceilings.

xxix. Battery room & all other areas coming in contact with acid/alkali shall have acid and caustic resistant paint of approved make.

xxx. Oil resistant paint shall be provided in oil canal, oil equipment room etc.

xxxi. All hollow metal door & rolling doors shall have two coats of oil paint over a coat of primer of red-oxide/zinc chromate.

xxxii. All wooden doors shall have both side plastic lamination.

Roof Drainage Systems

xxxiii. The system shall be provided for disposal of rain water from roof surface to avoid damage to the roof structure of all buildings and shall consist of the following :

- Roof Drain Heads
- Rain Water Down comers
- Fixtures

xxxiv. UBC as appropriate or other equivalent approved code of practice for building drainage shall be followed for this purpose.

xxxv. Multiple drains (min.2) shall be provided for all roof areas. System shall be designed to handle rainfall intensity of the area and in accordance with stipulations of Codes & Standards.

xxxvi. Roof drains shall dispose water to storm water drains.

xxxvii. PVC Pipes shall be used for Rain water pipes.

Plumbing, Drainage & Sanitary Fixture

All major plant buildings & facilities shall be provided with the arrangement of potable water supply.

Galvanised MS pipes of medium class conforming to UBC as appropriate or other equivalent shall be used for internal piping works for potable water supply. Copper pipe shall be provided for hot water supply.

Water cooler & water heater shall be provided adjacent to toilet block and in toilet area and other wet area as required.

Cast iron pipes & fittings of reputed manufacturer shall be used for sewerage disposal.

WC & Urinals, wash basin shall be provided in the building. The size & nos. of toilets shall be decided by taking consideration of no of users & location of facility and subject to acceptance to the Owner.

Each toilet block for plant buildings, administrative buildings, gate house shall have the following minimum fixtures & fittings:

i. 1 no. WC squatting pattern with all fittings and fixtures flush valve system and 1 no. WC (western type) with toilet paper roll holder and other fittings and fixtures including flush valve system.

ii. 2 Nos. urinals with all fittings & automatic flush valve system.

iii. 1 no. wash basin with all fittings.

iv. 1 no. bathroom mirror.

v. 1 no. CP brass towel rail.

vi. 1 no. each of soap-holder & liquid soap dispenser.

For Residential Units in Housing Complex, each toilet shall have the following arrangement:

vii. One vitreous china WC squatting type/western type with all fittings and fixtures including flush valve system

viii. One CP brass shower unit

ix. One vitreous china wash basin with all fittings and fixtures

x. One CP brass towel rod

xi. One bath room mirror

xii. 1 no. each of soap tray and liquid soap dispenser

Landscaping

Generally the natural contour shall be retained except where modifications needed for plant sitting, drainage or other technical reasons. Trees etc. shall be chosen to match with prevailing landscape. Special landscaping shall be made around entrance of administrative building and other important buildings.

Civil/Structural

All masonry walls from ground floor shall be placed on reinforced concrete grade beams. However, light internal partitions may be placed on ground floor slab. Minimum embedment of the grade beam below grade level shall be 300 mm.

The steel column base plate along with stiffening gusset plates shall not be protruded above floor level.

The steel columns below ground floors and up to minimum 100mm above finished floor level shall be encased in concrete.

Ramps for building entrance shall be cast in situ RCC slab and the slope of ramps shall not be more than 15^{0}.

Minimum 75mm thick levelling (lean) concrete shall be provided below all underground structure, trenches etc., to provide a base for construction.

All buildings shall have RCC framed super structure. All walls shall be non-load bearing in filled panel walls.

Duct banks consisting of PVC/GI conduits for cables shall be provided with reinforced concrete encasing. The minimum depth of top of duct bank from grade level shall be 500mm.

Angles 50x50x6mm (min.) with lugs shall be provided for edge protection all round of cut-outs/opening in floors, edge of drains supporting grating covers, edges of RCC cable/pipe trenches, manholes supporting covers, supporting edges of pre-cast covers and any other places where breakage of corners of concrete is expected.

All steel work for hand rails gratings and chequered plates shall be hot dip galvanised.

Trenches located outside building shall project at least 100mm above the finished formation level so that no storm water shall enter into the trench. The bottom of the trench shall be sloped suitably for draining out the collected water into the sump pit. The pre-cast covers shall not weight more than 65 kg. Lifting hooks shall be provided in the pre-cast covers. The minimum drainage slope along line shall be 1 in 500.

For open drains shall be of concrete lining on sides & bottom. The thickness of lining shall be minimum 100mm or as per design consideration whichever is higher.

All underground concrete structure such as basement, sumps water-retaining structure shall be designed for water tightness.

All underground concrete structure like basements, sumps, water retaining structure etc., shall have plasticizer cum water proofing cement additive. The concrete surface of these structures in contact with earth shall also be provided with two coats of bituminous painting for water/ damp proofing. In case of water leakage in the above structures, injection method shall be applied for repairing the leakage.

All joints, including construction and expansion joints for the water retaining structure and others below subsoil water level shall be made water tight.

All mild steel parts used in the water retaining structures shall have anticorrosive epoxy based paint or equivalent.

Anti termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors, etc., as per relevant standards.

All walls and slabs shall have two layers of reinforcement for section having thickness 150 mm and above.

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REPUBLIC OF YEMEN PEC – ME 400 MW MARIB GTPS – II	TENDER DOCUMENT FOR ENGINEERING, PROCUREMENT & CONSTRUCTION (EPC)	7195-GE-EPC-700-001	C	10.2 Sheet No. 1

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FORMT&P REV-B

10.2 Surveying Works

10.2.1 Scope

This Specification covers the requirement in respect of instruments, materials, workmanship and quality for the general surveying and levelling works.

10.2.2 Codes and Standards

Unless specifically mentioned otherwise, American Standards, in their latest editions, local regulations shall govern in respect of field/office works workmanship, quality.

10.2.3 Site Survey

The Contractor shall carry out all necessary surveying work for the entire power plant area, housing complex and the respective access roads and shall ensure that the position and elevation of all works constructed by him are correct. The measuring methods and devices used must meet the standard of accuracy required for this purpose according to normally accepted practice, in order to obtain the following information.

- Location of sites relative to the available published maps of the area
- Location of data for setting out and levelling
- Establishment of site boundaries and reduced site datum level
- Location of existing buildings on the site and in the surrounding area
- Existing site levels on a 5 metre grid and resultant contours at 1 metre vertical intervals
- Condition of the site, including details of prominent features on the proposed site or adjoining land, which may affect the layout.
- Existing water supply network nearby
- Existing electricity supply network nearby

10.2.3.1 Clearing Bushes and Vegetation

It is the Contractor's responsibility to clear all the bushes, vegetation and slush, if any, so as to carry out the survey work without obstructions, hindrance. The contractor should obtain permission from the engineer before cutting trees, if any which obstructs the course of survey work.

10.2.3.2 Setting out and Levelling

The Contractor shall indicate and build a base line between 2 master benchmarks. The co-ordinate of the master benchmarks (XI, Y1 and X2, Y2) will be indicated by the Engineer based on inspection and according to the local conditions and local co-ordinate system.

At a later stage (as built drawings) all co-ordinates will have to be related to the international geographic system.

The Contractor will indicate and build also a cardinal surveying point, that should be located as indicated by Engineer on inspection. The base line and the cardinal point will serve as the basis for surveying in the horizontal plane. Documentation regarding data transfer from existing benchmarks to the new benchmarks (such as location, levels, co-ordinates, field book calculations) shall be prepared by the contractor.

10.2.3.3 Bench marks

The number of benchmarks and the measuring methods and devices used must meet the accuracy laid down in Codes.

All height measurements must be referred to the (+)0.00 m plant datum (ground floor level). The base point for height measurement will be indicated in the field.

Before starting of works the owner's Engineer shall verify the position in plan and elevation of all benchmarks installed by the Contractor and correct the co-ordinates and levels of the benchmarks, if necessary.

All existing and new benchmarks are to be secured and marked in such a manner as to ensure that they can be found at any time, that they will not be destroyed by the construction activities and that they can be constantly used for reference and check measurements.

The Bench Marks shall be constructed as follows:

A block of concrete at least 600 mm square, with the top 300 mm above the final ground elevation and the bottom 1200 mm below ground;

A vertical 20 mm diameter brass bolt approximately 100 mm in length, cast in and protruding above the top of the concrete block and scribed with crossed lines or a punch mark shall be cast in the concrete block;

The required accuracy of northing, easting and elevations shall be $\pm$10 mm relative to the existing benchmarks.

All benchmarks shall be secured and marked in such a manner as to ensure that they can be found at any time, that they will not be destroyed by the ongoing construction activities and that they can be constantly used for reference and check measurements.

10.2.4 Workmanship

The contractor shall be responsible for exact survey work, arranging all surveying instruments, checking of all dimensions, level and locations established by the surveyor. Not withstanding any approval by the Engineer due to incorrect measurements, errors / or levels, the contractor shall make necessary corrections at his expense.

The results of the survey shall be reported as follows:

10.2.5 Survey Report

10.2.5.1 Preliminary Site Survey Report

10.2.5.2 Final Site Survey Report

10.2.5.3 Acceptance Criteria

The field work records showed be recorded on a day to day basis as soon as the field work is carried out and should be jointly signed by the Engineer and the contractor /contractor's authorized personnel.

Despite of any approval, the contractor is fully responsible for his exact survey and no extra costs due to wrong measuring or levelling and/or errors will be refunded.

All levels of site as shown on different drawings shall be taken as guidance and the contractor has to verify himself about the exact site levels.

The Contractor shall submit sufficient copies the Contour Plan of the Site to the Engineer for approval.

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10.3 Subsoil Investigation

10.3.1 Scope

This specification covers the requirements in report of materials, workmanship and quality for subsoil investigation. The Contractor shall carry out geo-technical investigations necessary for detail design of power station and the respective accessories as a prerequisite for the design of the foundation/roads the and further assist in determining ground conditions for excavation.

The subsoil investigations shall be carried out to an extent so as to obtain satisfactory sub soil conditions and which are reasonable for deter mining the types of foundations

The contractor shall submit the soil investigation programme i.e, extent of the work based on power plant layout, methods and target dates to the engineer for approval, before commencing the soil investigation work. The subsoil investigation work shall be commenced only after the approval of the investigation programme by the engineer. The contractor should deploy qualified persons for carrying out in-situ testing and sampler testing. The testing shall be done in an approved laboratory.

10.3.2 Codes and Standards

The Contractor shall comply with all local laws, rules and regulations applicable to the works. The investigation procedure shall be governed by American Standards in their latest editions thereof.

10.3.3 Field works

The following works shall be carried out by the contractor as minimum. The contractor shall notify his intention to undertake the soil investigation work and submit the details of the proposed methods and tests to the engineer for approval before commencement of the work.

10.3.3.1 Bore holes

Exploratory bore hole 12 cm in diameter shall be sunk at the locations approved by the Engineer.

The depth of bore hole shall not be less than 20 meter unless rock is encountered. In case rocks are encountered, two bore hole for each site shall be examined to prove a thickness of 1.5 m. In cases where weak soils are encountered, bore hole shall be confined up to a load bearing stratum and two bore hole shall be examined for each site to prove a thickness of 3.0m.

The bore hole shall be drilled by local trained drillers under the direct supervision of the contractor, as per approved instructions and specifications. Casings shall be provided where ever necessary to prevent the collapse of the bore hole wall.

Disturbed and undisturbed samples shall be collected for visual examination and laboratory testing.

Bore hole shall be sunk by dry-sunk method and by using approximate boring techniques, so as to facilitate easy identification and sequence and depth of each soil layer for the soil samples.

The use of bentonite slurry or clay as drilling fluid shall be avoided. The soil stratification encountered in the bore hole shall be logged during drilling and the bore holes shall include the following information.

Soil stratification

Soil sample

Corrected penetration resistance

Grain size distribution

Soil index and engineering properties of the representative samples collected from different strata.

10.3.3.2 Standard Penetration Tests (SPT).

SPT shall be performed in the bore holes at 1.5 m intervals, in both cohesive and non-cohesive soils up to the depth of drilling.

A standard split spoon sampler (5.08 cm O.D.) shall be driven into the bottom of a properly cleaned hole by a 63.65 kg hammer falling from a height of 76.2 cm, to ensure the desired 450 mm sampler penetration or a maximum of 50 blows. The penetration resistance (i.e. the number of blows) for the first 150 mm penetration shall be recorded for reference and the subsequent second and third 150 mm penetrations shall be recorded as apparent N-values.

After any necessary correction according to the groundwater table, the corrected N-values (N') shall be entered in the bore hole log.

The groundwater table shall be recorded and described in the bore hole log after the water level has settled.

10.3.3.3 Sampling

During SPT at 1.5 m intervals, disturbed samples shall be collected with the standard spoon and submitted in polythene bags with proper identification.

Undisturbed samples shall be collected for cohesive soils at 1.5 m intervals. A thin-walled sample tube of 63.5 m ID and 610 mm in length shall be pressed into the cohesive soils by means of hydraulic pressure produced by the drilling rig. The undisturbed samples shall be trimmed and scaled with non-shrinkage wax at both ends and clearly labelled.

Disturbed and undisturbed soil samples shall be sent for laboratory tests.

10.3.3.4 Rock Coring

When rock is encountered, it shall be cored into using a core barrel with a diamond bit and a reamer which is to be fitted onto the lower end of the drilling rods. The core diameter shall be 89 mm. The rock sample shall be examined, classified and kept in clearly labelled core boxes for further examination, to determine, for example, the core recovery rock quality

designation and fracture index. The rock strength shall be classified by means of unconfined compression tests. The coring results shall be entered in the bore hole logs.

10.3.3.5 Groundwater Level Measurement

The water level in each bore hole shall be recorded before commencement and after completion of drilling. The depth of the bore hole and the casing (if any) shall be also recorded.

10.3.3.6 Soundings

Soundings shall also be carried out as a second method of soil investigation (after bore hole sinking) at the locations approved by the Engineer.

The soundings shall be carried out using lightweight or medium-weight dynamic penetrometers for qualitative examination of soil layers, predominantly for soils with low cohesion, as well as with static penetrometers (Dutch cone apparatus) for determination of the soil type, density and consistency.

The results of the soundings shall be entered in the sounding logs as specified in Sub-Clause "Reporting".

10.3.3.7 Test (Trial) Pits (TP)

Test or trial pits shall be used as a third method of soil investigation in order to visually identify the individual strata and the sequence of strata, as well as to obtain at least one disturbed and one undisturbed sample of each stratum encountered. The samples shall be sent for laboratory tests as described in Sub-Clause "Sampling".

The description of the encountered strata and of the strata sequence, accompanied by coloured photographs, shall be submitted in the soil investigation report.

10.3.3.8 Plate-Bearing Test

The plate-bearing or plate-loading test shall be carried out to determine the bearing capacity and the modulus of vertical sub grade reaction, by obtaining a "load versus deformation" curve from which a modulus of deformation is computed.

10.3.3.9 Block Vibration Test

In-situ dynamic properties of the soil shall be determined by performing Block vibration tests in accordance with American Codes at the location and depth indicated. The test pit should be of suitable size having sufficient clearance for conducting the test. Forced vibration tests shall be conducted. The wave propagation test for determination of shear modulus shall also be conducted by exciting the block to the steady state vibrations in the vertical direction. The block shall have suitable provisions to fix the oscillator in different modes and at different frequencies. By suitable and adequate instrumentation, the soil responses to the excitation are measured and various dynamic properties are computed. Based on these tests, the Contractor shall recommend design values to be adopted in design. Before back filling the pit, the concrete block shall be dismantled and broken and all rubbish shall be disposed off as directed by the Engineer.

10.3.3.10 General Soil Characteristics

A general soil/subsoil description shall be made comprising:

Soil conditions at the surface;
Expected soil conditions below the surface (slopes, etc.);
Inclination of the ground surface, inclination of cracks and fissures as well as their stratification, evaluation of slope stability, in case there is a potential for sliding;
Statement as to whether flooding or scouring action is possible during heavy rain.

This information shall be provided to the Engineer through intermediate reports, to enable him to give instructions for more intensive or additional investigations, if necessary.

10.3.4 Laboratory Tests

The selected disturbed and undisturbed samples from various bore holes and depths as well as from trial pits shall be sent for laboratory tests, which are specified below.

10.3.4.1 Natural Moisture Content

Tests to determine the natural moisture content (natural water content) and the in-situ wet and dry densities shall be performed on undisturbed samples.

10.3.4.2 Atterberg Limit Tests

Tests to determine the liquid limit and the plastic limit shall be performed on representative soil samples collected from different strata. The Liquidity Index/Consistency Index shall be determined.

10.3.4.3 Grain Size Distribution

The specific gravity and the grain size distribution of representative soil samples collected from different strata shall be determined with standard sieves and a hydrometer.

Grain size distribution curves of representative samples shall be submitted in the soil investigation report.

10.3.4.4 Unconfined Compression Tests

Unconfined compression tests shall be performed with a constant strain rate on representative undisturbed specimens with a diameter of 3.56 cm. Stress-strain diagrams of these shall be attached to the soil investigation report.

10.3.4.5 Consolidation Tests

With a 1:1 load increment ratio and a 24 hour duration for each increment, standard consolidation tests shall be performed on 2.54 cm thick, representative undisturbed specimens with a diameter of 5.08 cm. Graphical interpretation of tests shall be attached with the soil test report.

10.3.4.6 Chemical Analyses

The groundwater and soil shall be analysed and classified with regard to their aggressive action on concrete. The classification shall comply with American Code.

The results and recommendations shall be part of the soil test report.

The chemical analyses shall determine the sulphate and chloride contents as a minimum as well as the pH value.

The suitability of the groundwater for drinking purposes shall be demonstrated.

10.3.4.7 Other Tests

The contractor shall make arrangement to conduct any other tests (if required) for ground improvement and / or piling works.

10.3.5 Reports

10.3.5.1 Intermediate Reports

Short intermediate reports shall be submitted to the Owner's Engineer in order to:

- Indicate the work progress;
- Provide quick information about soil characteristics;
- Describe the constraints encountered, if any;
- Proposed improvements, if any.

10.3.5.2 Final Report

Within four weeks of completion of the soil investigation work, the Contractor shall submit the draft final report to the Engineer for comments and approval. The draft report shall be complete and shall contain, but not be limited to, the information specified below.

a) Description of the scope of the work carried out, showing:

- Follow-up work programme;
- Methods and systems (equipment) used;
- Work carried out (field investigations and laboratory tests);
- Conclusions and recommendations.

Conclusions shall be formulated regarding the position of the bearing layers as well as the bearing capacity and the depth of the groundwater table, especially the maximum groundwater level.

Recommendations for foundations shall be derived from the in-situ investigations and from the laboratory tests.

b) Layout location plan of soil investigations showing:

- The area;
- Locations of bore hole, soundings, trial pits and plate tests (if any) carried out;
- Comprehensive map surrounds.

c) Logs & Tables

The subsurface conditions, for example the sequence of the strata, the nature and properties of the individual strata as well as the groundwater conditions shall be determined and described in the bore hole logs. The results of the laboratory tests and the diagrams of the test results shall be included in the report.

Bore hole logs, trial pit logs and surroundings logs shall include:

Actual ground level;

- Description and limits of various soil layers;
- Samples taken;
- SPT results;
- Water levels;
- Depth of bore hole/pit/sounding.

A summary of the laboratory test results (table) is to be presented.

d) Soil Profiles (cross-sections):

The results of the subsoil investigations shall (in addition to the bore hole logs) also be shown in the form of cross-sectional drawings with a vertical scale of 1:100 showing, e.g.:

Actual ground level at the points of investigation;

Results of boreholes including standard penetration test (SPT) graphs;

- Trial pit profiles;
- Sounding diagrams;
- Proposed foundation levels
- Limit lines of soil layers (soil strata)
- Groundwater level
- Legend (key).

e) Soil classification

The soils shall be classified according to American Standard.

f) **Groundwater classification**

After the chemical analysis, the groundwater shall be classified according to its aggressive action on concrete. The classification shall comply with American Standards.

The Owner's Engineer will provide comments after receiving the draft. Within two weeks of receipt of the Engineer comments or approval of the draft, the Contractor shall submit the final report.

Bore well yield test shall be conducted to determine ground water potential for the proposed water treatment plant requirement.

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10.4 Site Preparation

10.4.1 Scope

This specification covers the requirement in respect of materials, workmanship and quality for clearing, grubbing and site preparation but is not necessarily limited to

Removal and disposal of obstructions
Demolition of existing structures
Removal of all debris and stripping of top soil

10.4.2 Codes and Standards

Unless specifically mentioned otherwise, American Codes and Standards in their latest editions, local regulations shall govern in respect of design, workmanship, quality and properties of materials and method of testing.

10.4.3 Quality Assurances

The Quality Assurance shall comply with, but not limited to the requirements of applicable codes and standards.

10.4.4 Preparation

The Contractor to visit site and carry out inspection and list out objects to be demolished/preserved and shall notify to the Engineer two full days in advance prior to commencing of works and shall locate all existing utilities and determine all requirements for disconnection and capping. The Contractor shall arrange for disconnection of all utility services in the vicinity (if any) and protect the same at no cost to owner.

10.4.5 Site Clearance

The Contractor shall clear all areas of the Sites and all other works as outlined in scope of work, over which the Works are to be constructed. He shall remove all existing structures, debris and vegetation except for those structures / objects earmarked to remain at sites approved by the Owner's Engineer (referred as Engineer) and no debris shall be deposited except on such sites as including burning if necessary. In the event of damage to objects earmarked to remain, the Contractor shall make good for repairs/replacements at no extra cost to Owner. The Contractor shall use all means necessary to prevent spread of dust during site clearance work.

10.4.6 Surface Levels

Before any work on any section of the Works is commenced, the Contractor shall carry out the survey of the site by taking accurate cross sections based on grid lines chosen by the Engineer based on ground profile and submit drawings for record purposes to the Engineer. All levels shall relate to the existing Datum.

10.4.7 Contractor's Lay down Area

The Contractor's temporary construction and storage area shall be prepared, levelled and graded to enable the contractor for utilising it.

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10.5 Earthwork in Site Grading and Embankment

10.5.1 Scope of Work

Scope of Works includes requirements in respect of material, workmanship and quality for earthwork in site grading and embankment.

The Contractor shall be responsible for the final layout of site and building, setting out Bench marks, reference points and grade stakes in complete conformity with the layout and existing and final grades as outlined in the drawings and specifications.

Earthwork required for this work is not necessarily limited to excavation for footings and foundations but also includes

Cutting and back filling to attain indicated grades, Trenching and trench back filling, Rough and finish grading of the site, Supplying and filling select fill under all interior concrete slabs on grade and Site preparation.

10.5.2 Definitions

a. Soil

Soil with any naturally occurring materials not classified as hard rock.

b. Top Soil

By definition its nutrient content should be capable of supporting growth of vegetation.

c. Silt

Any material having 80% of its particle with particle sizing ranging between 0.002 mm to 0.06 mm.

d. Moisture Content

Moisture content shall be measured in accordance with American Code.

e. Plastic Soil

Soils on which plasticity index test can be conducted in accordance with American Code.

f. Non Plastic Soil

This includes weathered or weak rocks and shelly materials, which are not solid rock.

Less than 50% of material shall be of cobble size and size of remainder shall be of gravel or smaller.

Uniformity co-efficient of these soils shall be based on the formula D60/D10 from grading curves based on grading analysis as per American Code.

g. Soil fill materials

This includes all suitable material with the exception of rock fill

i. Granular Sub-Base Material type 1

Shall consist of crushed rock or crushed concrete. The material shall be well graded & tested as per American Code.

and shall be non plastic.

ii. Granular Sub-Base Material type 2

Shall consist of natural sands, crushed rocks or crushed concrete. The material shall pass through 425 mm sieve and have a plasticity index of less than 6.

iii. Granular Fill type 1 A

The particle size distribution of the fill material, determined in accordance with American Code shall be within the following grading:-

Sieve size	% by mass passing (%)
63mm	<15
125mm	100

The fill material shall have a uniformity coefficient of not less than 10%.

10.5.3 Top Soil

Any top soil material, except where it is earmarked in place, shall be stripped from all areas of cutting and from all areas to be covered by embankments or by other areas of fill.

Top soil wherever practicable shall be immediately used for after stripping, if not shall be stacked in stock piles of heights not greater than 2 m or other heights as specified by the Engineer. Stock piles shall not be surcharged or over loaded and multiple handling shall be kept to a minimum.

The Contractor shall make his own arrangement for stock piling. The stock piles shall be stacked in such away that it will not adversely effect the stability of excavations or fills.

10.5.4 Suitable and Unsuitable Materials

Fill material whether obtained on or off the site shall be classified as being either suitable or unsuitable. Suitable fill is fill material which has been demonstrated to The Owner or is considered by The Owner to be capable of being placed and compacted as a stable fill in accordance with this Specification. All suitable fill will be subject to the Engineer's approval before being used.

10.5.4.1 Suitable Material

Material, which is considered by the Owner to be deposited, treated and compacted to form a stable fill in accordance with this Specification is suitable material. Such treatment shall be to the approval of the Engineer and may include the removal of material larger than permitted by this Specification or modification of the moisture content.

10.5.4.2 Unsuitable Material

Unsuitable material shall comprise

a. any material from swamps, marshes or bogs.

b. peat logs stumps and perishable material.

c. highly organic clay or silt.

d. material having a water content outside the limits permitted by the Contract Documents.

e. Fill material with a soluble sulphate content exceeding 1.9 grams per litre when tested in accordance with American Code is unsuitable for use within 500mm of concrete structures or cement bound materials, unless specially approved precautions are taken to protect the concrete or cement bound material.

f. Material susceptible to volume change, including marine mud, soil with liquid limit exceeding 65% or a plasticity index exceeding 35%, swelling clays and collapsible soils.

g. Dangerous or toxic material or material susceptible to combustion.

h. Metal, rubber, plastic or synthetic material.

Fill material with a total sulphur content exceeding 0.5% by mass, expressed as SO3 of fill material, is unsuitable for use within 500mm of metalwork.

10.5.5 Excavations

The Contractor shall carry out all excavations required for all the permanent works in whatever soil material they may be met with. All excavations shall be carried out to lengths, widths, depths and profiles necessary for the construction of the Works or to such other dimensions as may be approved in writing by the Engineer. Use of explosives if warranted shall be in strict accordance of local codes and regulations.

Where excavation is in unsupported open cut the Contractor shall be entirely responsible for ensuring that the side slopes are suitable for stability. The sides of excavation in trench shall be made secure by means of adequate supports, timbering, close sheeting, timber and steel piling as required for the Works and the means adopted shall be to the satisfaction of the Engineer. The Contractor shall be entirely responsible for the sufficiency of all temporary timbering and supports to the excavations. Where excavation is to be carried out adjacent to and lower than existing structures the Contractor shall submit to the Engineer his proposals for supporting the existing works before excavation is started.

The excavation shall be carried out by the Contractor in such a way as to avoid disturbance to the surrounding ground. The Contractor shall comply with all instructions of the Engineer regarding the supporting of the sides of excavation but such compliance shall not relieve him of any of his responsibilities under the Contract for the safety of the Works and to personnel.

The excavated surfaces shall be kept dry and clean by pumping or otherwise and no concrete, masonry, brickwork or other materials shall be placed or built until the surfaces are properly drained. The methods employed shall in all cases be to the satisfaction of the Engineer, and if water is removed by pumping, it shall be done so that the material in or around the excavations will not be disturbed by the pumping and adequate sumps be provided.

The Contractor shall submit his proposals for the approval by the Engineer for disposing of water arising from de-watering excavations. The Contractor shall also be responsible for obtaining approval from the local authorities.

Particular attention is drawn to de-watering of excavations at works in the close proximity to Coast lines or other masses. The Contractor shall provide, maintain and operate pumps and related equipment, including standby equipment, of sufficient capacity to keep excavation free of all water and other fluids at all times. The ground water level shall be maintained in the bearing strata at safe levels by suitable methods. If the methods are not adequate and bearing capacities of soil are reduced, contractor shall carry out remedial measures as directed by Engineer at no expense to owner.

Samples of excavated materials removed by the Contractor shall be authorised by the Engineer and stored till all the works are completed.

10.5.6 Stable Fill

Stable fill forms part of the permanent works and is a compacted material. It is defined as a proportion of maximum dry density determined as per American Code unless specified otherwise in the contract.

10.5.7 Grading

10.5.7.1 Formation (Grade) and Sub grade

Formation grade shall mean the surface of ground after completion of earth works. Sub grade mean material below formation work.

10.5.7.2 Excavation Formation

It shall mean the surface of ground after completion of excavation and prior to placing of overlying fill.

10.5.7.3 Foundation Formation

It shall refer to the surface of ground below the foundation as shown in the drawings.

10.5.7.4 Fill Materials for Road sub grade

Fill material for the road sub grade shall have the following characteristics :

a. 100% of material passing 75 mm sieve

b. Less than 20% of material missing the 63 mm sieve

c. Liquid limit less than 35

d. Plasticity index less than 12.

10.5.8 Blinding Concrete

After foundation formation surfaces are approved by the Engineer it shall be covered with a layer of blinding concrete as shown in the drawing and well compacted and levelled.

10.5.9 Approval of Excavation

The Contractor shall intimate the Engineer after carrying out excavation work accurately whether in open or for trench works as per profiles or dimensions indicated for the works. The Excavation shall be inspected by or on behalf of the Engineer.

10.5.9.1 Excavation Beyond True Line and Level

If due to any reason whatsoever excavations other than for concrete work are carried out beyond their true line and level other than as directed by the Engineer, the Contractor shall at his own cost make good to the required line and level with concrete or other approved material and in such a manner as per the Engineer's directions. If due to any reason whatsoever excavations for concrete works are carried out beyond their true line and level other than as directed by the Engineer, the Contractor shall, when directed by the Engineer, and at his own cost make good for the required line and level with concrete similar in grade to that intended to be used in the true excavation unless otherwise directed.

10.5.9.2 Disposal of Spoil

The Contractor shall remove spoil from excavations and shall store it at a dumping point designated (or approved) by the Engineer which may be stacked in from of stock piles in temporary dumps, or in permanent spoil tips, according to the quality of the spoil, the need of it for filling and other circumstances shall be as directed by the Engineer. The Contractor shall make his own arrangement for disposal of spoils.

10.5.10 Filling

Areas to be filled shall be free of construction debris, refuse, compressible or decayable materials and standing water. All filling shall not be started until all conditions has been accepted by the Engineer. All fillings for the entire Site, in embankments, refilling of trenches and other earthworks shall unless otherwise specified be formed with selected materials as approved by the Engineer. The materials shall be placed in layers not exceeding 200 mm thick when loose except wherever otherwise specified, thoroughly compacted with fresh water to the satisfaction of the Engineer and trimmed to the levels and slopes required. The compaction of this fill shall not be less than 95% of the maximum dry density as determined by the compaction test as per American Code using

the 4.5 kg rammer. Water containing a high chloride and/or sulphate content shall not be used for compaction of fill material within 5 metres of concrete.

Compaction tests shall be carried out on every layer and every 100 sq.m area.

The Contractor shall, before commencing any filling, survey and levels over the whole of the site to be filled shall prepare plans and sections of the areas measuring accordingly and furnish the same to the Engineer for his approval.

The Contractor shall take particular care in placing and compacting filling around pipes, cables , structures and the like, and shall take such steps as may be necessary to prevent damage thereto.

The Contractor shall make good any damage or defects to the Work caused by settlements, slips or falls to any excavations or embankments and shall do all necessary work to prevent or remedy the same in accordance with the Conditions of Contract.

The embankments shall have a minimum gradient of 1:4 and be stabilised with a stone armouring system to the as directed by the Engineer.

All surfaces at the agreed finished levels shall be treated with a penetrating spray applied bonding agent to stop erosion, avoid dust contamination, and assist vehicular access for site works.

10.5.10.1 Embankments

The finished formation width, side slopes and grade of the embankment shall be true to the line and level as shown on the drawings.

The embankment shall be made up in layers not exceeding 250 mm thickness (un-compacted thickness) over the whole width between the surface of the side slopes and shall be slightly concave in section so as to retain the water for water subsidence. All large clods shall be broken up. When the embankments are on side long ground the whole area of the embankment on slope shall be spread out or stepped so as to prevent the material from slipping.

In construction of embankment over the culverts or pipe drains care shall be taken to bring the embankment up, equally on both sides and over the top of the structure. Earth embankment shall be compacted as specified in grading and in rock embankments, the rock filling shall be carefully packed for the depths as soon as the drawing. If embankments are made from borrow pits, the Contractor shall excavate the earth from borrow pits at the locations indicated on the drawings. They shall be regular in width and shape and shall be properly graded, drained and finished with neatly trimmed sizes.

10.5.10.2 Pipes in Embankments

Fill shall be deposited in even layers and shall not be heaped over the pipe spreading and compacting shall be carried out evenly without dislodging, distorting or damping the pipe. Power rammers are not be used within 300 mm of any part of the pipe or joint.

10.5.11 Blasting

The Contractor shall not make use of any explosives without the permission in writing of the police or other concerned local authorities. The use and storage of all explosives in magazines shall be subject to their approval and shall be to the satisfaction of the

Engineer. The Contractor shall further arrange at his own expense for the provision of safety men for the protection of the public and others during blasting.

Where blasting is permitted it shall be carried out strictly in accordance with arrangements previously agreed in writing by the Engineer.

Blasting shall not be permitted in close proximity to foundation, plant and equipment; in these areas other methods shall be employed. The Contractor shall submit to the Engineer for approval full details of his proposed procedure before blasting is carried out in any area.

10.5.12 Testing and Acceptance Criteria

10.5.12.1 Equipment

In general the Contractor will be permitted to use machine excavation to the bottom of select fill under concrete slabs on ground. The final 15 mm under footings, foundations and in trenches shall be excavated by hand with hand shovels.

10.5.12.2 Inspection

When excavations have reached prescribed depths, inspection has to be carried out by the Engineer and shall be approved by the Engineer complying with the local codes & regulations before starting filling. After filling the contractor shall carry out at his own cost the required tests to prove that the soil has been compacted to the desired dry density. These tests shall be carried out at different stages of filling and also after the entire height of the fill has been completed.

10.5.12.3 Moisture Content

Since the degree of compaction largely depends on moisture content of a soil, moisture content shall be clearly monitored and corrections to optimise the same has to be carried out. The Contractor shall submit the following for the approval of Engineer one week in advance prior to commencement of contract.

Values of max dry density and optimum moisture content as per American Code using 2-5 Kg rammer or by vibratory means as applicable for every 1000 m3 of fill as per the codal guidelines.

Graph of density plotted against moisture content.

Particle size distribution curve as per American Code.

Atterberg limits values

Chemical testing

The quality control operations shall include but not limited to the following items of work

i) Lines, levels and grades

a) periodic surveys

b) establishment of markers, boards etc

ii) Grading

a) checking the quality of fill material

b) checking moisture content of fill material

c) checking degree of compaction

If a layer fails to meet the required density, it shall be reworked or the material shall be replaced and method of construction/equipment altered as directed by Engineer to obtain the desired density.

10.5.13 Slope Protection - by Turfing

10.5.13.1 Surface Preparation

Prior to turfing the area shall be brought to a fine tilt by approved mechanical means or by hand raking, and if found necessary regrading of the surface shall be carried out to conform to the prescribed finished levels. All stones over 30mm diameter shall be removed. The finished level after turfing shall be 25mm above any adjacent hard surface area.

10.5.13.2 Material

The turf shall be free from weeds and any other impurities. The grass should be of an even density and green in colour, forming a turf which is sufficiently fibrous to hold together when handled. The grass shall be free from pest or disease. The turf shall be 300 x 300mm with a minimum thickness of 40mm. A sample of 10 turfs shall be submitted for approval before implantation on site commences. Trial areas may require to be turfed before approval is given.

10.5.13.3 Soiling & Fertilizer

Prior to turfing, all areas to be turfed shall be covered with a layer of black mould free from stones and lightly compacted to thickness of 75mm. Where the turf is to be laid on slopes, no black mould shall be laid if directed and an suitable fertilizer shall be applied to all such areas to be turfed at the rate of 40gms per sqm, evenly spread over the area and lightly worked into the soil.

10.5.13.4 Laying

The turfs shall be laid on the prepared soil bed and firmed into position in consecutive rows with broken joints (as in stretcher bond brickwork), closely butted and to the correct levels. Where the turf is to be laid on slope, each turf shall be pegged down with 2 pegs 300mm long driven flush with the soil.

The turf shall be laid off planks working over turfs previously laid. Where necessary, the turf shall be lightly and evenly firmed with wooden beater, the bottom of the beater being frequently scraped clean of accumulated soil and mud.

A dressing of finely sifted topsoil and topsoil mix shall be applied and well brushed into the joints.

10.5.13.5 Maintenance

The Contractor shall water turfs as often as is necessary or as required by The Owner to ensure knitting. Any bare patches shall be aerated, cultivated and returfed at the expense of the Contractor to maintain full ground cover. When shrinkage occurs and the joints open, fine topsoil or compost shall be brushed in and well watered. The Contractor shall maintain turfed areas up to the end of the Defect Liability Period including any necessary cuts to restrict growth to below 100mm.

10.5.14 Slope Protection by Hydroseeding

Hydroseeding shall mean the pressure spraying of grass or other seeds in a suspension of water / mulch / binder and fertilizer.

10.5.14.1 Constituents

The constituents of the Contractor's proposed hydroseeding mix shall be submitted for approval at least 3 weeks prior to the commencement of hydroseeding operations.

The Contractor shall notify The Owner of his intention to order seed at least 3 weeks before any order is placed. The Owner reserves the right to propose alterations to the mixture of seed according to prevailing site conditions up to 3 weeks prior to the commencement of hydroseeding operations.

10.5.14.2 Application

Constituents shall be combined in proportions such that an even cover of the slopes to be treated is achieved at the accepted seeding rates. The Contractor shall submit the seeding rates for approval.

Access to areas to be hydroseeded shall be agreed by The Owner and the Contractor shall ensure that such access does not disturb any of the completed works. The hydroseeding operations shall be carried out such that disturbance of the pre-trimmed slopes or drainage channels which have already been laid is minimised. Any such damage shall be made good at the Contractor's own expense. The Owner reserves the right to suspend hydroseeding operations in the event of inclement weather or weather which in their opinion will prevent successful coverage of slopes or germination of seeds.

Unless otherwise directed the Contractor shall cover freshly hydroseeded slopes with an approved biodegradable fabric. The fabric shall be firmly stapled to the ground and shall have sufficient overlap between adjacent sheets to avoid local erosion.

The Contractor shall ensure that even growth is achieved on all hydroseeded areas and that adequate watering is undertaken to encourage even germination and establishment. Any area which fails to show successful establishment after 28 days from initial seeding shall be reseeded at the Contractor's own expense. Such areas shall be determined accordingly to the areas affected and shall be at the discretion of the Engineer.

10.5.14.3 Aftercare

Aftercare of hydroseeded areas shall take place for a period of 12 months from the satisfactory germination and acceptance of the seeded areas or to the end of the Defect Liability Period, whichever is the later.

In very hot and dry weather the grass shall be watered with sprinkler or spray to obtain a moisture penetration of 72mm - 125mm. Watering shall be frequent enough to ensure vigorous growth of grass and shall occur no less than once daily during the dry season, or

as directed. The Contractor shall cut all hydroseeded areas upto the end of Defect Liability Period to restrict growth to below 100mm.

The Contractor shall be required to make good any areas which are indicated as having failed to show an acceptable standard of grass cover as a result of faulty materials or workmanship or damage caused by operating in unsuitable weather conditions or tracking across grass areas. The Contractor shall take steps to repair or rectify sub-standard grass during the contract and after care period by re-seeding, watering and other means at his disposal. The cost of making good, repair and rectification shall be borne by the Contractor.

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10.6 Concrete Works

10.6.1 Scope

This specification covers all aspects of the supply manufacture, conveying, pouring, vibrating, compacting, finishing of concrete to be used in the permanent works, separate sections are included to cover reinforcement, formwork to tolerances and finishing, requirements in respect of materials, workmanship and quality for all types of concrete works for all types of structures in foundation and superstructure are also included.

10.6.2 Additions

The owner shall submit his proposal regarding alteration or variation to the parts of specifications well in advance to the owner for approval. If, required necessary tests shall be performed by the contractor. No variation to this specification is permitted without prior approval.

10.6.3 Codes and Standards

Unless noted otherwise all works shall be executed as per American Codes and Standards in their latest editions. Local Regulations wherever applicable shall govern in respect of Design, Workmanship, material, quality etc.

10.6.4 Quality Assurance

The quality assurance shall comply with, but not limited to the requirement of applicable codes and standards.

10.6.5 Submittals

The Contractor shall submit a method statement with the tender, indicating the following

- Details of mix design, list of all materials and their proportions, along with addresses of manufacturers, supplier's etc.
- The work procedure the contractor is proposing to complete the concrete works fully complying with all the requirements of this specification.

10.6.6 Materials - General

All the material used for concrete and reinforced concrete structures shall be of best quality free from defects, likely to undermine the strength and duration of service of the works.

All material to be incorporated in the Works shall be used subjected to the approval of the Engineer and shall conform to the relevant Standards. Where locally quarried or similar naturally occurring materials exhibit particular properties, e.g., salt contents, such properties not being catered for by the Standards, the Contractor must supply sufficient information for the Engineer to consider the suitability of such an alternative material. In considering such a material, samples from other alternative sources and chemical analysis may be required. If the Engineer accepts at his discretion such a material, more stringent or different tests than those herein, may be required, the contractor shall make arrangements for these tests to the owner.

The contractor shall notify the source of material such as manufacturing place etc., if the same is not done at site works, to the Engineer to enable him to conduct inspection to all stages of work.

The Contractor shall provide, erect and maintain proper sheds and temporary structures, for the storage and protection of materials, and for the execution of work which may be fabricated or brought onto the Site.

All materials shall be stored and handled in a manner that will prevent contamination and for deterioration. Deteriorated and / or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of Contractor.

All proprietary materials shall be used in strict accordance with the relevant manufacturer's instructions and / or recommendations.

10.6.7 Inspection and Testing

As provided in the Conditions of Contract, the whole of the materials used in the Works shall be subject to inspection and tests as directed by the Engineer to time as the work proceeds.

The Contractor shall submit to Engineer, a list of the suppliers from whom he proposes to purchase the materials necessary for the carrying out of the Works as soon as practicable after the award of contract. The Contractor shall arrange for Engineer's visit to the supplier's premises during working hours for the purpose of obtaining samples of the materials in question. Alternatively, if required by the Engineer, the Contractor shall deliver the samples of the materials at Engineer's Office.

Samples shall be taken in accordance with the relevant American Standard wherever applicable. Materials subsequently supplied shall conform within specified tolerances as that of the already approved samples.

The information regarding the names of suppliers may be amended at different times, as may be appropriate, but no sources of supply shall be changed without the Engineers approval.

10.6.8 Quarries

The Contractor shall propose the source of quarries or borrow pits he is proposing for the purchase of aggregates to the Engineer for his approval.

Quarried rock must be dense and sound. The quarrying must be done selectively with scalpings from the primary crusher rejected; the final aggregate must be washed and drained.

Once washed, aggregate must be protected from any further contamination. Aggregate on Site must be stored in a bin or on an approved concrete hardstanding. Bins shall be fitted with sides to prevent inter-mixing of the different aggregates and shall be provided with a solid concrete floor atleast 150 mm thick.

Aggregates shall comply with American Code. The maximum size of aggregates used in the particular location shall be consistent with the form and dimensions of the section being placed, spacing of the reinforcement and method of vibration. The aggregates sizes shall be such that dense uniform concrete without irregularities and without excessive water shall be produced. The combined flakiness index and elongation shall not exceed 35%.

Sand shall be uniformly graded, free from excessive fines, organic materials or other deleterious substances.

10.6.9 Concrete

The provisions of the following clauses shall apply to both Site mixed and ready mixed concrete. Compliance with the American Standards is required for equipment and personnel.

10.6.9.1 Cement

The type of cement to be used for each item of concrete shall be as indicated on the drawings. All cement to the site shall be delivered from the single approved source in sealed containers or bulk cement lorries of suitable design. The cement used throughout the Works shall be obtained from manufacturers approved in writing by the Engineer.

High Alumina Cement shall not be used in any part of the Works.

The Contractor's attention is drawn to the practice of certain manufacturers of grinding Sulphate Resisting Cement to a high degree of fineness with consequent reduction of setting time which poses a difficulty in achieving a satisfactory finish. The Contractor shall take all necessary measures including the use of approved additives to ensure that the finished concrete complies fully with his Specification.

10.6.9.2 Cement Testing

The manufacturer's test certificate will normally accepted as proof of compliance with specification but the owner at no discretion may order for tests of cement as specified in the appropriate American Standards. The confirmatory tests are to be conducted by a recognised quality control organisation. The Contractor shall bear all expenses required for the preparation, despatch and test of the samples. In case the results of such tests show any sample inferior to specifications, the whole consignment from which the sample was taken shall not be used. The consignment shall be immediately removed from the site. No cement shall be used until it has been approved by the Engineer.

10.6.9.3 Storage of Cement

The cement shall be delivered to the Site of Works in bulk or in sound and properly sealed bags and while being loaded or unloaded and during transmit to the concrete mixers, whether conveyed in vehicles or by mechanical means, must be protected from the weather by effective coverings. Efficient screens are to be supplied and erected where directed by the Engineer to prevent wastage of cement during storing winds.

If the cement is delivered in bulk, the Contractor shall provide at its own cost approved silos of adequate size and numbers to store sufficient cement to ensure continuity of work and the cement shall be placed in these silos immediately after it has been delivered on the Site. Approved precautions shall be taken during unloading to ensure that the resulting dust does not constitute a nuisance.

If the cement is delivered in bags, the Contractor shall provide at its own cost perfectly waterproofed and well-ventilated sheds having a floor of wood or concrete raised at least 150 mm above the ground. The sheds shall be large enough to store sufficient cement to ensure continuity of work and each consignment of each type of cement shall be stacked separately therein to permit easy access for inspection, testing and approval. On delivery at the Works the cement shall at once be placed in these sheds and shall be used in the order in which it has been delivered.

Cements of different types shall not be mixed together.

All cement shall be used within three months of the date of manufacture.

10.6.10 Aggregate

The Contractor shall obtain approval of proposed aggregate sources, and shall select suitable aggregate and samples of sand and stone for specified testing before obtaining aggregate. Laboratory tests shall be made at regular intervals to confirm the suitability of aggregate.

10.6.10.1 Aggregate Storage

Aggregate shall be stored in concrete-based bins or on stages or on hard paved self-draining areas to prevent intermixing and the inclusion of dirt and foreign materials. Each size of aggregate shall be stored separately.

The aggregate must be protected to ensure saturated conditions when batched.

10.6.10.2 Quality and Testing

Aggregate shall be free from earth, clay, loam and soft, clayey, shaley or decomposed stone, organic matter and other impurities (hard to dense). Aggregates shall not contain hollow shells, or shells of unsuitable shapes.

The tests shall be carried out in accordance with American Standards as may be applicable and the results shall comply with the limits given therein.

Grading tests shall be carried out daily or per $100m^3$ whichever is the more frequent when concrete is being produced on a regular basis or beforehand when production is irregular.

The combined grading of aggregate shall be constant. The percentage passing any sieve size as determined by approved trial mixes shall be the target grading for all concrete of that type. The combined grading of the Works concrete shall not vary by more than 4% from that target. If the estimated or measured combined grading of the permanent works concrete does not meet this requirement then a new trial mix shall be prepared for approval by the Engineer.

10.6.10.3 Fine Aggregate

Fine aggregate shall be capable of passing through a 5 mm American test sieve and shall be so graded that when mixed with the coarse aggregate and cement a concrete of maximum density is produced. It shall not contain appreciable amounts of flaky or elongated particles.

Crushed sand may be added to natural sand in approved proportions in order to achieve the required grading. Crushed sand alone shall not be used without approval. The amount of material passing a 75 micron fine sieve when tested in accordance with American Code (wet-sieving method) shall not exceed 3% by mass.

When subjected to five cycles of the soundness test specified in American Code, fine aggregate shall show a loss not exceeding 10% when magnesium sulphate solution is used.

Beach sand shall not be used except with the prior permission of the Engineer.

10.6.10.4 Coarse Aggregate

Coarse aggregate shall be totally retained on a 5 mm test sieve; the grading shall be within the limits as prescribed in American Code, so that when mixed with the approved fine aggregate and cement a workable concrete of maximum density is produced. The densities of the classes of concrete shall be as approved after tests have been carried out on the Site.

The amount of material passing a 75 micron fine test sieve when tested in accordance with American Code (wet-sieving method) shall not exceed 1% by mass.

Coarse aggregate shall be tested for drying shrinkage characteristics in accordance with American Code.

When subjected to five cycles of the soundness test specified in American Code, coarse aggregate shall not show a loss exceeding 10% when magnesium sulphate solution is used.

The flakiness and elongation indices of the predominant size fractions in each single-sized coarse aggregate, determined in accordance with American Code.

Material for use in concrete which is subject to abrasion and impact shall comply with the test requirements of American Code.

10.6.11 Potential Alkali Reactivity

Aggregate shall not contain any materials that are reactive with alkalis in the aggregate itself or in the cement, the mixing water or in water in contact with the finished concrete or mortar in amounts sufficient to cause excessive localised or general expansion of the concrete or mortar.

The Contractor may initially assess an aggregate source by testing in accordance with American Code. It potential reactivity is indicated, then mortar bar tests in accordance with American Code or equivalent codes shall be carried out and the results shall comply with the limits given in American Code for overall effect on the permanent works mixes, before use of the aggregate is approved.

10.6.12 Sulphate and Chloride Content

Sulphate

Sulphate and chlorides content shall be within the limits as specified in American Code.

10.6.13 Water

The Contractor shall make his own arrangements, and shall obtain approval from the Engineer for the provision of fresh water for the manufacture and curing of concrete.

Water to be used for mixing and curing concrete and mortar shall be fresh and free from sediment and dissolved or suspended matter which may be harmful and shall comply with the requirements of American Code. Water samples from the intended source of supply shall be taken for analysis before any concrete work is commenced, and at intervals throughout the duration of the Contract. If the samples are unacceptable, the Contractor shall either change to a new supply or take steps to improve the existing source, as approved at this expense.

The Contractor shall state the sources from which it proposes to obtain water and submit evidence to show that an adequate supply is assured.

10.6.14 Steel for Reinforced Concrete

Steel reinforcement, used in reinforced concrete shall comply with American Code.

The Contractor shall furnish the Engineer for approval copies of the manufacturer's certificates (including chemical composition and tensile / rebend test) of tests for the steel reinforcement to be supplied. The Engineer may, however, order independent tests to be made at the Contractor's expense and any steel which does not comply in all respects with the appropriate foregoing specifications will be rejected. All tests and reinforcement shall be carried out in accordance with American Code.

The owners shall furnish drawings to the contractor showing the reinforcement layout, numbers of bar required, type of reinforcement, general locations and typical details required together with Bar Bending Schedules as necessary. Any modifications to the requirement shown on the drawings shall be submitted to the Engineer for approval.

Cutting and Bending

- Bends and cranks in reinforcement bars shall be carefully formed in accordance with the approved Drawings and appropriate standards. Reinforcement shall not be bent or straightened in such a way that it is not detrimental to the material. Reinforcement shall not be heated to temperatures above 100°C

Each bundle of bent bars shall be clearly identified and tagged.

The number, size, form and position of all steel reinforcing bars, ties, links, stirrups and other parts of the reinforcement shall be in exact accordance with the Drawings and they shall be placed in the correct position and with the required cover without displacement during the process of compacting the concrete in place in a manner approved by the Engineer.

Steel fabric shall be delivered in flat sheets.

The Contractor shall provide all necessary distance pieces and space bars at its own cost to maintain the reinforcement in the correct position. The type of distance piece shall be subject to the approval of the Engineer.

Wherever welded splices of reinforcement is to be provided, the bars shall be butted and welded to develop in tension atleast 125 percent of the specified yield strength of the bar. Alternate longitudinal bars shall be spliced at any section splices of adjacent bars shall be 610 mm or more as measured along the longitudinal axis of the member.

Only approved concrete or plastic spacers shall be used to achieve the required minimum thickness of concrete cover to reinforcement. Concrete spacers shall have non metallic ties. Timber blocks for wedging the steel off the formwork will not be allowed.

Any ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced and the inside of hooks and bends shall be in actual contact with the bars around which they are intended to fit.

All reinforcement shall be blast cleaned with proprietary grit immediately prior to concreting.

10.6.15 Concrete Cover to Reinforcement

Cover to concrete reinforcement shall confirm to American Standards. For all structures exposed to water, soil or aggressive environment, the concrete cover shall not be less than 75 mm. For all other environments the relevant standards will be applicable.

10.6.16 Storage of Reinforcement

Steel reinforcement shall be stored in an approved manner raised above ground, on a concrete slab, under cover and racked for protection from aggressive elements and physical damage and to prevent excessive rusting.

If reinforcement is to be cut and bent on Site it shall be delivered in straight lengths. Any reinforcement arriving on Site already bent for whatever reason may be ordered off the Site.

Damaged, reworked or deteriorated material should not be used. Any materials which are unidentifiable or those which do not comply with this specification shall be removed from the site immediately.

10.6.17 Miscellaneous Materials

The contractor shall submit a variation report in case of variations to the materials shown on the drawings (or as listed below) for approval by the Engineer before using them in works.

- Joint fillers
- Joint Sealings
- Bearings

10.6.18 Design, Ancillaries, Placing, Protection of Concrete

10.6.18.1 Mix Design

Concrete shall consist of cement, graded aggregate and water thoroughly mixed, compacted and placed to achieve strengths as required for various uses.

To ensure the durability of concrete, the recommendations of American Code should be followed with regard to minimum cement contents.

Concrete grade shall mean the specified compressive cube strength of concrete (MPa). Specified compressive strength means the value of strength below which no more than 5% of works test results for each concrete grade shall fall.

In no case shall the water / cement ratio be greater than 0.42.

Each mix shall be designed to produce the concrete of grade the minimum workability consistent with full compaction in positions in which they are placed.

With reference to the above limits, the Contractor shall submit for the Engineer's approval details concrete giving type of cement, maximum aggregate size, minimum cement content and 7 and 28 day works cube strengths for grades indicated on the Drawings.

The works cube strengths in the schedule referred to above are for concrete made into 6 inch cubes, cured and tested in accordance with American Code. The 7 days strengths are to be used only as a guide to the 28 days strengths.

Before the placing of any concrete, the Contractor shall submit to the Engineer and obtain his approval of:

a. Details of the materials (including the proposed sources), grading of fine and coarse aggregates in tabular form, proportion of different sizes of aggregates, cement content for batch and per cubic metre of concrete, the Contractor proposes to use including results of tests specified by the Engineer.

b. Results of preliminary cube and other tests justifying the design of concrete mixes of various classes.

c. Instructions for determining the quantity of water to be added and the estimated compacted volume of concrete that can be produced.

d. The Contractor's proposed method of ensuring that concrete work complies in all respects with this specification and is placed in all cases without interruption.

e. The aggregate / cement ratio by weight.

f. Water / Cement ratio by weight

g. The type and quantity of any proposed additive

h. The estimated workability in terms of slump values or compaction factor values.

i. Flakiness index of aggregate

j. The designed target cube strength of mix (28 days strength)

k The estimated maximum standard deviation, which shall not exceed 5.0 N/mm²

l. The proposed mixing time

The Contractor is to be responsible for ensuring that, at all times during the Contract, the quantity and quality of the constituents and placing of concrete are as approved by the Engineer and shall submit the proposed total quantity control plan for approval by the Engineer prior to pouring of concrete.

Trial mixes using representative materials shall be carried out under full scale conditions using the Contractor's proposed method subject to the Engineer's approval. Testing shall be carried out in accordance with American Code.

The trial mixes shall be carried out on three days within one week during which the workability will be recorded and six cubes made on each of the days. Of each set of six cubes, three shall be subjected to crushing at 7 days and the remaining cubes shall be tested after 28 days.

A trial mix shall be approved any if the requirements of American Code are satisfied.

10.6.19 Test Cubes

Test cubes from random batches of concrete to be used in the Works are to be made in sets of six, or otherwise as approved, as and when required by the Engineer but with a minimum of 6 cubes per 25 m^3. The Contractor is to include in his Tender for all charges in connection with concrete testing.

The testing of cubes shall generally be in accordance with the requirements of American Code. Test cubes shall be made, cured, stored, transported and tested in compression in accordance with American Code. The method of compacting cubes by vibration shall be subject to the approval of the Engineer.

10.6.19.1 Water Cement Ratio

The contracts shall submit a proposal regarding method of control of water / cement ratio to the Engineer for approval. The water / cement ratio for the various grades of concrete shall be determined based on trial mixes and in no case shall the water / cement ratios used be allowed to exceed by more than 5%. The method approved by engineer shall be used by the contractor for the trial mixes under full scale conditions.

10.6.20 Workability

The Contractor shall carry out compaction factor, slump or other workability tests for every truck delivery during concreting of permanent Works in order to relate the degree of workability of the mix with the numerical value obtained during the trial mixes.

10.6.21 Compaction and Slump Tests

Compaction factor tests shall be carried out in accordance with the procedures laid down in American Code except when otherwise specified or approved by the Engineer. Slump tests in lieu of compaction factor tests shall only be adopted where specifically approved by the Engineer.

10.6.22 Batching

The aggregates and cement shall be proportioned by means of efficient weigh batching machines and volume of material in each batch shall not exceed manufacturers rated capacity. The machines shall be carefully maintained and cleaned, shall be provided with simple and convenient means of checking the weighing mechanism and shall be available for checking as and when required by the Engineer. The mixing period shall be measured from the time all the materials are fed into the mixed drum and shall be automatically controlled.

Cement shall be considered as having a density of 1440 Kg/m^3. When weigh batching is not used the constituents shall be measured by volume in suitable gauge boxes. Volume batching of pours will only be permitted when approved by the Engineer.

10.6.23 Mixing Concrete by Machine

The concrete is to be mixed in batches in machines which comply with American Code. The machines are to ensure that all the concreting materials including the water are thoroughly mixed together between the time of their deposit in the mixer and before any portion of the mixture is discharged. The machines must be capable of discharging their content while running.

10.6.24 Mixing Concrete By Hand

Where it is impossible to employ machine mixing and prior approval has been obtained from the Engineer concrete shall be mixed by hand as near as practicable to the Site where it is to be deposited. Clean mixing platforms of sufficient area for the proper carrying out of the work shall be provided. These platforms if constructed of timber shall consist of planks closely jointed so as to avoid the loss of any grout or liquid from the wet concrete. The whole of the aggregate and cement shall be turned over on the bunker in a dry state at least twice for Portland cement. The water shall then be added gradually through a rose head, after which the materials shall again be entirely turned over in a wet

state at least three times for Portland cement before leaving the bunker. Where hand mixing is approved, the cement content of the mix shall be increased by at least 15%.

Truck Mixers and Agitators

These may only be used when authorised in writing, in which case the practice shall conform to specific requirements below;

a. All materials shall be mixed in a batching plant before being discharged into a truck agitator. The batching shall be completed by further revolutions at mixing speed on arrival at the point of discharge.

b. Provided the workability at the time of placing is still within the acceptance limits without the addition of further water, then agitation may be continuously used for up to 2½ hours after mixing.

c. Truck mixers and agitators shall be accompanied by a docket detailing the mix and the time at which water was added.

10.6.25 Transfer of Concrete

The concrete shall be discharged from the mixers and transported to the Works by means which shall be approved by the Engineer and which shall prevent contamination (by dust, rain or other causes), segregation or loss of ingredients. The means of transportation shall ensure that the concrete is of the required workability at the point and time of placing.

10.6.26 Ready-Mix Concrete

Delivery trucks will not be permitted to discharge any concrete that has been batched for more than 30 minutes.

Should the Contractor wish to pump concrete to any section of the Works, then he shall satisfy The Owner regarding his proposals, and shall provide such spare items of Plant as the Engineer considers necessary to avoid delays due to mechanical breakdown. The Contractor shall demonstrate, by trials, that his designed mixes can be pumped.

Precautions shall be taken to avoid depositing water or grout in the Works during starting-up operations or in flushing or clearing of the pipeline. The concrete shall pass through the pipeline in not more than 20 minutes.

10.6.27 Placing of Concrete

The concrete shall be placed in the positions and sequence previously approved by the Engineer.

Except where otherwise directed, concrete shall not be placed unless the Engineer or his representatives present and has previously examined and approved the positioning, fixing and condition of reinforcement and any other items to be embedded and the cleanliness, alignment and suitability of the containing surfaces or formwork.

The concrete shall be deposited as nearly as possible in its final position without rehandling or segregation and in such a manner as to avoid displacement of the reinforcement, or other embedded items or formwork. Wherever possible bottom opening skips shall be used. Where chutes are used to convey the concrete their slopes shall not be such as to cause segregation, and suitable spouts or baffles shall be provided where necessary. Concrete shall not be dropped through a greater height than 2.5 m except with the approval of the Engineer who may order the use of bunkers and the turning over of the deposited concrete by hand before being placed. Tremies or pipelines shall be used for drops in excess of 2.5m.

Concrete shall not be placed in standing water or running water unless so specified or approved.

The Contractor may at its own option and expense with the prior approval of the Engineer place concrete by pumping. Concrete pumps shall be operated by mechanically applied pressure and shall produce a continuous stream of concrete without air pockets.

Placing for Formed Finishes

The concrete shall be placed in one continuous operation rising uniformly in the formwork at a rate not less than 2m per hour. The concrete shall not be handled in any manner that may cause segregation.

The concrete shall not be placed directly against a vertical form face but shall be caused to flow to this surface during the compaction process. Care shall be taken to avoid the form face being splashed with mortar during the placing operation.

When pumps are used the velocity of discharge shall be regulated by suitable baffles or hoppers, where necessary to prevent segregation or damage and distortion of the reinforcement, embedded items and formwork, caused by impact.

When pumps are used on large or complicated pours a standby pump shall be provided.

Precautions shall be taken to avoid depositing water or grout in the Works during starting up operations or in flushing or clearing the pipeline. The pipeline shall pass its own length of concrete in not more than 20 minutes.

When pumping is completed the concrete remaining in the pipeline if it is to be used in the Works is to be ejected in such a manner that there will be no contamination of the concrete or separation of the ingredients. After this operation the entire equipment is to be thoroughly cleaned.

The Contractor shall submit to the Engineer for approval full details of the design of the concrete mix to be used for pumping prior to pouring of concrete.

The Contractor must ensure that there is no variation of the water / cement ratio of pumped concrete due to the ingress of water at the pumping plant.

Placing Concrete to Large Pours

a. Definition

For the purpose of this specification a large pour is defined as one having a least dimension thickness of 1.5m or where in the opinion of the Engineer the combination of pour dimension concrete mix and pour location require the procedures for large pours to be implemented.

b. Criteria

The criteria for concreting of large pours is to control the cracking strains induced by the heat of hydration of cement during the curing of concrete. This may be achieved by one of two methods, either by dividing the pour into a number of smaller sub pours to an agreed sequence or by adopting the technique of large pours as one continuous operation.

c. Procedure

The Contractor shall submit his detailed proposals for approval by the Engineer at least four weeks before he wishes to commence any large pours. His proposals should show how he proposes to deal with the requirements of the particular method he chooses to adopt. These requirements are outlined in d. and e.

d. Sub Division of Large Pour into Smaller Sub Pours

These shall be constructed in lifts not exceeding 1.5m deep and each lift shall be sub divided so that the maximum horizontal dimension in length or breadth of each pour does not exceed 12.5m. Vertical joints shall be staggered by at least 1m with the pour above or below and bays at any level shall be joggled in plan to ensure that joints are not continuous in any vertical plane.

The sequence of pouring shall be arranged so as to minimise the effects of differential shrinkage between pours. The arrangement of lifts, joints and the sequence of pouring shall be to the approval of the Engineer.

e. Large Pours in One Continuous Operation

To achieve this the following criteria must be met with:

i. Internal thermal strains must be controlled.

ii. External applied restraint must be avoided.

iii. The complete reinforced concrete section must be cast in one continuous section.

The contractor method statement shall highlight the following to satisfy the Engineer's requirement.

i. Limit on temperature by adequate thermal insulation of exposed surfaces throughout the curing period.

The maximum temperature at any point within the pour shall not exceed 85°C. The maximum temperature differential within a single pour shall not exceed 25°C. The maximum value of mean temperatures between adjacent element cast at the same time shall not exceed 25°C. The maximum value of mean temperatures between adjacent elements cast at different times shall not exceed 15°C.

ii. Arrange pouring sequence to avoid external restraint to movement and in particular to avoid "trapped bays".

iii. Ensure the adequacy of the supply of concrete, the means of placing, compaction and covering to guarantee that a pour, once commenced, will be completed.

iv. Provide all necessary means of measuring and recording concrete temperature, both inside and on the surface of the concrete, to ensure that temperature differentials are being kept within the required limits and to assist in determining formwork stripping times.

f. Concreting Final Preparation and Inspection

The Contractor shall make necessary arrangements to comply with the above clause.

The contractor shall commence concreting of large pours only after obtaining a permit from the Engineer.

10.6.28 Temperature Records

The Contractor shall supply suitable maximum / minimum thermometers to record the maximum and minimum temperatures of the ambient shade adjacent to all parts of the Works where concrete is being placed.

10.6.29 No Partially Set Material to be Used

All concrete and mortar must be placed and compacted within 30 minutes of its being mixed unless otherwise approved; no partially set material shall be used in the Works.

In the case of ready mixed concrete, the concrete shall be transported in truck mixers complying with the requirements of American Code. Concrete shall be discharged from the delivery vehicle within 1 hour of loading subject to the approval of the Engineer.

10.6.30 Compaction of Concrete

The concrete shall be fully compacted throughout the full extent of the layer and shall be brought up in level layers of such depth that each layer is readily and properly incorporated with the layer below by the use of internal vibrators.

Whilst concrete is being placed in position it shall be compacted in such a manner as to produce a dense uniform mass, special care being exercised to ensure that fresh concrete is properly incorporated with adjacent unset concrete and that the concrete between and around the reinforcement and adjacent to the forms is free from voids and other imperfections.

During the placing of concrete for reinforced work a competent steel fixer shall be made available by the contractor to adjust and correct the position of the reinforcement if necessary.

Except where otherwise permitted by the Engineer, concrete shall, during placing, be compacted by vibrators of a type approved by the Engineer. The vibrators shall be suitable for continuous operation. Whenever concrete is being vibrated one spare vibrator in each type in use shall be made available by the contractor at site in case of braked down. They shall be disposed in such a manner that the whole of the mass under treatment shall be adequately compacted at a speed commensurate with the supply of concrete from the mixers. Vibration is to continue until the concrete being placed is fully compacted and all air bubbles have been expelled. Care must be taken that segregation of mortar and aggregate by excessive vibration is avoided.

Vibration is not to be applied directly, or through the reinforcement, to sections or masses of concrete which have hardened or after the initial set has taken place. Vibration must not be used to make the concrete flow in the formwork.

Unless otherwise specified all structural concrete shall be compacted by mechanical vibrators appropriate for the type of concreting.

External vibrators shall not be used without prior approval.

10.6.31 Concreting in Adverse Weather Conditions

No concreting will be allowed to take place in the open during storms or heavy rains. In places where such conditions are likely to occur the Contractor shall arrange for adequate protection of the materials, plant and formwork so that work may proceed under proper cover. Where strong winds are likely to be experienced additional precautions shall be taken to ensure protection from driving rain and dust and the evaporation of water from the concrete surface.

The temperature of the concrete at the time of placing shall not exceed 32°C. In hot weather it will be necessary for the Contractor to take precautions, such as spraying coarse aggregate with cold water; painting all plant and equipment white; shading of aggregate stockpiles, water and machinery; protecting moulds and mixed concrete from the direct rays of the sun; cooling of the mix constituents, machinery reinforcement and moulds; and restricting transportation time to a practical minimum. The addition of crushed ice into the concrete mix in lieu of water will be necessary during the summer months.

During placing suitable means shall be provided to prevent premature stiffening of the concrete placed in contact with hot surfaces. All concreting areas, formwork and reinforcement shall be shielded from the direct rays of the sun, protected from drying winds, and sprayed with clean water when necessary.

If the surface exhibits cracking when the concrete is still plastic, then the same shall be retamped to close the cracks.

The Engineer may withhold approval of commencement of concreting until he is satisfied that full and adequate arrangements have been made by the contractor.

10.6.32 Concreting at Night or in the Dark

Where approval has been given to carry out concreting operations at night or in places where daylight is excluded the Contractor shall provide adequate lighting at all points where mixing, transportation and placing of concrete are in progress.

10.6.33 Records of Concrete Placement

The Contractor shall submit weekly a complete record of the concrete work done showing the time and date when concrete was placed and of all test cubes, cores or other samples taken from them in each part of the Works.

10.6.34 Curing and Protection

Immediately after compaction and for at least 7 days thereafter concrete shall be protected against harmful effects of sunshine, drying winds, cold, rain or running water. During this period the measures given below shall be taken to prevent the loss of moisture from the concrete and to minimise thermal stresses caused by the difference in temperature between the surface of the concrete and the core of the concrete mass. No other methods shall be employed except with the Engineer's approval.

Where water is to be used for curing concrete it shall be fresh water of concreting quality in accordance with this Specification.

Unless otherwise agreed by the Engineer curing is to be carried out as follows :

Horizontal surfaces :

i. Polythene sheeting shall be placed in contact with the concrete surface immediately after finishing and held in position to prevent moving air from evaporating water from the surface.

ii. After final set has taken place, the polythene shall be replaced by wet hessian which shall then be covered with polythene held down as above.

iii. After at least 7 days the hessian and polythene shall be removed and an aluminised or white pigment resin based curing compound sprayed on the surface. The rate of application shall be strictly in accordance with the manufacturer's recommendations.

The particular compound and method of application are to be approved by the Engineer.

iv. The hessian shall be kept wet at all times.

v. Concrete shall be shaded at least for the first 7 days and as long as possible thereafter as instructed by the Engineer.

vi. Where specific surface textures are required, e.g. brush finishing on road slabs then alternative methods may only be employed with the approval of the Engineer.

Vertical surfaces :

i. Immediately after stripping, the member shall be wrapped with wet hessian and then covered with polythene which shall be held firmly in place to prevent wind drying of surfaces. The hessian shall not be allowed to dry out.

ii. After an initial curing period of at least 7 days the hessian and polythene may be removed and the concrete surface sprayed with an aluminised or white pigmented resin based curing compound as an alternative to retaining the hessian and polythene in place for at least another 7 days.

Where timber or other insulating formwork is used it must either be struck as specified or it shall be left in place until such time after the temperature peak is reached as directed by the Engineer.

Air circulation along the exposed faces of concrete shall be prevented during the curing period.

All joints which have to be filled with sealing compound, or surfaces formed as construction joints, shall be protected in a manner which will ensure that no curing compound is placed on the bending surface, e.g., by placing wet hessian. The protection is to ensure proper curing of the joint surface and adjacent concrete and is to remain in place until the joint surface is sealed or for the periods specified.

All concrete shall be protected from anything likely to interfere with the process of setting. No load of any kind shall be imposed upon any concrete members after the removal of the struts until the concrete is thoroughly set and hardened and has reached the specified 28 day strength.

Where curing membranes are used they shall be compatible with waterproofing or other materials that may subsequently be applied to the surface of the concrete.

All concrete liable to be affected by running water or wave action shall be adequately protected from damage during the setting period and all temporary protective works shall be to the satisfaction of the Engineer.

The Contractor's attention is drawn to the particular importance of proper and adequate curing. Failure to carry out satisfactory curing can lead to cracking in the concrete. This is turn can lead to accumulation of salt on the reinforcement and consequential failure of the structure.

If in the opinion of the Engineer cracks occur in a structure which in his judgement are severe enough to affect the structure, the Contractor shall cut out and replace the defective concrete at his own cost.

10.6.35 Construction Joints

Concreting shall be carried out continuously up to construction joints, the position and arrangement of which shall be as previously approved by the Engineer.

The Contractor shall allow for working beyond the ordinary working hours where necessary in order that each section of concrete may be completed without any laps while the work is in progress. All construction joints shall be shuttered square to the work. Keyways shall be formed in all horizontal and vertical construction joints except where ordered by the Engineer to be omitted.

When work is resumed on a surface which has set the whole surface shall be thoroughly roughened or scabbed with suitable tools so that no smooth skin of concrete that may be left from the previous work is visible. These roughened surfaces shall be thoroughly cleaned by compressed air and water jets or other approved means and brushed and watered immediately before depositing concrete.

10.6.36 Preparation of Surfaces to Receive Concrete

Prior to placing of reinforcement and concreting, a blinding concrete 75 mm minimum thickness shall be placed over the ground below the underside level of the reinforced concrete to form a hard even surface.

Unless mentioned otherwise on the Drawings or directed by the Engineer, concrete placed against rock shall be dowelled by means of steel reinforcing bars and anchored into the rock. The Contractor shall drill holes of the necessary diameter into the rock to receive the anchors. Each hole shall be flushed out with water, filled with 1:1 sand-cement mortar and the anchor bar inserted to the full depth of the hole.

Immediately before depositing concrete on or against a surface of rock, masonry, brickwork, old concrete or the like, the following preparation shall be carried out. All lose material shall be removed and the surface washed down; all water emerging at the surfaces shall be stopped as far as possible or suitably channelled or piped away from the Works.

10.6.37 Waterstops

Waterstops are to be 250 mm minimum width and manufactured from moulded natural or synthetic rubber, neoprene or PVC and are to be of a type and quality approved by the Engineer. Where used in works liable to hydrocarbon contamination or containing oil, the waterstops shall be appropriately made contamination resistant. The waterstops shall form a continuous network and jointed strictly in compliance with manufacturer's recommendations.

10.6.38 Expansion and Contraction Joints

Expansion and contraction joints shall be provided at intervals not exceeding 5 m to allow for all movements and to minimise shrinkage and thermal strains in the concrete. The number and locations of all joints to be shown on the working Drawings.

Contraction joints shall be formed as deliberate planes of discontinuity in the concrete structure. To form such a joint the face of concrete slab or block first formed shall be painted with two coats of approved rubber bitumen paint before the adjoining slab or block is concreted. The exposed edges of joints shall be sealed with an approved polysulphide rubber sealing compound to American Code or other approved oil, ultra-violet and water resistant sealing compound.

Expansion joints shall be formed in the same way as contraction joints but in addition a resilient flexible non-decaying fibrous material impregnated against attack from insects and water shall be supplied and placed in the joint to provide freedom for two adjacent concrete slabs or blocks to expand. The exposed edges of the joints shall be sealed with an approved polysulphide rubber sealing compound to American Code or other approved oil and water resistant sealing compound.

Performed joint filler shall be of the required thickness within a tolerance of ± 1.5 mm. It shall be 25 mm less in depth than the thickness of the slab, within a tolerance of ± 3 mm and in suitable lengths, each not less than 1.2 m. Holes to accommodate dowel bars shall be accurately bored or punched out to be a sliding fit on the dowel bars.

The material comprising joint filler shall be of approved quality such that it can be satisfactorily installed in position at the joint.

Joint filler materials shall comply with American Code requirements and shall be approved by the Engineer.

Dowel bars for expansion joints in concrete shall consist of mild steel complying with the relevant requirements of American Code.

Dowel bars shall be straight, free from burred edges or other irregularities and shall have their sliding ends sawn. The sliding half of each dowel bar shall be painted with a thin coat of bond breaking compound and the end of this half shall be provided with a close fitting plastic or waterproof cardboard cap at least 100 mm long, the end 20 mm of which shall be filled with a disc of joint filler or a pad of cotton waste.

Bond breaking compound for dowel bars shall consist of a bitumen paint containing 68 percent of 200 pen bitumen blended hot with 14 percent light creosote oil with the addition, when cold, or 20 percent solvent naphtha. It shall in no way retard or otherwise affect the setting of concrete.

Wherever a design joint is envisaged in a water retaining structure, or where otherwise ordered, the joint shall be made watertight by the provision of a continuous waterstop strip fixed across the joint. Special care shall be taken to ensure that the concrete is well worked against the embedded parts of the strips and is free from honeycombing. Precautions are to be taken to protect any projecting portions of the strips from damage during the progress of the works and in the case of rubber and plastic from light and heat.

For joints in water retaining structures or continuously submerged in water, the joint is to be normally constructed as specified. This joint is to be further protected / sealed with a joint bridge comprising water resistant plasticised PVC strip with polyester felt edges fixed with epoxy resin adhesive.

10.6.39 Workmanship and Construction

10.6.39.1 Construction and Preparation of Formwork

The design, preparation and maintenance of formwork shall be responsibility of the contractor.

The Contractor shall submit for the approval of the Engineer details of the method and materials proposed for shuttering each section of the work including in estimate of the loads likely to be applied on to the forms details of all proposed wrought shuttering and shuttering to produce special finishes shall be submitted for approval in writing by the Engineer before any materials are brought on to the site. If the Engineer so requires, samples of formwork shall be constructed and concrete placed so that the proposed

methods and finish effect can be demonstrated. Proprietary form work support systems and materials shall be used for all Works.

Forms shall be constructed from sound materials of sufficient strength, properly braced, strutted and shored to ensure rigidity throughout the placing and compaction of the concrete without visible deflection. Forms shall be so constructed that they can be removed without shock or vibration to the concrete. Internal ties shall be of metal and capable of removal without permanent injury to the concrete. No part of any metal tie or spacer remaining permanently embedded in the concrete shall be nearer than 75 mm to the finished surface.

All metal ties shall be cranked and incorporate a puddle flange water stop.

All joints shall be close fitting to prevent leakage of grout and at construction joints the formwork shall be tightly secured against previously cast or hardened concrete to prevent stepping of ridges to expose surfaces.

Release agents used for the work shall be of the following types and shall be stored and used strictly in accordance with manufacturers recommendations.

Cream emulsion

Neat oil with surfactant added

Chemical release agent

Formwork shall be constructed to provide the correct shape, lines and dimensions of the concrete within the tolerances specified hereafter. Due allowance shall be made for any deflection which will occur during the placing of concrete within the forms. Panels shall have true edges to permit accurate alignment and provide a neat line with adjacent panels and at all construction joints. All panels shall be fixed with their joints either vertical of horizontal unless otherwise specified or approved. When chamfers are to be formed the fillets shall be accurately cut to size to provide a smooth and continuous chamfer.

10.6.40 Forms for Exposed Concrete Surfaces

Forms for all permanently above ground concrete surfaces shall be such as to ensure no surface irregularities greater than 3 mm and, in the case of reinforced concrete, the full cover to steel shall be maintained. Wrought shuttering shall be used such as to produce a smooth and even surface free from perceptible irregularities, and tongued and grooved planed boards or plywood or steel forms shall have their joints flush with the surface. The Contractor shall make due allowance for the renewal and / or repair of shuttering for which more than one use is intended.

Suitably sized chamfers shall be provided to all exposed arises unless otherwise agreed by the Engineer.

Rebate features 15 x 15 mm shall be provided at all construction joints. Alignment of all rebates shall be absolutely straight.

The Contractor's attention is drawn to the protective coating requirements of Clause 4.36. The whole formwork surfacing, finish and alignment, shall be such that the protective coating finish shall not be impaired or defective due to the formwork utilised.

10.6.41 Forms for Non-Exposed Concrete Surfaces

Where the finished surface of concrete is not to be permanently exposed, the forms may be constructed of plain, butt jointed sawn timber unless otherwise directed by the Engineer. In mass concrete, surface irregularities may be permitted but in reinforced concrete construction the surface shall be true and the full cover to the reinforcement shall

be maintained at all points. The tolerances for the finished concrete dimensions shall not be exceeded.

Sealers on Timber Surfaces

Where their use has been specified or approved, sealers shall be applied to surfaces which are dry and free from dirt, grease or other impurities. Before a surface is sealed it shall be sanded to remove any protrusions or to smooth any rough areas. Any holes or indentations shall be stopped with a water-proof filler.

Whether or not the surfaces of the formwork in contact with the concrete are sealed, all edges and joints to plywood or other timber including the edges of any holes drilled through it shall be sealed.

10.6.42 Preparation of Forms for Concreting

Before concrete is placed, the form shall be thoroughly cleaned and freed from sawdust, shavings, dust or other debris by hosing with water, compressed air or other approved means. Temporary openings shall be provided to assist in removal of the water and rubbish.

After cleaning the forms shall be coated with an approved shutter oil, which shall not be allowed to run on to reinforcement or other embedded steel work.

10.6.43 Holes and Fixing

Where holes or fixings for equipment are required these shall be set-out to a tolerance of plus or minus 5 mm unless otherwise directed. Holes and pockets shall be formed square to the formwork. Permanent liners and formers shall not be used unless of expanded metal or similar material. When metal liners are used specified concrete cover shall be maintained.

Threaded inserts and cast-in-bolts shall be fixed square to the formwork by a temporary bolt or nut and the concrete cast around them. All threads shall be cleaned of grout and projecting parts protected from rusting with bituminous paint.

All bolt holes shall be cleaned, prepared, primed and filled with a proprietary non-shrink cementitous material.

The responsibility for the safe removal of any part of the formwork solely rests with the contractor.

All formwork shall be inspected and approved by the Engineer before concrete is placed within it though this shall not relieve the Contractor from the requirements as to soundness, finish and tolerances of the concrete specified elsewhere.

The contractor shall not reuse damaged formwork, if it is found to be causing a detrimental appearance of concrete in the opinion of the Engineer.

10.6.44 Concrete Tolerances

The line grades and dimensions of the concrete shall conform to those detailed on the Drawings within the following tolerances :

a.	Overall dimensions and level	:	-6 mm to +6 mm
b.	Column sizes	:	-0 mm to +5 mm
c.	Beam sizes	:	-0 mm to +5 mm
d.	Slab thicknesses	:	-0 mm to +6 mm
e.	Wall thicknesses	:	-0 mm to +10 mm
f.	Foundations and RC walls and slab below ground level	:	-5 mm to +10 mm
g.	Vertical lines out of plumb	:	-5 mm in 5 but not exceeding 8 mm in total

h. Formwork for beam soffits shall be erected with an upward cam ber of 5 mm per 3 m of span.

i. The gap under a 3 m long straight edge placed on any plane surface or edge in any direction shall not exceed 3 mm.

10.6.45 Removal of Formwork

Forms shall be removed in such a manner as will not damage the concrete. No forms shall be removed until the concrete has gained sufficient strength to support itself. Centres and props may be removed when the member being supported has gained sufficient strength to carry itself and the lad to be supported on it with a reasonable factor of safety. External loading shall not be applied until the concrete has reached its characteristic cube strength.

If the formwork props are to be left in place when soffit forms are removed they shall not disturbed during the removal of forms without approval from the Engineer. Removal of form work shall confirm to American Code.

10.6.46 Precast Concrete

Concrete members specified to be fabricated as precast concrete units shall be fabricated with concrete of the specified class placed into a grout-tight mould. If so required the mould shall be laid on a vibrating table and vibration applied while the concrete is placed. The Engineer's approval shall be sought concerning which faces of the concrete member shall be the exposed faces and the specified surface finish shall be applied to them.

With the approval of the Engineer the Contractor may be permitted to precast members which were specified to be constructed in situ and in such cases the Contractor shall carry out the work as described above. Generally members which are structurally dependent on a rigid fixing with the adjoining structures will not be permitted to be constructed by the recasting.

10.6.47 Concrete Returns

The Contractor shall submit weekly a concrete return to the Engineer which shows the quantities of cement and the number of mixings of concrete used in each section of the Works including temporary Works. The quantities of cement used for all purposes in the Works shall bear a proper relation to the quantities of cement tested and concrete mixed and approved by the Engineer. In the event of any difference occurring the measures at the mixers for cement shall be adjusted by the contractor as ordered by the Engineer.

10.6.48 Exposed Surfaces

The finished faces of all concrete work shall be sound, solid and free from honeycombing, excrescences and blemishes.

Plastering of defective concrete as a means of making good will not be permitted. Surfaces showing minor porosity shall, if the Engineer so approves, be rubbed down with cement and sand mortar of the same richness as the concrete immediately after the removal of formwork. All such remedial work shall be carried out in accordance with the Engineer's instructions at the Contractor's expense. The materials for filling holes shall be compatible with and to the approval of the manufacturer(s) of the final coating materials.

10.6.49 Treatment of Cast Concrete

Unless otherwise directed no treatment of any kind, other than that required for curing the concrete, shall be applied to the concrete after removal of the forms until it has been inspected.

The Contractor's methods of making good any defects are subjected to the approval by the Engineer in each case.

Formed Concrete Finishes

a. General

Where a particular type of finish is required on the concrete surfaces it will be indicated on the drawings, the reference to finishes shall have the meanings described below.

Where no finish is indicated on the drawings a smooth dense surface free of large voids and honeycombing is required. The Contractor shall obtain the Engineers' approval of his proposed methods of forming the concrete surfaces.

b. Class F1

Form materials shall be of good quality plywood or similar and shall be uniform with panels and fixings arranged in a regular pattern.

Small surface blemishes caused by entrapped air or water may be expected, but the surface shall be free from voids, honeycombing or other large blemishes. The finish shall be left as struck except that if required by defects such as fins and other minor blemishes shall be made good by an approved method.

c. Class F2

Form faces shall be of an impervious material such as plastic-laminate-faced plywood, G.R.P. or steel. Form panels shall be as large as practicable and arranged in an approved regular pattern. The finish shall be smooth without significant blemishes or discolouration. The contractor shall obtain Engineers approval for making good the defective workmanship. Internal form ties and spacers for maintaining concrete cover will not normally be permitted.

d. Class F3

Formwork type F3 is to be generally as specified for F2 but extra care is to be taken to ensure that the concrete surface has no blemishes or discolouration and meets with the Client's approval.

The surface of each prefabricated formwork panel is to be inspected for marks, indentation holes or blemishes, which are either to be made good to the Engineers' satisfaction or the panel discarded for use as 3F formwork.

When concrete is being placed, the surfaces of the panels are not to be splashed with concrete or grout and the formwork joints shall be watertight.

Unformed Concrete Finishes

Class U1	The concrete shall be uniformly levelled and tamped.
Class U2	The concrete shall be uniformly levelled and tamped and subsequently wood floated by hand to produce a uniform surface.
Class U3	The concrete shall be uniformly levelled, tamped and floated. When sufficiently hard it shall be steel floated by hand or machine to produce a dense, smooth, uniform surface free from tool marks.

The concrete shall be uniformly levelled and tamped

The concrete shall be given a smooth finish and subsequently wood floated by hand to produce a uniform surface. The surface shall then be scratched with a stiff brush to give a slightly roughened even texture.

10.6.49.1 Quality of Exposed Concrete Surface

Appearance

Any finished work which The Owner judges to be inferior in any respect or to be unacceptably different in appearance from parts of the Works already constructed or which is subsequently stained or damaged will be classed as defective work.

Protection

Surfaces which will be exposed to view in the finished Works shall be protected from spillage, stains and any other damage.

10.6.49.2 Protection of Unformed Concrete Finishes From Damage Due to Rain

Prior to the casting of any concrete floor, the Contractor shall take all necessary precautions to ensure that the freshly cast concrete can be protected from damage due to rain should rain occur.

Where surface hardened finishes have been specified, the Contractor shall take measures to ensure that the application of the surface hardener can take place in accordance with the Manufacturer's specification whilst the concrete surface is protected from rain.

10.6.50 Fair Finish

Where the surface of the concrete is specified to be "fair faced" as distinct from wrought finish, it shall be rubbed smooth with a carborundum brick immediately on removal of the shuttering and while the concrete is green and all small holes shall be stopped with cement mortar of such a mix as to render the stopping invisible.

10.6.51 Integral Waterproofing

Integral waterproofing of concrete shall be achieved where indicated on the Drawings by the use of an admixture approved by the Engineer.

10.6.52 Grouting of Base Plates, etc.

Spaces between base plates and foundations and columns, plant, machinery, etc., shall be grouted with an approved non-shrinking grout. The space between the base plate and foundations shall be completely filled with grout and must provide maximum support over the complete area of these base plate and posses good impact resistant qualities.

Proprietary brands of grout shall be used. The type of grout used and method of application shall be by the Engineer, in particular air holes shall be provided where necessary in base plates to eliminate all possibility of any entrapped air pockets.

If required the Contractor shall demonstrate to the Engineer by means of samples and tests that the proposed grout is satisfactory.

10.6.53 Protective Coatings

External protection to all foundations and concrete substructures is required with an approved self adhesive bituminous type membrane with three layer cross laminate reinforcement applied in accordance with the manufacturer's instructions. The membrane is to be continued to the finished ground level.

All exposed concrete surfaces above tanking membrane tuck-in level shall be coated with an approved penetrating saline water-repellent, chloride resistant coating and subsequently overcoated with an approved compatible two coat smooth finish acrylic paint system. Sample panels of minimum area 10 m² shall be made on finish concrete to prove the finish quality and enable the colour to be selected. Only these panels finally approved may be included in the Works.

10.6.54 Admixtures

Admixtures may be permitted in mixes at owner's discretion, provided the details of admixture and the associated mix design and final results are approved. Admixtures containing calcium chloride shall not be permitted.

10.6.55 Testing of Concrete

Frequency of Routine Tests; Works Concrete

Samples shall be taken at point of discharge from the delivery vehicle, or at the point of placing the concrete, as directed.

Unless directed otherwise, the rate of sampling shall be the greatest of:

(a) one per 10m³ of concrete or part thereof placed in columns or cantilevers;

or

(b) one per 20m³ of concrete or part thereof in beams and slabs (other than cantilevers) walls and footings;

or

(c) one per 50m³ of concrete or part thereof in solid raft foundation;

or

(d) one on each day that concrete of that grade is used;

or

(e) one per column, beam or foundation element.

Where more than one rate of sampling is carried out on the same concrete mix the results of all cube tests from these samples shall be considered together for assessments of compliance with the strength requirements of this Specification. The location of the poured concrete that has been sampled shall be clearly recorded.

Each sample shall consist of 3 cubes, which shall be made, cured, and tested in accordance American Code.

One of the three cubes shall be tested at 7 days and the remaining two at 28 days for compressive strength.

The workability of each sample shall be checked and shall be within the limits given in this Specification.

10.6.55.1 Test Failure of Works Concrete

Any concrete which does not comply with the requirements of this Specification will not be accepted.

In the event of such non-compliance the affected works shall be classed as defective work and the Contractor shall :

i. Take all necessary steps to avoid repetition on subsequent concrete mixes.

ii. Submit his proposals for rectification of the affected works to The Owner for approval.

10.6.56 Setting Out and Tolerances

10.6.56.1 Contractor's Proposals

Before commencement of any concrete works on site the Contractor shall submit for approval his detailed proposals for dimensional setting out and control. Acceptance of such proposals shall not relieve the Contractor of any responsibility for complying with the requirements of this Specification.

Dimensional Criteria

The permissible variation from dimension, lines given in the drawing shall be within tolerances specified in the relevant American codes/other applicable standards or as indicated by the Engineer. Generally the following tolerances shall be considered.

Tolerances for R.C. Buildings :

i) Variation from the plumb

a. In the lines and surfaces of columns, piers, walls and in arises 5 mm per 2.5 m or 25 mm, whichever is less.

b. For exposed corner columns and other conspicuous lines

In any bay or 5 m max.	-	5 mm
In 10 m or more	-	10 mm

ii) Variation from the level or from the grades indicated on the drawings

a. In slab soffits, ceilings, beam soffit, and in arises

In 2.5 m	-	5 mm
In any bay or 5 m max.	-	8 mm
In 10 m or more	-	15 mm

b. For exposed lintels, sills, parapets, horizontal grooves and other conspicuous lines

In any bay or 5 m max.	-	5 mm
In 10 m or more	-	10 mm

iii) Variation of the linear building lines from established position in plan and related position of columns, walls and partitions.

In any bay or 5 m max.	-	10 mm
In 10 m or more	-	20 mm

iv) Variation in the size and locations of sleeves, openings in walls and floors - 5 mm except in the case of and for anchor bolts

v) Variation in cross-sectional dimensions of columns and beams and in the thickness of slabs and walls

Minus	-	5 mm
Plus	-	10 mm

vi) Footings

a. Variation in dimension in plan

Minus	-	5 mm
Plus	-	50 mm

b. Misplacement or eccentricity

2% of footing width in the direction of misplacement but not more than 50 mm

c. Reduction in thickness

Minus	-	5% of specified thickness subject to a max. of 50mm

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vii) Variation in steps

a.	In a flight of stairs		
	Rise	-	3 mm
	Tread	-	5 mm
b.	In consecutive steps		
	Rise	-	1.5 mm
	Tread	-	3.5 mm

Tolerances in other Concrete Structures

a. All structures

i.	Variation of the constructed linear outline from established position in plan		
	In 5 m	-	10 mm
	In 10 m or more	-	15 mm
ii.	Variations of dimensions to individual structure features from established positions		
	In 20 m or more	-	25 mm
	In buried construction	-	50 mm
iii.	Variation from plumb, from specified batter or from curved surfaces of all structures		
	In 2.5 m	-	10 mm
	In 5 m	-	15 mm
	In 10 m or more	-	25 mm
	In buried-construction	-	Twice the above amounts
iv.	Variation from level or grade indicated on drawings in slab, beams, soffits, horizontal grooves and visible arises		
	In 2.5 m	-	5 mm
	In 7.5 m or more	-	10 mm
	In buried construction	-	Twice the above amounts
v.	Variation in cross-sectional dimensions of columns beams, buttresses, piers and similar members		
	Minus	-	5 mm
	Plus	-	10 mm
vi.	Variation in thickness of slabs, walls, arch sections and similar members		
	Minus	-	5 mm
	Plus	-	10 mm

b. Footing for columns, piers, walls, buttresses and similar members

i. Variation of dimension in plan

Minus - 5 mm

Plus - 10 mm

ii. Misplacement or eccentricity

2% of footing width in the direction of misplacement but not more than 50 mm

iii. Reduction in thickness

5% of specified thickness subject to a max. of 50 mm

Tolerances in other types of structures shall generally conform to those given in 2.4 of Recommended Practice for Concrete Formwork (ACI 347)

Tolerances in fixing anchor bolts shall be as follows:

i. Anchor bolts without sleeves ± 1.5 mm in plan

ii. Anchor bolts with sleeves ±5.0 mm in elevation

a. For bolts upto and including 28 mm dia ± 5 mm in all directions

b. For bolts 32 mm dia and above ± 3 mm in all directions

iii. Embedded parts - ± 5 mm in all directions

Measuring Equipment

The Contractor shall ensure that all setting out and measuring equipment is adequate to achieve the accuracy required by this Specification.

All optical and electrical equipment shall at all times have satisfactory test certificates not more than six months old and shall be re-tested as necessary to maintain this or as directed.

Dimensions of Completed Work

The Contractor shall keep records in an approved form of the dimensions of all work as constructed.

These records shall be made available for inspection at any time and shall be submitted immediately after completion of each section or as directed by the Engineer.

10.6.57 Defective Work

Where any of the finished Works or the materials or workmanship in any part of the Works fails to comply with this Specification, that part of the Works will be classed as defective.

Defects shall be repaired by the Contractor at his own expense as approved by The Owner.

10.6.57.1 Testing to Establish Acceptability of Work

Any tests which are proposed by the Contractor or required by The Owner as a result of any failure of any part or parts of the Works to comply with this Specification shall be at the Contractor's expense irrespective of the outcome of the tests. The Contractor shall in addition be responsible for any consequential costs or delays.

The Owner will not necessarily accept the result of these tests as proof of adequate materials or workmanship.

10.6.57.2 Defective Appearance

Where for any reason the appearance of the concrete is in the opinion of the Owner spoilt, that part of the work will be treated as defective work.

Any surface which is marred by rubbish left in the mould and (when using smooth-surfaced formwork) any surface which is discoloured by leakage of water or grout will be treated as defective work.

10.6.57.3 Load Tests

Test procedures and standards of acceptance will be specified by the Owner to accord with the design.

Where the results of such tests indicate that any part of the Works does not comply with this Specification that part of the Work will be classed as defective work.

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10.7 Special Requirements for Concrete Channels and Ducts

10.7.1 Scope

This specification covers the requirement in respect of materials workmanship and quality regarding special requirements for concrete channels and ducts.

For cables and pipes the contractor shall provide channels and ducts in such areas where installation above ground is not possible or advisable. Cables and pipes shall be generally laid in separate ducts.

Exceptions shall be approved by Engineer.

10.7.2 Codes and standards

Unless specifically mentioned otherwise American codes and standards in their latest editions, local regulations shall govern in respect of design, workmanship, quality and properties of materials and methods of testing.

10.7.3 Quality assurance

The quality assurances shall comply with, but not limited to the requirements of requirements of applicable codes and standards.

10.7.4 Ducting works

The ducts are to be constructed of reinforced concrete according the specifications "Concrete Works" - Section No 10.6 specified herein, and must be watertight under the prevailing ground water conditions. Particular attention must be paid to satisfactory expansion joints. The walls and roofs of the ducts must be designed to resist the forces acting on it. The ducts are to be provided internally with anchor rails for the easy attachment of clips and cable racks. Plugging and shooting of fixing devised are permissible only in isolated cases and are subject to agreement.

All ducts covered by removable covers will have to provided with metal protection angles for purpose of protecting edges of removable covers and edge of duct walls beyond the removable covers.

The ducts shall be located away from roads in order not to disrupt or endanger traffic during subsequent necessary work such as overhauls and repairs. The interior of the duct walls in the vicinity of junctions, inlets and bends must be fitted so that no damage is suffered by the cables when they are being drawn in, allowing for the minimum bending ratio.

For drainage purposes the cable and pipe ducts shall be provided with slopes (min.slope 0.5%) towards drainage system or accessible pump sumps. The pump sumps to be provided with permanently installed automatic pumps. However, the using of pump sumps and pumping system can be avoided by providing rational drainage design. In this case the level control system must comply with the requirements of the electrical section of this specification. Electrical connections shall be considered. For the c/w piping trenches, permanent drainage for leakage cases shall be provided. All the other pump sumps will be pumped out, if necessary, by portable pumps delivered by the contractor, however the final method of drainage ducts shall be decided based on final design.

No drainage water or steam from installation and equipment shall be discharged into the channels. Sound construction practice shall be followed for construction of cable and pipe ducts.

10.7.4.1 Installation of Pipework

The pipe installation procedure and practises chosen shall meet the design requirements specified herein. The contractor shall employ on a full - time basis the services of one or more qualified field representative of the pipe manufacturers the pipe installation using and commissioning period, and shall execute the work as per the directions of the contractor.

10.7.4.2 Setting Out

The contractor shall be responsible providing the surveying instruments, surveyors skilled staff and everything necessary for setting out the works to line and level and for checking the accuracy of pipe laying and jointing, installation of valves and meters.

10.7.5 Special Requirements

10.7.5.1 Accessible Pipe and Cable Ducts

The contractor shall submit a proposal indicating special requirements and programme, and methods adopted for executing the work well in advance for the engineer's approval before commencing the work.

Additionally the contractor shall include the following in his specification.

The clear width of the ducts is to be appropriate to the width of the cable and pipe racks. Each duct, however, must have atleast 0.80 m of free width for access. The clear height must be least 2.20 m. Removable covers shall be provided.

Access manholes must be provided approximately every 45-50 m and also at junctions, inlets and bends and must be closed with covers suitably designed for traffic loads. Furthermore, the positions of the access manholes must be well connected with those of the fire-resisting bulk heads, of the pump sumps for dewatering and of the fire hydrants so that effective fire-fighting action may be taken in the event of fire in the ducts. The manholes for escape purposes must be located taking into account that no escape way longer than 30 m is permitted and that they must be located away from roads. These escape manholes must be provided with quick release covers, which can be easily opened by hand from inside.

Accessible cable ducts shall have fire resisting bulkheads at distances between 15 m and 20 m under the switchgears (with bulkheads following the profile of switchgear building) and up to 100 m for the remaining accessible cable duct. The bulheads shall be fitted with fire resisting doors, which shall close automatically in the event of smoke.

Adequate ventilation must be provided for the ducts to allow for heat dissipation from steam pipes and power cables. The air temperature and humidity in the ducts not exceed the specified limits.

10.7.5.2 Small Pipe and Cable Ducts

For ducts located above ground level removable covers (such as chequered plates, gratings, iron sheets etc., for indoor ducts and reinforce concrete covers for outdoor ducts) but only if shall be provided.

The dimensions of ducts shall be such that width of duct is equal to the width of the cable and pipe racks so as to ensure smooth maintenance operations. If the upper level of duct covers coincides with the finished ground level then no access manholes shall be provided.

10.7.5.3 Trench Excavation

The bottom of the trenches shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of the pipe.

The contractor shall inform the engineer in advance when the formation levels of the trenches are ready for inspection. No bedding material shall be laid until the bottoms of tracks have been inspected and approved by the engineer and the depths of the trenches and the kind of excavation have been recorded and agreed upon by both the contractor and the engineer.

Trench excavation, permissible bearing pressures and working space must meet the requirements of safety regulations. There must be considered whether the local pipe installation requires a different form of construction (e.g. concrete jacketing) or whether simple laying in a sand bed is sufficient. The working space should be increased appropriately if conditions necessitate this. Reference shall be made to specification No. 10.10, 10.5 for sub clauses related to preparation of foundation and sub-base and site filling and excavation respectively.

The contractor shall pay special attention to the following.

In works for pipe trenches, cable trenches and separate structures such as inspection shafts and the like, particular attention shall be given to the risk of asphyxiation, poisonous substances and explosions, and to the proper execution of the necessary isolating operations. Existing services shall not be utilised without the approval of Engineer.

Suspended and supported pipelines, sewers or cables shall not be interfered with or subjected to load. All measures adopted for protecting building structures, pipelines, sewers or cables shall be done as per regulations outlined by the engineer.

If the use of equipment prevents immediate support sheeting of the trench, it may be necessary to provide a temporary safety lining. Safety provisions must be made for pipe trenches greater than 1.25 m in depth. In special circumstances, for example when traffic loading is high, necessary safety precautions will have to be followed for trenches of depth lesser than above.

10.7.5.4 Inspection

In addition to the inspection and test done at time of delivery of materials, pipes and fittings, shall be inspected by the contractor immediately before and after installation and any damaged pipe or fitting shall be repaired or replaced by the contractor as directed by the engineer, at no extra cost of the owner.

The Engineer may, without there by relieving the contractor of any of its obligations, inspect and test the pipes and fittings by any means it considers appropriate and any damaged pipe or fitting discovered by such inspection shall be repaired or replaced by the contractor as aforesaid.

10.7.5.5 Support for Pipes

The support for the pipes shall ensure uniform distribution of the supporting forces.

The pipes may be laid on :

Type A Concrete supports / jacketing

Type B Special forms of construction

The above alternatives shall be designed and executed in detail as follows :

Type A Concrete Supports for Jacketing

In order to increase the load-bearing capacity of pipes, concrete supports / or jacketing may be provided. In designing the jacketing (for static loads), it is important to consider whether the concrete will be cast against the undisturbed soil or, for example, against sheet piling. Incase of sheet piling adverse effects on relieving action of horizontal earth pressure due to extraction of sheet piling are to be considered.

The minimum concrete quality for pipe jacketing shall be as per American Standards.

Construction joints shall be bridged by short reinforcing bars. The concrete jacketing may be subdivided by suitably spacing concrete joints at pipe connections.

Type B Special forms of construction. Concrete saddles (e.g. prefabricated pipe supports)

If supports are provided in this case, the suitably of supports shall be supported by calculation is special precautions are to be taken by the contractor where ever the ground is not stable or large settlements are expected. The suitability of such methods is to be supported by calculations. Suitable precautions must be taken at transitions between types of ground possessing different settlement properties. For pipes laid beneath embankments provision shall be made for sustaining any longitudinal tensile stresses and bending stresses that may occur.

10.7.5.6 Penetration of Pipes through Buildings

The penetration of pipes through buildings, shafts, thrust blocks and other structure or the transition from the pipes to any structure must be designed in such a way that differential settlements do not occur or cannot cause leakage's or damage. Such penetrations or transitions shall be designed to be flexible if not otherwise approved by the owner.

10.7.5.7 Supporting and Anchoring

Channel for pipelines laid in groundwater shall be secured against uplift by anchoring or by welding additional loads. The branches, bends, transition pieces, closures and the like in pressure pipelines shall be provided in such a way that they do not transmit longitudinal force, they shall be so secure that these forces shall be suitable secured.

Thrust blocks and other fixing structures are to be arranged in such a way that the ends of the reinforced / prestressed concrete or other pipelines are subjected to all forces and displacement within specified limits.

The pipe line forces have to transmitted by bottom friction from this gravity structure into the ground. The bend structures shall be designed accordingly. No unevenness is allowed at transitions between bend and pipe.

10.7.6 Pipe Laying

Assembling of the pipes shall be carried out centrally along the pipe axis, using levers, gripping tackles, winches of jacks. Each individual pipe length shall be accurately located to line and gradient. Suitable lifting equipment's to ensure accurate raising and lowering shall be provided by the contractor.

Pipe surfaces which come into contact with seals must be cleaned, during assembly and sealing the pipes must be protected from dirt. Pipe jointing shall be carried out with proper care, even under difficult site conditions.

10.7.7 Special Measures for Aggressive Water and Soils

In the presence of aggressive water or soils, in addition to the use of pipes made from specially resistant materials, shall be used and surfaces of pipes and joints shall be protected by suitable precautions. suitable corrective protective measures as governed by local codes shall be adopted the contractor.

10.7.8 Shafts and Pits

10.7.8.1 Shafts and Manholes

Manhole shall be provided at each inlet to the drainage system, at each change in gradient or direction and at maximum intervals of 45 m. The diameter of manhole should be chosen as a function of the pipe cross-section. Either prefabricated or cast in situ concrete manholes shall be provided. In exceptional cases, a manhole of brick construction can be provided upon approval by the engineer. The construction of manholes shall meet the requirements set out in the relevant American Codes.

10.7.8.2 Covers, Trash Gratings

Shaft and manholes covers shall be made of reinforced concrete, of watertight construction, with and without dirt-traps, to suit local requirements. The dimensions of trash gratings shall be those determined by proper structural design. Trash gratings shall be removable, made of welded mild steel and painted with epoxy.

Climbing irons there shall be made of corrosion resistant materials only. Where shafts are constructed of reinforced concrete, the step spacing shall be 33.3 cm, and for brick shafts 35.5 cm. Climbing irons shall be staggered, maintaining and horizontal axial spacing of 30 cm shall be provided.

10.7.9 Cable Conduits (Pulling wires, Line of ducting)

Cables are to be laid in lines and levels as approved by the Engineer. Their depth below ground level will depend upon the voltage associated with the cables but in all cases the excavation must provide a clear trench sand filling below, around and above the cables will always be required and protection covers as tiles will be placed in position over the sand filling before final backfilling to the ground level. The line of the cable trenches shall be marked with suitable posts.

For the purpose of laying cables, 3-mm thick pulling wires shall be laid in the conduits. The conduits shall be laid at least 80 cm below ground level (with a corresponding increase in depth in the region of roads of areas subjected to vehicle traffic) and shall be laid without unnecessary curves. A layer of concrete of minimum depth 10 cm and width 60 cm (1.10 cm for two ducts) shall be laid along the cable route beneath the conduits to prevent unequal settlement.

Where branches or changes in direction are required, cable pulling pits, suitable for the number and size of cables to be laid, shall be placed upon a sand bed. On straight runs, through pulling pits shall be provided at maximum intervals of 75 m.

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10.8 Structural Steel

10.8.1 Scope

This specification covers labour, material, equipment and services required to complete all structural work indicated in drawings and as specified herein. The work includes all structural steel work but not necessarily limited to :

- Practices as defined in the American Code
- Field bolts and other structural steel accessories
- Angles and miscellaneous steel to support metal decking
- Steel assembles that are fixed to concrete as shown on the structural drawings.
- Related work specified elsewhere in the specifications – concrete, reinforcing steel, grouting of base and setting of plates.

10.8.2 Codes and Standards

Unless specifically mentioned otherwise American Codes and Standards in their latest editions, local regulations govern in respect of design, workmanship quality and properties of materials and methods of testing.

10.8.3 Quality Assurance

10.8.3.1 Qualification of Welders

- All welding shall be performed by operators who are qualified for the types of welds used.

- Welders are required to give on requalification test, if any reasonable doubt about welders proficiency is noticed by the Engineer. If the welder does not requalify he / she shall not be employed on the project. The Fabricator shall pay all costs associated with welder qualification.

- Quality Control

  Shop fabrication of steel indicated on the Structural Drawings will be inspected by an independent testing laboratory retained by the Contractor and approved by the Owner.

- Testing

  Contractor shall furnish testing agency with the following :

  - One complete set of fabrication and erection drawings.
  - Material bills and mill test reports
  - Information regarding time, place of rolling and shipment of materials to shop
  - Sample pieces for testing as requested by the Engineer
  - Full and ample means and assistance for testing materials

- Source Quality Control – Structural steel work (including miscellaneous steel work items)
  - General: Materials delivered with certificates are classified as identifiable; those without certificates are classified as unidentifiable.

  Testing of Unidentifiable Material: by independent testing agency: paid for by Contractor.

10.8.3.2 Submittals

The Contractor shall arrange for the submission of all designs and shop drawings for the whole of the steelwork to the Engineer for his approval before commencement of fabrication work. All such drawings shall show the dimensions of all parts, anchor bolt setting plan and details of general arrangement fabrication and erection, method of construction, spacing of bolts, welded sectional areas and all other details. Bolted or welded construction may be employed, subject to approval and neatness of design. Where welds are used either at Works or on site, they shall wherever possible, be continuous and returned round any meeting face to ensure that the joint is completely sealed against corrosion. Indicate those welds that are to be finished and grooved smooth (reference architecturally exposed steel). Space welds will not normally be accepted without the specific approval of the Engineer. The details in the drawings shall be properly referenced and numbered. Review of shop drawings is of a general nature only. However, responsibility for conformance with intent of drawings shall remain with the Contractor.

Review does not imply or limited to the correct interpretation of drawings by the Contractor. Contractor shall submit details and calculations for all non-seismic connections to the Engineer for review. Review in general nature only. Seismic connections shall be designed as per the seismic guidelines submitted with the Contract documents. The calculations shall be submitted by the Contractor to the Engineer for approval.

The details of connections on drawings shall be such as to avoid formation of pockets to hold condensation, water or dirt and a 12 mm minimum gap between abutting ends of bolted members and the like shall be provided to eliminate any traps and facilitate maintenance painting. Gaps between adjacent members shall be either sealed or wide enough to permit maintenance painting. Overlaping gaps left after welding shall be sealed.

Materials shall not be ordered nor fabrication commenced until such drawings are approved by the Engineer.

Tests, in accordance with ASTM Standards, shall be carried out. These shall be done in presence of the Engineer if so required.

All members of prefabricated frames shall be cut to jig and all holes shall be punched or drilled to jig. All parts shall be carefully cut and holes accurately located so that when the members are in position the holes will be truly opposite to each other before being bolted up.

The drilling, punching, cutting and bending of all fabricated steelwork shall be such as to prevent any possibility of irregularity occurring which might introduce difficulties in the erection of the structures on the Site.

Mill Reports

- Submit the mill report for each heat of steel used to The Owner prior to the start of fabrication.
- Mill reports shall show chemical content mechanical properties of the structural steel provided. For unsatisfactory mill test report – retest steel.
- Certification of inspection test reports for each production lot, indicating proof load. Tensile strength and hardness of high strength bolts. For unsatisfactory test report, retest bolts.
- Welding
  - The Contractor shall submit to the Testing Laboratory written welding procedures for all welding works.
  - The welding sequence and procedures shall minimise the effect of weld shrinkage, residual stresses, and maintain erection tolerances.

10.8.3.3 Delivery, Storage and Handling

- Use all means necessary to protect the structural steel and paint before, during and after installation and to protect the installed work and materials of other trades.
- In the event of damage, immediately make repairs and replacements necessary, to the acceptance of the Engineer and at no additional cost to The Owner.
- Storage

Material shall be stored in a manner to preclude damage and to permit ready access for inspection and identification of each shipment and piece. Materials showing evidence of damage will be rejected and shall be immediately removed from the site.

- Steel materials either plain or fabricated shall be stored above the ground. Material shall be kept free from dirt, grease and other foreign matter, and shall be protected from corrosion.

10.8.3.4 Materials

A. **Structural Steel :**

1. Shapes and Plates shall conform to the following :

   ASTM A 36

   ASTM A 242 Improved Weathering and Corrosion Resistance required where specified in plans.

   ASTM A 441

   ASTM A 572

   Bend Test shall be required where specified on Contract Drawings.

2. Pipes and Tubing shall conform to the following :

   ASTM A 53 Grade B

   ASTM A 500

   ASTM A 501

B. **Fasteners :**

1. High Strength Bolts shall conform to ASTM A325 (Types 1 and 3) or ASTM A490 (Types 1 and 3) and shall be heavy hexagon bolts with hexagon nuts and hardened washers. Type 3 bolts when specified on contract drawings shall not be replaced by type 1 bolts.

   Galvanized bolts and nuts shall conform to ASTM A 325 (Type 1) only.

2. Unfinished Bolts shall conform to ASTM A307 regular hexagon bolts with nuts and shall be of low carbon steel.

3. General dimensional requirements for Fasteners shall conform to the following :

   ANSI B 18.2.1 Square and Hex Bolts & Screws

   ANSI B 18.2.2 Square and Hex Nuts

   ANSI B 27.2 Plain Washers

   ANSI B 27.4 Beveled Washers

C. **Welding :**

Welding electrodes for manual shielded metal-arc welding shall conform to the AWS A 5.1, AWS A 5.5 and shall be of low hydrogen type.

Bare electrodes and granular flux used in the submerged-arc process shall conform to F60 or F70 AWS – flux classification of AWS A 5.17, or the provisions of applicable AISC specifications.

10.8.3.5 Fabrication & Erection

The work of fabrication and erection shall be carried out in accordance with AISC. Provide holes and accessories required for securing other work to the structural steel. Beams and columns shall be provided with natural camber upward, unless otherwise shown or indicated in the drawing.

10.8.3.6 Shop Welding

All shop welds shall be carried out by welders qualified for the work, under proper supervision and in accordance with AISC. The Engineer may call for a test of a welder's capabilities though machine welding should be used whenever possible. Welders must have been tested within a period of 12 months before welding operations start using the same class of electrodes and welding positions which will be used in the work. The work shall be properly prepared for welding and all welding procedures shall be submitted for

the Engineer's approval prior to the start of welding. It is expected that all fabrication welding will be carried out in a correctly sequenced manner to minimise distortion and / or potential cracking.

10.8.3.7 Site Welding

All Site welding shall be carried out by the manual metal arc or tungsten inert gas processes and the root runs of all full penetration but welds shall be made by the tungsten inert gas process. All manual metal arc welding shall be carried out using coated electrodes of the low hydrogen type and the Contractor shall submit his proposals for the receipt, storage drying, issue and return to store for all approved welding consumables to be used on Site.

The welding plant shall be of modern design and of ample capacity to provide the required current to each welding point without appreciable fluctuations.

Site welding of high yield steel will not be permitted without the Engineer's consent.

The welding procedure for making each joint shall be approved by the Engineer before the work is started and the Contractor shall make such trial welds as the Engineer may require to demonstrate the soundness of the proposed method and the competence of its workmen. The Engineer may require such Site made test welds to be radiographed and / or subjected to bend or impact testing as deemed necessary.

Input testing where required by the appropriate code or by the Engineer shall be carried out to the requirements of an approved specification. Mill test certificates shall be provided for all high tensile steel to be welded and the mill test certificate identification shall be included on the certificates issued for the weld tests required.

Whenever possible all welding shall be done in the downhand or horizontal - vertical positions. All parts to be welded shall be accurately prepared in accordance with the requirements of the appropriate code and / or weld geometry so that on assembly they will fit closely together as specified in the code. All groove or butt welds shall be full penetration welds unless noted otherwise on the drawings.

Where structural steel members are to remain exposed in the finished work, all exposed views shall be made uniformly.

Run-off tabs and grind surfaces to be removed, wherever tabs interfere with architectural treatment.

After assembly and before the general welding is commenced, the parts may be held together for welding by the use of mechanical clamps and / or tack welds. Tack welds should be of sufficient size to fulfil their function and small enough to be fully and properly incorporated into the weld without cracking and / or other defects. If mechanical clamps and / or restraints are employed, care shall be exercised in determining their location and the potential effects on weld cracking and / or distortion.

Welding Procedures

Notch sensitivity in steel shall be included in the welding procedure to prevent brittle and premature fracture during fabrication and erection. Welding shall be carried out in such a way that accumulation and concentration of trough thickness strains due to weld shrinkage is minimised. The welds shall be properly sequenced to reduce residual stresses (due to welding) to a minimum.

Machine Bolts

Machine bolts shall be tightened to snug tight condition to prevent ply in the connection materials.

10.8.4 Cleaning, Protection and Painting

10.8.4.1 General

The protection of all items of plant, supporting metal-work, structures, pipework and other metallic items, including bolts and fasteners, is essential to ensure the plant as a whole operates efficiently and in accordance with the design requirements.

All ladders, stairs, handrails, platforms, kick plates etc. are to be galvanised and painted.

The Contractor, or its protection sub-contractor, is required to acquaint itself fully with the prevailing environmental conditions at site to ensure he is capable in every respect of carrying out the protective coating works in accordance with the Specification.

All paint systems, paint specifications and other material specifications shall be submitted to the Engineer for approval before commencement of work.

The painting system and finish used for both internal and external surfaces shall be suitable for the particular conditions to be experienced in shipping, storing, erection, commissioning and operation. Where the surfaces to be painted are subject to heat or attach by chemicals, oil, acid, fumes or other aggressive agents, special paints having the appropriate resistant qualities shall be used.

The different paints used for painting, undercoat and finish at. Works and Site shall all be mutually compatible.

Protection of steelwork by painting or any other finish shall not be considered as a substitute for any corrosion allowance specified for any particular applications.

Final painting shall be done to the colour code, the details of which will be advised during the term of the Contract.

The painting system and finish proposed for the different times of equipment are to be listed.

10.8.4.2 Preparation of Surfaces

New unprimed iron and steels surfaces shall be thoroughly cleaned to remove all dirt, grease, condensation and moisture. Rust and mill scale shall be removed by an approved process such as shot blasting or picking. Surfaces shall be grit blasted to a minimum finish using cast steel shot. Slag shall not be used to clean any surface except structural steelwork without the specific approval of the Engineer.

In the case of structural steelwork including paint supports and pipe trestles, it is essential that regular checks for retained millscale should be carried out using copper sulphate. Tenacious millscale may take on the appearance of a bright metallic surface after shot blasting and subsequently disrupt the paint protection if not completely removed.

The surface profile achieved by blast cleaning shall be appropriate for the protection to be applied. In the case of structural steelwork the surface amplitude from peak to adjacent valley shall not exceed 0.07 mm with a maximum of 0.10 mm. In all cases where the surface profile is considered to be coarser than that necessary to give an over-peak paint film thickness within the range specified by the paint manufacturer for the particular paint, one additional coat shall be applied.

Areas of severe profile damage which after blast cleaning will not meet the necessary surface profile requirements shall be ground to a uniform smooth finish prior to re-shot blasting to the correct profile. If such grinding significantly reduces the local thickness, the item will not be accepted.

All blast cleaning and preparation operations shall be carried out by skilled operators and on completion of cleaning, all spent shot, oxides and dust shall be effectively removed by vacuum cleaner or other approved means. If any foreign material is trapped in or under the paint cover, the affected area shall be reblasted to the Engineer's satisfaction and repainted with the appropriate paint.

All surfaces which have been blast cleaned shall be kept dry and shall be paint protected within 4 hours of blast cleaning. No paint or protection shall be applied to any surface which has become discoloured by initial rusting.

Steel surfaces which are intended to be embedded in concrete shall be galvanised but not painted.

All items to be galvanised shall be blast cleaned to suitable profile to allow the required thickness of zinc to be readily obtained during the hot dipping process. To achieve this, suitable grit shall be used for the blast cleaning of structural items. Surfaces to be galvanised shall, after blast cleaning, be pickled in dilute hydrochloric acid, fluxed and stored prior to immersion in the galvanising bath. Particular care is necessary with grey iron surfaces and any free graphite should be removed from the cleaned surface prior to fluxing.

All galvanised surfaces shall be cleaned to remove any oil, grease or dirt by an approved degreasing process and all damage made good by an approved process prior to etching and / or printing and painting as specified.

Before any painting is carried out on Site, the surfaces to be coated shall be thoroughly washed with clean water of potable quality to remove all traces of salt and other impurities.

In the case of structural steelwork and fitting, any rends or splashes of cement, grout or concrete which occur during erection and building works shall be immediately removed by pressure hosing with fresh water or other approved method. Site welds shall be blast cleaned or needle gunned to remove all traces of alkaline flux residues prior to painting.

All damage to existing protected surfaces shall be cut back and suitably prepared before any application of further coats of paint.

Where epoxy paints are used the surface should generally be shot blasted to AAa2½ finish although chemical cleaning may be permitted for surfaces which do not require a degree of roughness to aid mechanical keying of the protective finish.

Immediately after preparation the surface shall be painted with the appropriate primer.

Primed surfaces shall be examined to ensure that they have been properly prepared and that the primer is adhering firmly and in good condition. If considered unsatisfactory the surfaces shall be blast cleaned thoroughly to bare metal. The surfaces shall then be repainted immediately with the appropriate primer.

If the condition of the primer is satisfactory the surfaces shall be cleaned to remove dirt, grease or condensation before application of any further treatment.

Surfaces which have been previously painted shall be thoroughly cleaned and all loosely adhering defective paint shall be removed by cleaning back to a firm edges or shall be completely stripped if necessary. All such areas shall be repainted with the original paint prior to any application of new coats.

All rust or loose scale shall be completely removed by an approved process to clean metal. All bare metal shall be appropriately primed in an approved manner. If the primed and / or painted surfaces have deteriorated by overall rust spotting to a state which in the opinion of the Engineer is not suitable for local repair, the whole of the affected surface shall be blast cleaned and primed or painted to the original specification.

Where they are to be eventually painted, unpainted aluminium alloy surfaces shall be cleaned down to remove dirt and grease and then shall be painted with an approved etching primer. Surfaces to be painted shall have surplus paint removed by cleaned to a firm edge. The appropriate primer shall then be applied as soon as possible.

Lead and copper pipes and / or surfaces shall be thoroughly cleaned with abrasive paper and white spirit prior to application of the approved paint system.

When copper pipes are to be lacquered these shall be cleaned immediately prior to application of the lacquer.

10.8.5 Painting and Protection

10.8.5.1 Application of Paint Systems - General

All paints shall be applied evenly to completely cover the surface.

Painting of machinery and auxiliary compartments is to be done by hand and the use of paint spraying equipment is not allowed. Prior to painting by hand, all rubber components, moving spindles, gauges control, governors, and sight gauges and similar items, are to be properly masked.

Each coat shall be allowed to harden before any subsequent coat is applied and all work shall be properly cleaned and prepared prior to the application of any paint.

The paint manufacturer's instructions including but not limited to paint thickness, drying and overcoating times and method of application, must be rigidly adhered to. Successive paint coat shall be of differing colours.

All painting and corrosion protection shall be carried out in steel accordance with manufacturer's written instructions. Paints application consecutive coats shall be of a different tint. All laying surfaces and site welds shall be left unpainted.

Detailed schedules of painting and protection will be required at the design stage and should include all relevant information on the paints proposed, including manufacturers data sheets, the stages of application and the proposed inspection and repair procedures.

As an integral part of the exercise, the Engineer may require test plates to be prepared and exposed at relevant on Site locations before approval for the use of specific paints or paint systems is given.

No paints or protectives other than those scheduled and approved by the Engineer shall be used.

In all cases the approved paints and protection, including decorative and identification paints shall be applied strictly in accordance with the approved manufacturer's instructions. All painting and protection shall be carried out by skilled operators with appropriate supervision.

Painting shall not be permitted during adverse weather and / or atmospheric conditions such when the humidity is greater than 70%, in rain or fog, at low temperatures, when surface temperatures are less than 3°C above the dew point or when the metal temperature is higher than 50°C. Painting shall not be carried out when the surface to be painted is exposed to direct sunlight.

Paint thinners shall only be added to paints in strict accordance with the approved manufacturers instructions and viscosity tests shall be carried out on random samples of mixed paints as directed by the Engineer.

Except as herein specified, no paint shall be applied to any surface when it is in the slightest degree damp and any paint so applied shall be removed and replaced to the Engineers satisfaction at the Contractor's cost.

All precautions necessary shall be taken to prevent dust, dirt and moisture from coming into contact with freshly painted surfaces or with surfaces being painted. All grit, shot or other cleaning processes shall be screened off from painting areas and all dust, residues and grit or shot shall be removed prior to painting in any designated area.

Attention is drawn to the specific requirements for painting and protection in the following sections.

10.8.5.2 Structural Steel and Associated Items

The surfaces of all structural steelwork, including plant support steelwork, pipe trestles and associated items, steel stairs, galleries and handrails shall be protected by galvanising and a compatible paint system to take account of specific aggressive conditions.

Particular care shall be taken, for example by the application of a stripe coat, to maintain strong paint films on all cleats, arises, bolt holes, bolt heads and similar items. Second and subsequent coats shall only be applied when the previous coats have dried and hardened and the manufacturer's instructions for curing are to be strictly observed. A suitable drying and curing time is to be allowed before packing for shipment.

The Contractor shall ensure the suitable precautions shall be taken in bundling, packing and crating for shipment to ensure that the protective treatment, applied prior to shipment is not damaged during transport to the Site. Straps, rope, wire or chain slings used for handling shall be properly padded or wrapped to minimise damage in handling.

All steelwork, including plant support steelwork, and gratings, not fully encased in concrete shall be protected by a system similar to or better than that detailed below :

a. For steelwork inside buildings :

i. Shot blast as previously specified.

ii. Prime Coat single pack inorganic zinc silicate
solids volume 55 - 60%
dry film thickness (dft) 75 microns

iii. Undercoat two-pack epoxy polymide
solids volume 60 - 65%
dft 125 microns

At Site :

i. Thoroughly wash with clean water to remove all traces of salts, make good damage by shot blasting as necessary and repair prime coat with materials as above.

ii. Top coat two-pack aliphatic polyurethane
solids volume 45%
dft 50 microns

iii. After erection make good all damage by blast cleaning as necessary and building the whole system to completion.

b. Steelwork for stairs, handrailing, ladders etc. shall be :

i. Shot blast as previously specified

ii. Hot-dipped galvanised to 85 microns coating thickness (610 g/m² coating weight.

iii. Degrease, apply mordant wash and etch primer.

iv. Prime coat two-pack epoxy polymide
solids volume 45 - 50%
dft 125 microns

At Site

Thoroughly wash with clean water, sweep blast if required for adhesion, apply two-pack aliphatic polyurethane, solids volume 45% dft 50 microns)

10.8.5.3 Protection and Painting of Metallic Materials

Structural and holding down bolts shall be hot dip spun galvanised minimum average coating 305 g/m² and painted as for adjacent galvanised steelwork. The nuts shall be not dipped and reamed out of newly threaded blank nuts which have been not dipped.

Steelwork partially encased in concrete or blockwork shall be protected at the junction by a strip of approved alkali resistant mastic filler.

Machinery and cubicles, particularly of pressed metal may require additional paint treatment unless than manufacturer's standard finish is shown to be adequate and sufficiently durable for the duty.

Aluminium, unless of an alloy or grade resistant to corrosion, shall anodised to 40 microns or be adequately primed and painted or otherwise surface traced to provide the required durability.

Aluminium for external architectural applications shall have a natural anodized finish and thickness of the anodozing shall not be less than 40 microns.

The surface of copper pipes, brass fittings and similar items, shall be washed with pure white spirit, rubbed with fine emery paper and shall be painted with one coat zinc chromate primer two undercoats and once high gloss finishing coat. The paint type shall be suitable for the expected atmospheric conditions and alkyd base paint shall not be used for items exposed to outside environments.

All dissimilar metal contacts should be designed and / or protected with due regard for the potential electrochemical corrosion possibilities. For all non-current carrying applications, it is expected that metal to metal contact between dissimilar metals will be avoided by the use of suitable electrical insulation. Particular care should be taken in the use of aluminium, zinc, copper, nickel and their alloys in contact with each other or in contact with ferritic materials. Care should also be exercised in the use of these materials in contact with each other or in contact with ferritic materials in contact with alkaline solution, and / or materials (concrete, lime, plaster and cement) and in the exposure of such materials or material couples in rainwater drains and run offs from materials which could impact either acidic or alkaline characteristics to the water.

Material	**To be isolated / insulated from**
Aluminium and Zinc	Copper and its alloys, Nickel and its alloys, Steel and its alloys (also as below)

Non-ferrous metal generally Alkalis (concrete, cement, lime and plaster).

In addition to the above, protection shall be provided from rainwater run off from aggressive materials.

Where non-ferrous metals are to be painted they shall be treated in the same way as ferrous materials, above the priming coat.

All non-ferrous metals shall be thoroughly degreased before painting in a solvent bath vapour degreaser or other means approved by the Engineer. The Contractor's attention is drawn to the importance of proper degreasing for non-ferrous metals. Any defective paintwork resulting from inadequate degreasing shall be stripped off, the metal degreased properly and the paint system reapplied at he Contractor's cost.

Non-ferrous metals generally shall be treated up to and including the priming coat as follows:

Preparation

Metal	Factory	Site	Suitable Primers
Aluminium (smooth surface, e.g., sheet extrusions aluminised steel)	Phospating Acid or alkalichromate baths Anodising (mainly as alternative to painting)	Degreasing compounds Emery and white spirit (not wire wool) Phosphoric acid treatments	Etch-primer (not after phospating)
Aluminium (rough surface e.g., castings metal)	Smooth off nibs with emery paper. Clean off dust and dirt	Smooth off nibs with emery paper. Clean off dust and dirt	Etch-primer Zinc chromate (not lead-based and sprayed primer).
Zinc (sheet hot-dipped galvanised or electro-galvanised)	Degrease Phosphate and / or chromate treatments	Degrease with white spirit. Weathering for at least several months plus washing. Phosphoric acid treatment (not as effective as factory processed)	Calcium plubate etch-primer (not after phosphating) Zinc chromate primer Zinc dust / zinc oxide primer or Zinc rich paint.
Zinc (sprayed or sherardised coatings)	Clean off dust and dirt	Clean off dust and dirt	Etch-primer (preferably plus Zinc chromate primer)
Copper (also brass and bronze)	Special processes Electro-deposited tin.	Emery and white spirit. (Do not weather, do not abrade dry). Phosphoric acid treatments	Etch-primer Aluminium pigmented primer
Tin coatings	Degreasing	Light abrasion (do not abrade through coating). Degrease with white spirit.	Etch-primer Zinc chromate
Cadmium (coatings)	Phosphating	Emery and white spirit. Phosphate treatments. No weathering.	Etch-primer.

10.8.6 Planning and Milling

General

Bearing surfaces shall be milled to true planes. The ends of columns perpendicular to centreline axis of connection and mid depth, points at ends of columns shall be milled. The columns and bearing stiffeners shall be cut and fixed in such a manner to provide bearing across the entire cross section.

Column Base Plates

- For column base plates of 2" through 4" thickness, straighten than by pressing.
- For column base plates exceeding 4" – plane the top of base plate for column bearing plane the bottom when bearing is on steel.

10.8.7 Fabrication Inspection

- As a minimum, all testing and inspection as per ASTM Standards.
- Inspections : Inspection of shop and field welding operations during welding performance shall be carried out as follows :
  - Verify that welders are certified.
  - Inspect every weld for quality and conformance
  - List of defective welds, including :
  - Location and type of weld.
    a. Identification marks of welders
    b. List of defective welds.
    c. Manner of correction of defects.

  It shall be confirmed that the welding equipment is used per manufacturer's recommendations, pre-heating is properly used, proper use of runout plates, jigs and fit-up, check structural steel to comply with the specified dimensional standard.

10.8.8 Workmanship and Construction

10.8.8.1 Conditions of Surface

- Prior to commencing with the erection of structural steel the contractor shall inspect the job site and verify that the structural steel may be erected in accordance with the Drawings and Specifications.
- Discrepancies
  - In the event of discrepancy, the contractor shall immediately notify the Owner in writing.
  - The contractor shall not proceed with construction in the region of the discrepancy until all such discrepancies have been resolved.

10.8.8.2 Preparation

- The Contractor shall secure field measurements required for proper and adequate fabrication and installation of the work covered in this Section and assume responsibility for exact measurements.

- Templates shall be provided at exact locations of items that are to be embedded in concrete and masonry and any setting instruction required for installation.

10.8.8.3 Erection

- General

  - Structural steel shall be erected in accordance with the Drawings and Specifications.

  - Care shall be taken to protect work already installed from damages resulting from structural steel erection.

- Temporary Shoring and Bracing

  - Provide temporary bracing adequate to protect the structure against damage due to construction loads.

  - Provide temporary guy lines to achieve proper alignment of the structure as erection proceeds. In addition, guy lines shall be provided to brace the incomplete structure against loads such as wind and seismic forces comparable in intensity to that for which the structure was designed.

  - Provide temporary floors as required to erect the structure.

  Items installed before concrete is placed shall be properly braced to prevent distortion by pressure of concrete. Watch and maintain bracing during concrete operations.

- Field Assembly

  - Set structural members to the lines and elevations indicated. Align and adjust the various members forming a part of the a complete frame or structure before permanently fastening to the total structure. Perform necessary adjustments to compensate for discrepancies in elevations and alignment.

  - Before assembly clean bearing surfaces and other surfaces which will be in permanent contact after assembly.

  - Members shell be spliced only where indicated on Structural Drawings or where accepted by the Engineer.

  - Do not use gas cutting torches in the field for correcting fabricating errors in the structural framing unless accepted by the Engineer. Finish gas cut sections equal to a sheared appearance shall be done wherever it is permitted by the Engineer.

  - The quality of field welds or bolting shall be the same as that performed in the shop.

  - Erection bolts for welded connection shall be tightened securely and left in place.

- Setting Base Plates

  - Clean concrete bearing surfaces and roughen to improve bond. Clean the bottom surface of base plates.

  - Tighten anchor bolts after the supported members have been positioned and plumbed. Do not remove wedges or shims, but if protruding, cut off flush with the edge of the base plate prior to packing with grout.

  - Grout shall be installed and cured according to the manufacturer's recommendations such that no voids remain. All exposed surfaces shall be finished neat.

- Expansion/Chemical Anchor Bolts

  - Install in accordance with the manufacturer's recommendations.

  - Use washers on all bolts.

  - Use care to avoid cutting or damaging reinforcing bars.

  - When exposed to view in the final structure, bolts shall be of a length that will extend entirely through but not more than one quarter of an inch beyond the nuts unless otherwise shown on the Drawings. All such bolts are to be identified in the construction document.

- Weld

  - General

    Weld shall be as per AISC procedures. Preheating shall be carried out where required.

  - Welding shall be carried out in such a manner to prevent warping or distortion of finished product. Use jigs, which will not restrain piece from moving during welding or cooling after welding. Sequence weld passes at a joint to prevent excessive heat build-up or cause shrinkage cracks to form. Adequately peen and brush joint after successive passes to prevent slag inclusions, open pockets and inadequate fusion.

- Bolting

  Comply with AISC codes & specification.

- Frame Tolerances

  Code of Standard Practice for General construction in Steel ASTM A6

10.8.8.4 Touch-Up Painting

- Immediately after erection, clean and paint all field welds, bolted connections, anchor bolts and abraded areas.
- Use same materials and standards as for shop painting.

10.8.8.5 Field Quality Control

- All field welding shall be inspected by a full-time inspector employed by an independent testing laboratory approved by The Owner.
- Observe all Direct Tension Indicators to see if proper tightness was achieved or test bolt with calibrated manual torque wrenches.
- Field quality control shall, as a minimum, conform to the requirements specified under Source Quality Control.
- Expansion anchors shall be proof tested after installation
- Field Welds. Test all welds as per Fabrication inspection

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10.9 Masonry

10.9.1 Scope

This specification covers the requirement in respect of design requirements, supply of materials, workmanship erection and quality with regard to block masonry works of all power stations buildings and structures as per the specifications and as shown in the respective drawings.

The blockwork shall include all mortar reinforcing, anchors, control joints and all other accessories required for the complete installation of blockwork. The concrete unit masonry for the above work shall comply with requirements of American Code.

Locally available materials can also be used for masonry work. The workmanship in general shall be as per the following specifications. Material shall have sufficient density & compression strength similar to concrete block.

10.9.2 Codes and Standards

Unless mentioned otherwise American codes and standards in their latest editions, local regulations shall govern in respect of design, workmanship, quality and properties of materials and methods of testing.

10.9.3 Quality Assurances

The quality assurances shall comply with but not limited to the requirements of applicable codes and standards.

10.9.4 Materials

The concrete blocks used for load bearing curtain walls, and partition walls, walls shall be either solid or hollow, cracks, flows or other defects. The density of blocks should not be less than 1500 kg/m³ and shall be in accordance with American Code.

10.9.4.1 Size of Blocks

Co-ordinate size	:	400 mm x 200 mm
Work size	:	390 mm x 190 mm
Thickness	:	100 mm, 150 mm, 200 mm

Tolerances for Sizes		
Length	:	+3mm or -5mm
Height	:	+3 mm or -5mm
Thickness	:	+2 mm or -2mm average
	:	+4 mm or -4mm average

Compressive Strength

The compressive strength at 28 days after moulding as calculated over the gross cross section area shall not be less than

a. External walls - 150 mm thick
   14 N/mm² (Average of 10 Blocks)
   11.2 N/mm² (Minimum for any one block)

b. Internal works - 100 mm thick
   3.5 N/mm² (Average for any one block)
   2.8 N/mm² (Minimum for any one block)

c. Internal walls - 150 mm thick and 200 mm thick
   14 N /mm² (Average of 10 blocks)
   11.2 N/mm² (Minimum for any one block)

10.9.4.2 Damp-proof Courses

Damp-proof courses shall be bitumen comply and suitable for the climate in which the Works are located. Horizontal damp proof course shall be provided beneath all block work and shall be bedded on mortar. Vertical damp proof course shall be provided at all windows and door reveals. Damp proof course to walls shall consist of one layer of bitumen felt or polythene as specified. The damp proof course shall be fully lapped at corners, lapped 150 mm at running joints and bedded in cement lime mortar to form a uniform surface.

10.9.4.3 Mortar

Sand for mortar shall be confirm to American Code.

Cement for mortar shall be Ordinary Portland cement.

The use of an approved plasticiser will be permitted in lieu of lime and shall be used strictly in accordance with the manufacturer's recommendations.

10.9.4.4 Movement Joint Materials

The filler material in movement joints shall be expanded compressible or similar material. Movement joint sealant shall be an approved coloured polysulphide sealant compatible with the backing material. All materials shall be obtained from a source approved by the Owner and used in accordance with the manufacturer's recommendations.

10.9.4.5 Wall Insulation

Wall insulation shall be 75 mm thick rigid expanded polystyrene complying with American Code to suit wall tie spacing.

10.9.5 Storage

Walling materials shall be stacked so that they are stable and clear of the ground. They shall be protected from inclement weather and kept dry. Blocks shall not be used prior to one month after the date of manufacture.

10.9.6 Joints

Walls which are to be left unplastered shall have a fair face consisting of flush struck and clean wiped joints as the work proceeds.

All vertical joints shall be filled with mortar as the work proceeds.

Walls which are to be plastered or rendered shall have the horizontal joints raked out to a depth of 15 mm to form a key.

Movement joints shall be formed in concrete blockwork walls in the positions shown on the Drawings. The joint filler shall be built in as the work proceeds and before the sealant is applied the exposed surfaces of the joint filler shall be isolated with an approved bond breaker to the recommendations of the sealant manufacturer.

Metal ties shall be incorporated in the joints as the work proceeds where shown on the Drawings.

10.9.7 Mortar Mixing

The mortar shall be thoroughly mixed dry until a uniform mix is obtained. Sufficient water shall then be added and the mixing continued until a homogeneous mix is obtained. Excess water shall not be present in the mix. Care shall be exercised to ensure that mortars containing plasticizers are not over-mixed.

Mortar shall be mixed in an approved location and care shall be taken that no foreign matter enters the mix, and that no loss of liquid occurs during mixing.

Equipment and mixing boards shall be kept clean at al times.

Mortar shall be used in the works as soon as possible after mixing but in no case after the initial set commences or two hours have elapsed since mixing, whichever is the earlier.

10.9.8 Load Bearing Walls

Walling shall be constructed with all materials fully bonded or tied together and joints filled, to ensure compliance with the design requirements.

The faces of walls shall be kept clean and free from mortar droppings and splashes.

Walls shall be carried up regularly without leaving any part more than one metre lower than another. Work which is left at different levels shall be racked back. In the case of cavity walls, both thicknesses shall be carried up together and in no case shall one thickness be carried up more than about 400 mm in advance of the other.

The maximum height of blockwork in one day shall not exceed 1.5 meters.

The courses of blockwork shall be laid and jointed in mortar as specified with level horizontal joints. Each course shall be well flashed up with mortar throughout its full length and width. The vertical joints shall be properly aligned and quoins, jambs and other angles plumbed, as the work proceeds. All walls shall be plumbed vertical and built to the following tolerances:

Length	± 10 mm in 5 m
	± 15 mm in 5 m to 10 m
	± 20 mm over 10 m
Height	± 5 mm in 3 m

± 15 mm in 3 m to 6 m
± 20 mm over 6 m

Broken or chipped blocks shall not be used. Where part of a block is required to make up the bond this shall be sawn or purpose made.

Cavity walls shall be built to the dimensions shown on the Drawings and the two thickness shall be bonded together with wall ties spaced one metre apart horizontally and approximately 400 mm apart vertically and staggered. Extra ties shall be provided at reveals, quoins and openings, at 200 mm centres.

The cavity and ties shall be kept clear of mortar and debris by lifting screeds or other suitable means approved by the Owner.

Crevices shall be filled with concrete to a level 150 mm below damp-proof course and with top sloping towards exterior.

Insulation shall be tightly butted to completely fill the cavity as indicated on the Drawings ensuring that edges are not damaged and top edges are completely free of mortar and debris.

Walls shall be protected from sunlight by the use of awnings on all faces for a period not less than 3 days after completion of laying of the courses.

The Contractor shall cut and fit blockwork around steelwork etc., leave or form chases for edges of concrete slabs, staircases, ends of partitions etc., cut chases for pipes, conduits etc., and make good.

The Contractor shall build all oversailing courses, corbels, copings etc., where shown on the Drawings and build in or cut and pin ends of sills, steps, lintels, etc., as required.

Timber wall plates and door and window frames shall be bedded and exposed edges pointed in mortar and fixing cramps shall be built in.

10.9.9 Non-Load-bearing Blockwork Walls

Unless otherwise shown on the execution Drawings, all blockwork walls shall be non-load-bearing. They shall be constructed after the main steel or concrete construction and shall be adequately tied as shown on the Drawings.

A movement joint shall be provided between the top surface of the blockwork wall and the soffit of the structural concrete or steel members to allow for differential movement.

The joint shall be filled with a layer of easily compressible material according to the relevant details and shall be sealed as required.

Walling shall be constructed with all materials fully bonded or tied together and joints filled, to ensure compliance with the design requirements.

The faces of walls shall be kept clean and free from mortar droppings and splashes.

Walls shall be carried up regularly without leaving any part more than one metre lower than another. Work which is left at different levels shall be racked back. In the case of cavity walls, both thickness shall be carried up together and in no case shall one thickness be carried up more than about 400 mm in advance of the other.

The maximum height of blockwork in one day shall not exceed 1.5 meters.

The courses of blockwork shall be laid and jointed in mortar as specified with level horizontal joints. Each course shall be well flashed up with mortar throughout its full length and width. The vertical joints shall be properly aligned and quoins, jambs and other angles plumbed, as the work proceeds. All walls shall be plumbed vertical and built to the following tolerances:

10.9.10 Workmanship

10.9.10.1 General

Blockwork shall be executed in accordance American Code.

The blocks shall be laid dry and mortar shall be laid on the blocks and the joints shall be thoroughly flushed from top as the work proceeds and not faced in later. Blockwork shall be laid in a uniform manner, and no portion shall be raised more than 1 metre above at one time. All vertical angles, corner and like shall be maintained true and square, and shall be properly bonded together and levelled.

The Contractor shall execute and make good all necessary chases, holes, mortices, rebates and the like, build in lintels, sills, timber etc. The Contractor shall be responsible for covering and protecting the blockwork during the progress of the Works and shall clean down the whole upon completion and make good as necessary.

All blockwork shall be set out and built to the dimensions and type of bond shown on the drawings, ensuring that full length blocks occur beneath bearings of lintels.

No block shall be set in place within 28 days of mixing. Blocks cast on any day shall be stored in a group together with the date of casting marked on the block. The drying shrinkage of the blocks shall not exceed 0.06%.

The contractors shall provide a specimen of fair faced block work for approved by the owner before placing order for blocks. The owner shall reject a load or part load, if a group of blocks are found to be below required strengths cured etc. which is found to be detrimental in the opinion of the Engineer.

10.9.10.2 Testing

Sampling and testing for the above requirements shall be done in accordance with American Code and tests shall be conducted as instructed by the Engineer.

The contractor shall furnish to certificate complying with the specification as provided by the manufacturer. The certificate shall also state that the samples of blocks are tested at regular intervals.

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10.10 Roads and Paving

10.10.1 Scope

This specification covers the requirements of materials, workmanship and quality of all roads and paving works of the project area in order to meet the requirements of the power station. The extent of works is indicated on the attached layout drawing. The works shall consist of formation of new roads and concrete paved areas as well as flexible paving in small areas. All paving shall be heavy – duty type.

10.10.2 Codes and standards

Unless specifically mentioned otherwise, American codes and standards in their latest editions, local regulations, shall govern in respect of design, workmanship, quality and properties of material and method of testing.

10.10.3 Quality assurance

The quality assurance shall comply with, but not limited to the requirement of applicable codes and standards.

10.10.4 Preparation

Contractor shall visit the site and carry out inspection to familiarise himself with the site conditions, and to make necessary preparations for executing the work.

10.10.5 Design and materials

Roads shall generally comprise of a subgrade, subbase, base course and paving.

Description and requirements of sub-grade – reference shall be made to spec -No:10.5 – Earth works

Sub-base shall be provided to prevent excessive deformation or maintenance owing to settlement behaviour/insufficient bearing capacity of subgrade. Both flexible paving and rigid paving are envisaged. The choice of paving is decided based on location (on/off plot), imposed design loads, level and type of underground installations crossing the roads.

10.10.6 Surfacing

10.10.6.1 Compaction of Sub-grade

The area of the Works shall be cleared of any material or obstructions which in the opinion of the Engineer might adversely affect the stability of the fill or pavement and the top layer removed to a depth of 300 mm (or more if the design so required).

The sub-grade and formation shall be checked and accepted by the Engineer before placing and spreading operations are started. Any ruts or soft areas caused by improper drainage conditions, hauling or any other cause shall be corrected and rolled to the required compaction before sub-base is placed thereon.

The formation shall be compacted to a dry density of atleast 95% of the maximum dry density and a CBR of 15%.

Where the Contractor is unable to achieve this degree of compaction to the formation level further excavation shall be carried out to a depth to be defined by the Engineer (but not less than 300 mm). Selected backfill will thereafter be placed and compacted to the requirements of this Clause.

Where the land contours require it fill in embankment shall be placed and compacted with as minimum embankment slope of 1:4.

Compaction shall be carried out by means methods as approved by the Engineer. All construction equipment must operate over the full width of the formation to ensure uniform compaction.

10.10.6.2 Sub-grade

Subgrade design shall be based on 10.10.6.3., geotechnical report survey, grain size distribution/soil content, plasticity index, friction properties and permeability characteristics. Sub-grade shall be decided based on highest water level and in-situ permeability of the soil.

10.10.6.3 Tests for Sub-Grade

The sub-grade compaction test shall be carried out in a mould 10 cm internal diameter and 12.5 cm internal height. The mould shall be filled in five equal layers, each layer being given 25 blows of a 4.5 kg hammer falling freely for 45 cm.

Except when otherwise specified, the CBR specimens shall be soaked for 96 hours or such other period of soaking as may be determined by the Engineer to correspond with the moisture content pertaining under the most unfavourable conditions to which the material may be subjected. Laboratory tests shall be done using surcharge weights as required by the Engineer.

If due to the high proportion of granular material retained on the 19 mm sieve or for any other reasons, the Engineer decides to measure sub-grade compaction by the vibrating hammer method of using a CBR mould. The compaction requirements measured by this means shall be taken as that stipulated for the compaction test plus 5%.

Dutch cone penetration test (DCPT) or In-situ dry density tests on each layer of compacted material shall be carried out at an average of not less than 2 per 100 m length of carriageway. In-situ CBR tests shall be carried out as directed by the Engineer. Where any test fails, removal of unsuitable material and / or recompaction shall be carried out by the contractor to that extent as required by the Engineer. In such cases retesting shall be done by the contractor at no cost to the owner.

Classification tests shall be carried out as necessary to ensure that true comparisons can be made between in-situ densities, laboratory compaction densities and field trial densities, i.e. variations in the properties of materials being used in the test are not affecting results. Each in-situ dry density result shall be the mean of the in-situ dry density result shall be the mean of three close test holes approximately 0.5 m apart.

10.10.6.4 Sub-Base

Sub-base material shall be crushed rock or other approved local material having suitable properties and confirming to the following grading :

Table No 1

SIEVE SIZE mm	PERCENTAGE BY WEIGHT PASSING
75	100
37.5	85 – 100
10	45 – 100
5	25 – 85
0.6	8 – 45
0.075	0 - 10

Any material passing the 425 microns sieve, shall be non-plastic.

The material shall be spread evenly on the preceding material in layers not exceeding 150 mm compacted thickness. Segregation shall be avoided during transport and placing and any segregation evident after compaction shall be corrected by vibrating in fines or made good by removing and replacing with properly graded material. If necessary the material shall be spread using a spreader box or paving machine to minimise segregation and enable an even depth and the level tolerance to be achieved.

The sub-base shall be compacted by approved plant to a dry density which shall not be less than 98% relative compaction until movement of the surface ceases and the surface is closed. The CBR value shall be atleast 30% at the maximum moisture content.

Where the sub-grade can be compacted as specified by available plant to give a stable well knit surface which will resist deformation during sub-base placing and with in-situ CBR values of greater than 30%, then the sub-base layer may be reduced to 100 mm thickness based on the recommendation of the Engineer.

10.10.7 Macadam Road Base

10.10.7.1 Dry bound macadam road base

Dry bound macadam shall be constructed using course and fine aggregate consisting of clean durable crushed rock. The aggregate shall comply with either the 50mm or the 37.5mm nominal size of 63 mm sieve, and the aggregate shall pass the 5mm sieve size.

The fine aggregate shall be dry on arrival at site, and if stock piled should be kept dry.

10.10.7.2 Wet Mix Road Base

Wet Mix road base material shall consist of crushed gravel or crushed rock and shall be suitably proportioned to confirm to the following grading as approved by the Engineer.

Table 2

SIEVE SIZE mm	PERCENTAGE BY WEIGHT PASSING
50	100
37.5	90 – 100
20	60 – 80
10	40 – 60
5.00	25 – 40
2.36	15 – 30
0.600	8 – 22
0.075	0 – 8

The materials for road base and wearing course shall comply with the requirements of American Code and shall have a total loss factor not exceeding 10% when tested using the 10 minute immersed rotational test.

If additional material passing through 75 micron sieve is required for base course, then the material shall consist of crushed rock, portland cement, hydrated lime or other materials as approved by engineer and atleast 75% of the material pass through 75 micron sieve.

Quarry won material shall be extracted from the areas approved by the Engineer. The aggregate crushing value shall be monitored by regular testing of material prior to its inclusion in the construction.

The material shall be spread evenly on the sub-base in layers not exceeding 150 mm compacted thickness. Segregation shall be avoided during transport and placing and any segregation evident after compaction shall be corrected by vibrating in non-plastic fines or made good by removing and replacing with properly graded material.

The base shall be compacted by approved plant to a dry density which shall be not less than 90% relative compaction and until movement of the surface ceases and the surface is closed. The compacted layer shall have an in-situ CBR of not less than 80%.

The final surface shall be shaped and finished true to line and level within a tolerance of ± 10 mm to the levels shown on the drawings.

10.10.7.3 Chlorides and Sulphates

The level of the acid-soluble chloride (as NaCl) in the sub-base and roadbase layers shall not exceed 3.5% and 0.5% by weight respectively.

The level of acid-soluble sulphate (as SO_3) in the sub-base and roadbase layers shall not exceed 2.0% and 0.5% by weight respectively.

Potable water shall be used for compaction purposes.

10.10.7.4 Placing of Road Base

Wet mix road base material shall be crushed and mixed by approved mechanical placing plant. Water for adjusting the moisture content shall be added at the mixer. Wet-mix. If required, the moisture content shall be adjusted to allow for evaporation Roadbase loss during transportation. After mixing, the material shall be removed from the mixer and transported to the placing location without delay. The moisture content at the time of laying shall be within = 0.5% of the optimum value determined in accordance with the vibrating Hammer Method.

Vehicles carrying the plant-mixed material shall be of a capacity suited to the output of the mixing plant and size conditions, and shall be capable of discharging cleanly. After mixing is complete, the materials shall be removed at once from the mixer, transported directly to the point where it is to be laid and protected from the weather both during transit from the mixer to the laying site and whilst awaiting tipping.

The compaction procedure and plant shall be proved by trials at the commencement of the Works. The weight, type and number of passes of compaction plant shall be varied to determine the optimum compaction effect.

Road base material including any add filler shall be weighed or measured and added into a mechanical mixture and thoroughly mixed in such a way that all aggregates are uniformly coated, and shall be placed and spread evenly, without delay, using a paving machine, or spreader box operated with a mechanism which level off the material at an even depth and it shall be spread in layers not exceed 200 mm compacted thickness. Segregation shall be made good by removal and replacement.

The road base shall achieve a minimum dry density of 98% of the maximum laboratory dry density and an in-situ CBR value of not less than 80%.

Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse joints.

The completed surfaces of all layers shall be well-closed and free from movement under compaction plant, and shall have no compaction planes, ridges, cracks or loose material. All loose segregated or otherwise defective areas shall be made good to the full thickness of the layer and re-compacted.

Before placing the next construction layer or applying prime coat, the road base shall be mechanically swept then cleaned with compressed air to remove loose material. As soon as possible after cleaning of the surface, the road base shall be sealed by the application of a prime coat as specified. Should the surface of the material be allowed to dry out before the seal is applied, it shall be lightly watered and re-compacted immediately prior to spraying with prime coat. Should the full depth of layer be allowed to dry out, it shall be removed and replaced, at the Contractor's expense, with fresh material. Watering and re-mixing in place will not be permitted.

10.10.7.5 Hard Shoulders

The material used for any hard shoulders shall comply with the specification for wet-mix road base.

10.10.7.6 Tests on Sub-Base and Road Base

Before any section of the road works is commenced and during its construction, the Contractor shall carry out on the Engineers instruction, tests and control tests to determine the degree of compaction in the sub-grade, sub-base and base. No section of the work shall be covered until it has been approved by the Engineer.

Recommend the Engineers decision is final in recommending any of the following tests :

Density / Moisture tests

Compaction tests

CBR in-situ test

CBR remoulded test

The laboratory tests shall be carried out in accordance with code.

The specified requirements must be achieved in each successive layer. Checking that the specified requirements have been attained in lower layers after higher layers have been placed will not be accepted, except where existing road surfaces have been removed.

Any departure from the method of constructing in layers will not be permitted.

The results of control tests shall be furnished daily to the Engineer.

The Contractor shall be responsible for the cost and execution of all density tests, moisture tests and CBR tests necessary in establishing the compaction procedure and subsequent control tests required by the Engineer.

10.10.7.7 Frequency of Testing

In-situ dry density tests on each layer of compacted material shall be carried out at an average of not less than 2 per 100 m length or carriageway. In-situ CBR tests shall be carried out as directed by the Engineer.

Classification tests shall be carried out as necessary to ensure that true comparisons can be made between in-situ densities, laboratory compaction densities and field trial densities, i.e. that variations in the properties of materials being used in the tests are not affecting results.

The compaction procedure and plant shall be proved by trials at the commencement of the Works for approval by the Engineer. Compaction trials shall be carried out at varying moisture contents. The weights, types and numbers of passes of compaction plant shall also be varied to determine the optimum compactive efforts.

No traffic shall be permitted on the completed base in excess on the minimum required to place the overlying construction.

10.10.7.8 Bitumen Macadam

Aggregate shall be hard, clean durable crushed rock or gravel, and sand for wearing course and shall have a total loss factor not exceeding 10% when tested using 10 minute immersed rotational test, and shall be obtained from approved source which shall not include quarries containing significant proportions of weatherbed, decomposed or extensively fractured materials. The Contractor shall propose a suitable source, or sources, and samples shall be obtained for specified testing before arrangements for obtaining aggregate are approved. Laboratory tests shall be made at regular intervals to confirm the suitability of aggregate.

The Contractor shall obtain whatever permissions are necessary for the exploitation of quarries and borrow-pits and shall pay royalties, fees, and the like. The Contractor shall operate the quarry or pit in an approved manner and provide sufficient evidence by means of boreholes, test holes and the like to show that the quarry contains aggregate of the required quality and quantity of complete the Works, and he may be required to produce a geological map. The aggregate winning and processing operations shall not constitute a danger to health or safety either during or after completion of the Works, nor interfere with other operations.

When quarrying operations are complete, the Contractor shall leave the quarry in a safe condition by

a. Barring down all faces so that no loose rock remains on any face.

b. Bringing down overhanging rock safely.

c. Ensuring that the quarry is free draining and that no water can accumulate ; or in the case of quarry below ground level, minimising the accumulation of water and draining to approved areas.

d. Stockpiling surplus rock material to a height not greater than 5 metres with stable side slopes.

Aggregate and chippings for surface dressing, shall be stored so that segregation, intermixing of different aggregates and contamination by dirt and other foreign materials is prevented. In general, each size of aggregate shall be stored separately.

Coarse aggregate shall have physical properties which do not exceed the following test values when tested in accordance with Code.

Table 3

	WEARING COURSE	BASECOURSE
Aggregate crushing value	20%	25%
Flakiness index	25%	30%
Elongation index	25%	30%
Water absorption	2%	2%

Coarse aggregate may contain up to 15% of pieces with one uncrushed face in each grading size when tested in accordance with Code. Aggregate obtained from quarried rock shall be deemed to satisfy this requirement.

Bitumen shall be of Grade 60 / 70 penetration with properties corresponding to an interpolation between Grade 50 and Grade 70. The specific gravity and temperature / viscosity relationship shall be provided.

Binders used for bituminous sprays shall be either road tar or cut back bitumen confirming. Approved adhesion agent shall be mixed with the binder at the time of application. The frequency of testing of the penetration index shall be two tests per delivery of bitumen. The PI range shall be – 1 to + 1.

10.10.7.9 Design of Bitumen Macadam

Design mixes shall be submitted for approval and proved by means of laboratory, plant and field trials. Tracking tests may also be required.

The mixes shall be tested in accordance with the Code.

- The values for specific gravities of the aggregates to be used in calculating the voids shall be taken as the mean of the Bulk, Apparent and Effective Specific Gravities.
- The adhesion of bitumen to aggregate shall be proven by comparing the stability of specimens cured in water and air for eight days at 18 degrees C. The ratio of stability in the two shall not be less than 0.65.
- Wearing course mix shall be subjected to further Marshall tests at 80 degrees C after oven heating for a period of 2 hours; the stability / flow ratio shall not fall below 270 at this temperature.
- Mixes with a bitumen content corresponding to the maximum allowable for the selected job mix shall be compacted to refusal, or to 600 blows per face whichever shall be reached first, and the resulting voids-in-mix values shall be not less than 3%.

The designed mixes shall comply with the following :

Table 4

	BINDER COURSE	WEARING COURSE
Voids in mix (%0	7 – 10	5 – 8
Voids in mixed aggregate %	14 – 20	14 – 20
Minimum Stability (Kg)	750	1000
Flow (mm)	2 – 4	2 – 4
Minimum stability flow ratio (Kg/mm)	270	320
Bitumen content (% of total mix)	3.3 – 4.0	3.5 – 4.2
Voids filled with Bitumen (%)	48 – 60	48 – 60

After a design mix has been approved and adopted as a job mix, the maximum permitted deviations from the job mix shall be as follows :

Table 5

	PERMITTED DEVIATIONS
Sieve Size :	
6.3 mm or larger	± 5%
3.35 mm	± 4%
0.6 mm to 1.18 mm	± 3%
0.075 mm to 0.3 mm	± 2%
Smaller than 0.075 mm	± 1%
Bitumen	± 0.2%
Voids in mix	± 1%

The application of the above deviation percentages shall not result in values falling outside those specified in the clause covering the design and testing of bitumen macadam mixes.

Chlorides and Sulphates shall comply with Code requirements

10.10.7.10 Mixing and Laying

The mixing and placing of bitumen macadam shall be carried out in accordance with Code. The aggregate and bitumen shall be mixed in an approved plant of the batch type. Constituents shall be proportioned by weight; the bitumen may be proportioned using a metering pump. Facilities shall be provided in the mixer to enable the sampling of hot aggregates.

Bitumen and aggregates shall not be heated to above 150 degrees C and 170 degrees C, respectively, and the temperature difference between them at the time of mixing shall not exceed 15 degrees C. The mixing temperature shall be established from the bitumen viscosity / temperature graph. Approved facilities for continuous measurement of temperatures shall be provided.

The batching plant and equipment shall be properly maintained and cleaned and shall be provided with means of checking the accuracy of weighing mechanisms and metering devices. These shall be checked at monthly intervals or as directed.

Bitumen macadam shall be transported in clean vehicles. Dust, coated dust, oil or water may be used on vehicle bodies to facilitate discharge, but the amounts shall be kept to a minimum and any excess shall be removed by tipping or brushing.

Heat loss shall be minimised during transit and the macadam shall not be discharged into the paver at a temperature less than 120 degrees C.

Bitumen macadam shall generally be spread, levelled and tamped by approved self-propelled pavers.

Immediately after arrival at the site, the macadam shall be supplied continuously to the paver and placed without delay. The rate of the delivery of material to the paver shall be regulated so that the paver may operate continuously and it shall be adjusted to provide an even and uniform flow of material across the full laying width, freedom from dragging or tearing of the material and minimum segregation.

Excess material arising from placing base course shall be removed by booming or light raking. Over-raking causing segregation of the material shall not occur. The excess shall be discarded and not used elsewhere.

Hand-raking or wearing course material which has been laid by a paver and the addition of material by hand-spreading for adjustment of level shall be carried out with prior approval of the Engineer.

If the abutting lane or succeeding strip is not placed on the same day, the joint shall be cut back to an even line. Loosened material shall be discarded. The joint shall be brushed with a very light coat of hot bitumen before the next strip is placed. The whole face of the joint shall be treated before fresh macadam is placed against it. Joints shall be formed only in compacted material and fresh material placed against a cut face shall be properly compacted.

Joints in wearing course shall be offset by atleast 300 mm from parallel joints in the layer beneath.

Hand-laying of macadam will be permitted only for laying courses of irregular shape and varying thickness, and in confined areas where a paver cannot operate.

The Contractor shall obtain approval of compaction methods and plant by carrying out trials to demonstrate consistent achievement of the requirements. The degree of compaction achieved during the trials shall be not less that 1% greater than that required during the course of the Works. The methods and plant shall not be changed without approval. After placing, the macadam shall be compacted to the thickness shown on the Drawings by rolling to a density of not less than 98%of the maximum density of the approved daily Marshall laboratory density.

Should any individual core, tested in accordance with the clause titled "Testing of Bitumen Macadam", do not have the specified degree of compaction, additional cores may be taken in adjacent locations, at the discretion of the Engineer.

If the bitumen macadam fail to achieve the specified density, at the discretion of the Engineer re-rolling may be allow subject to the following conditions.

a. The densification to be achieved shall be 1% or less.

b. Only PTRs shall be used, weighing no greater than 18 tonnes.

c. Re-rolling shall take place within 72 hours after the time of the initial rolling of the bitumen macadam.

d. Re-rolling shall take place at the time of day when the bitumen macadam has attained it maximum natural temperature.

e. Re-rolling shall be applied for a maximum of two hours.

f. Re-rolling shall be carried out in the presence of the Engineer's Representative.

g. The section of the works in question shall be cored for density determination immediately after the completion of re-rolling.

h. If, after re-testing, the density achieved is equal to or greater than 99.5% of the specified density, the bitumen macadam will be accepted in the Works subject to a 20% reduction in the billed rates. If, on other hand the density achieved is less than 99.5% of the specified density, the bitumen macadam shall be removed and new material to the specification laid at the Contractor's cost.

Before pavement construction is commenced, a trial area of each pavement materials shall be laid. The extent and location of these areas shall be as approved. The materials, mix proportions, plant and methods shall be those which are proposed for the main work.

A priming coat of grade MC 30 petroleum bitumen shall be applied to the roadbase at the rate of 0.55 to 7 litre per m², before placing macadam. The bindercourse, shall not be laid until the priming coat has been cured.

The bindercourse shall be prepared to receive the wearing course by removal of dust and deleterious materials by air jetting or other approved means.

A tack coat of grade MC 30 cut-back bitumen or SS1H emulsion shall be applied to the binder course at the rate of 0.25 to 0.35 litre per m² before placing the wearing course. The wearing course shall not be laid until the tack coat has cured. The wearing course shall adhere satisfactorily to the base course.

If approval has been given for macadam to be placed at night, approved lighting shall be provided at locations where mixing, laying and testing operations are in progress.

The horizontal alignment of the road as constructed shall not deviate by more than 10 mm from the true alignment as given by the dimensions on the Drawings. The rate of deviation shall not exceed 1 in 1000.

The required levels of base course and wearing course shall be determined from the finished road surfaces calculated from the vertical profiles and the cross falls shown on the Drawings. The permitted vertical deviation from the true level of any point shall be 5 mm for base course and ± 3 mm for wearing course.

The thickness of the individual layers of base course and wearing course shall not vary by more than 5 mm from the theoretical thickness of the respective layers.

The combined thickness of binding course and wearing course layers shall not vary from the theoretical combined thickness by more than 10% of that thickness, or by 10 mm, whichever is less.

An irregularity is a variation greater than 3 mm or 7 mm in the longitudinal profile of the road surface as measured from a 3 m long straight edge.

No irregularities exceeding 8 mm shall be permitted.

Wearing course shall also be measured transversely for irregularities by a 3 m straight edge placed at right angle to the centre of the road. The maximum permissible deviation in this case shall not exceed 3 mm.

Traffic shall not be allowed to run on any surfaces without approval.

10.10.7.11 Testing of Bitumen Macadam

Unless otherwise specified in sampling and testing of bitumen macadam shall be carried out in accordance with Code requirements.

Frequent testing of the mix and the compacted macadam shall be carried out to ensure that the design requirements are being met with. Aggregate gradings shall be checked frequently to ensure that they comply with those used in determining the mixes. The bitumen metering equipment, the bitumen temperature and the temperature of the aggregate at the exit from the dryer shall be regularly tested.

Samples for analysis shall be taken from the final mix as it leaves the mixer and from around the augers of and / or behind the paver. Marshall cylindrical test specimens shall be made from the mix and tested. Cored samples shall be taken after placing and shall be tested in accordance with Code.

The entire operation of mixing and compacting bitumen macadam shall be performed under close control. Frequent testing of the mix and of the compacted pavement will be required as the work proceeds to ensure that the design requirements are being maintained. The Engineer may check the aggregate gradings in the various stockpiles to

ensure that they comply used those used in determining the mixes. The Engineer may test the bitumen metering equipment, the bitumen temperature and the temperature of the aggregate at the exit from the dryer.

The Engineer may take samples for analysis from the final mixture both as it leaves the mixer and after it is laid. In particular, Marshall cylindrical test specimens shall be made from the mix and shall be tested to ensure the continuing suitability of the job mix in relation to the design criteria specified herein.

The preparation and testing of Marshall cylindrical specimens shall be carried out as specified herein.

Specified gravity of the mixed material shall be measured and cored samples taken from the compacted pavement to measurement in-situ density.

The frequency of testings shall be as directed by the Engineer. In general, routine testing of the mix, which shall include atleast, Marshall type tests, bitumen extraction, and grading tests, shall be carried out atleast 4 times a day during full production or at the rate of one sample for every 100 tonnes produced whichever is the more frequent.

Cores shall be cut and tested at the rate of 1 per 500 sq.m. As soon as possible after cutting, core holes shall be painted on their sides with a thin coating of hot bitumen and refilled with bitumen macadam of the appropriate mix. Compaction shall be carried out with a Marshall hammer or other approved means.

If tests show that the specified requirements are not achieved, the whole process of mixing and laying bitumen macadam shall be stopped and shall not recommence until corrections have been made to the methods adopted for mixing and laying that will ensure that the minimum requirements are achieved.

10.10.7.12 Final Surfacing

The Bitumen Macadam binder course shall be kept clean and uncontaminated so long as it remains uncovered by a wearing course. Should the binder course become contaminated the Contractor shall make good by cleaning to the satisfaction of the Engineer and if this is impracticable by removing the layer and replacing it to specification.

When all heavy plant has been delivered and all soft, fatty or otherwise objectionable areas of the road have been reinstated and made good to the satisfaction of the Engineer, the wearing course shall be laid.

10.10.7.13 Jointing new to Existing Pavement

Where new pavement is required to join into existing road construction, the joint shall be formed and treated in accordance with the Drawings.

Unless shown otherwise on the Drawings, each layer of existing bituminous course shall be cut back to a clean vertical face and coated with hot bitumen of a grade suitable for the purpose immediately before laying adjacent new bituminous material.

If cutting back of the existing pavement layers is required to form a stepped pattern, the lower layers of bituminous courses shall be prepared to receive the new covering coats by removal of dust and deleterious materials by air jetting or other approved means, and shall be coated with bituminous tack coat.

Exposed existing roadbase surfaces shall be scarified then re-compacted and sealed with bituminous prime coat in accordance with roadbase specification.

10.10.7.14 Overlays

Overlays shall be placed in accordance with the requirements for placing bitumen macadam.

In addition to the requirements for basecourse preparation, the area to be overlaid shall be cleaned by soaking with potable water and mechanical brushing while wet. This operation shall be carried out twice and shall be followed by air-jetting.

Where the existing pavement layer is smooth or where bitumen, oil, rubber, dust etc. has accumulated, the area shall be cold-planed to a nominal depth of 10 mm, to provide a key for the overlay.

A bituminous tack coat shall be applied to the prepared surface before the overlay is laid.

Overlays shall be laid to achieve the minimum specified thickness. Protrusions of the existing pavement shall be removed to give the minimum depth required. Holes and local depressions shall be cut out to atleast 25 mm depth and filled with basecourse or wearing course material, as appropriate, prior to commencement or the overlaying course.

10.10.8 Interlocking Paving Blocks

Roads and areas to be paved with interlocking concrete blocks shall be excavated and placed with 300 mm depth of compacted material at the exact levels and falls required for the finished work.

If parts of the base are found to be unstable the Contractor shall excavate further to a firm bed and fill with layers of fine crushed rock or aggregate, thoroughly compacted. The upper surfaces of the base shall reflect the exact profile, fall or contour of the final paving as irregularities shall not be compensated for by varying the depth of sand bedding.

Compaction of formation and base for interlocking concrete slabs shall be carried out as outlined in clauses for compaction of sub grade), (Road base), (Tests on sub-grade and Road base).

A stable edge shall be provided to retain the paving units and sand bedding by means of precast concrete edging unit or kerbs set in-situ concrete.

The sand bedding shall be a fine, well graded sand in a dry to moist condition and laid to an uncompacted thickness of 50 mm.

Samples of the paving blocks are to be submitted to the Engineer for his approval. No orders shall be placed with the manufacturers until the Engineer's approval has been given.

The mix for paving blocks shall contain a water repelling additive.

The paving block shall be laid in accordance with the manufacturer's instructions and shall be compacted at completion of each day's work.

The interlocking block shall be a minimum of 80 mm thick and the concrete quality must be approved by the Engineer.

10.10.9 Site Surfacing

Chippings for site surfacing shall consist of a 75 mm thickness of 25 mm uniform gauge crushed and washed gravel as approved by the Engineer.

10.10.10 Sampling and Testing of Materials

Samples shall be taken in accordance with the relevant Code. Materials subsequently supplied shall atleast equal the approved sample in all respects. No source of supply shall be changed without prior written approval from the Engineer. Any samples not approved or materials falling to comply with the approved samples shall immediately be removed from the site of the Works.

The Contractor shall submit to the Engineer copies of all orders for materials to be incorporated in the Permanent Works if required to do so.

All materials to be used in the permanent Works shall be subject to inspection and tests as the work proceeds. The Contractor will be responsible for carrying out all tests required under the Contract or as instructed by the Engineer from time to time and will provide the necessary laboratory facilities, apparatus, equipment, skilled laboratory staff and labour required for this purpose. The Engineer and his staff shall have access at all reasonable times to the laboratories, laboratory staff and be furnished to the Engineer.

10.10.11 Kerbs

Kerbs, channels, edgings and quadrants shall be cast generally to conformity to BS but to the dimensions shown on the drawings where these differ from preferred dimensions. They shall be cast to the required radius for all curves not less than 12 metres.

Raised kerbs shall be laid with a 6 mm gap and pointed with 1 to 3 polymer modified cement mortar above road level only. Concrete bedding and backing to kerbs shall be cast-in-situ to the dimensions shown on the drawings.

Flush kerbs shall be similarly laid and jointed or may be cast-in-situ. The outside corner of the kerbs shall be chamfered.

In the cast of precast kerbs one joint in ten shall be left unpointed and 6 m compressible insert provided and a construction joint formed in the haunching at this point for expansion. Similarly expansion joints are to be formed in in-situ kerbs at 4.0 m intervals.

Marginal strips and kerbs shall be protected against covering or splashing with bitumen or cement. Kerbs and manhole frames shall be printed before bituminous macadam is laid.

All raised kerbs shall be alternately painted black and white in the plant area and at junctions.

10.10.12 Traffic Signs

Traffic signs shall be reflectorised and unless specifically stated to the contrary

The signs and their individual elements shall be capable of withstanding the minimum wind pressure referred to in the design requirements.

The Contractor shall design the signs, based on typical details provided by the Engineer.

Number, type and position of the signs to be as agreed with the Engineer.

All signs shall be fabricated from sheet aluminium.

Mounting posts shall be of circular hollow steel section structural steel.

Post caps shall be continuously fillet welded to the post heads to prevent the ingress of water.

Single post signs will generally be cast directly into a concrete base but signs having two or more posts shall have suitable base plates for mounting flat down to a previously constructed concrete base. The base plates shall be continuously fillet welded to the posts, shall be suitably stiffened if necessary, and shall be per-drilled to accommodate holding down bolts.

Where there is possibility of aluminium and steel coming into contact with each other at fixing points a suitable non-degradable inert packing shall be provided to prevent such contact.

All steelwork shall be hot-dip galvanised and shop painted according to Section of the Civil Specification (specification no. 10.8) in a salt and dust free covered area, the finishing colour coats shall be as approved by the Engineer.

10.10.12.1 Temporary Traffic Signs and Carriageway Markings

For road diversions the signs and markings shall generally follow the specification for permanent works.

Posts and foundations shall be designed to facilitate re-use but also must be robust.

Warning lights, heavy duty bollards, etc., are to be provided.

All diversion works and the location, quantity and specification for all signs, lights, bollards etc., are to be approved by the local Authorities and the Traffic Police Department.

10.10.12.2 Carriageway Markings

The materials shall confirm to relevant American Codes.

Carriageway markings shall only be applied to surfaces which are clean and dry. Where owing to the action to traffic or otherwise, the pavement has become polished before the application of road markings, at the direction of the Engineer a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's instructions. Markings shall be free from raggedness at their edges and shall be uniform and free from streaks. The laid thickness of the markings shall be 1.5 ± 0.5 mm. The Contractor shall indicate the maximum safe heating temperature, the temperature range of the apparatus and the method of laying to be used.

10.10.13 Concrete Paving Slabs

Areas to be paved with concrete paving slabs shall be excavated and replaced with 300 mm depth of compacted material at the exact levels and falls required for the finished work. If parts of the base are found to be unstable the Contractor shall excavate further to a firm bed and fill with layers of fine crushed rock or aggregate, thoroughly compacted. The upper surface of the base shall reflect the exact profile, fall or contour of the final paving as irregularities shall not be compensated for by varying the depth of sand bedding.

Samples of the paving slabs are to be submitted to the Engineer for his approval. No orders shall be placed with the manufacturers until the Engineer's approval has been given.

The paving slabs shall be laid in accordance with the manufacturer's instructions.

10.10.14 Crash barriers

Crash barriers shall be provided where considered essential to protect personnel and/or equipment and piping. For example road crossings over and under pipe(t)racks, roads close to pipe(t)racks, roads adjacent to (steep) slopes, T-junctions, (sharp) bends.

The preferred crash barrier system consists of I-beams, steel supports embedded in the soil at 3 m distance to carry a guard-rail of 0.75 m minimum height. The steel should be galvanized.

The system shall be able to absorb impact energy by deformation without collapse.

10.10.15 Drainage

The drainage of roads comprises surface run-off and sub-surface drainage systems.

Ditches and collectors along the roads shall form an integral part of the surface drainage system of the site. For surface drainage system, reference is made to section "Drainage System" of this specification (specification no. 10.15).

Open ditches and channels along roads shall be concrete-lined.

The subsoil under the road paving system shall be well drained.

The distance between underside paving and high ground water level shall be not less than 1,0 m.

In the event of a rocky sub-grade the highest ground water level shall be taken as the rocky sub-grade level. This applies only when the distance between rock level and underside paving is less than above specified values.

The necessity of a permanent sub-surface drainage system shall be investigated to ensure a proper drainage of the subsoil under and adjacent to the road.

The influence of unlined drain ditches, lined drain ditches and channels with weep holes on the ground water table shall be taken into account.

(PEC TENDER NO.: 12/2008)

CONTENTS

10.11 Finishing Works including Roofing and Cladding

10.11.1 Scope

This specification covers all the requirement in respect of material workmanship and quality for the work finishing works. The scope of work shall include the following but not limited to :

- repair of cracks, blow holes or other defects in cement rendering and the decorating thereafter
- rendering on blockwall shall be carried after 14 days after completion of block work, and that joints of blockwork shall be raked to 1.0m before rendering – exposed edges of external panels of rendering shall be finished with approved galvanised steel plaster stops.

10.11.2 Codes and standards

Unless specifically noted otherwise American Standards in their latest editions / local regulations shall govern in respect of material and workmanship.

10.11.3 Quality Assurance

10.11.3.1 Installers Qualification

For installation of metal doors and frames and associated hardware, personnel who are thoroughly trained in that trade and familiar with manufacturer's recommendation only shall be employed.

10.11.4 Submittals

The contractor shall submit schedule and drawings (indicating the materials to be used) for finishing works prior to commencement of work prior to approval by the engineer. The contractor shall notify the owner in advance about the inspection to be undertaken at manufacturer's works.

10.11.5 Metal Panel Walls

The following two types of wall construction may be used:

10.11.5.1 Type I: Metal panels with separated thermal insulation

Framework: Hot rolled galvanized steel profiles according to Section 10.8 "Structural steel works" of this Specification.

Wall panels: Interior:

- Horizontal grids connected to the columns
  Vertically mounted trapezoidal corrugated galvanized steel sheetmetal panels or aluminium panels

- Vapour barrier of plastic foil, UV-resistant, having a minimum ply thickness of 0.2 mm
- Insulation of mineral fibre board, fibre glass or equivalent as approved by the Engineer
- Number and Spacing girts as per requirement
  Rigid insulation board serving as gird insulation and wind penetration protection
- Exterior cladding of corrugated galvanized steel sheet metal panels with a surface finish of PVF2 or approved equal

Roof panels:

Top of roof deck shall be provided with trapezoidal corrugated galvanized steel sheet metal panels with a surface finish of PVF2 or approved equivalent.

- Insulation of mineral fibre board, fibre glass or approved equal
- Protective membrane against wind penetration
- Vapour barrier as in walls
- Bottom of roof deck shall be trapezoidal corrugated galvanized steel sheetmetal panels or aluminium panels

Mastic chaulking: Elastic sealant of butyl or silicone base supplied by Dow Corning or equivalent.

Closure strips: Closure strips shall be of a closed cell neoprene type supplied by Dow Corning or equivalent.

Flashings: Flashings shall be of flat sheet metal of same quality as adjoining metal panels.

Screws: Screws shall be the mechanical self-tapping type made of carbonized and galvanized steel, colour coordinated.

Rivets: Rivets shall be the airtight type (Blind rivets).

Doors: Doors shall be constructed of steel sheet metal mounted in steel frames equipped with metallic thresholds and suitable weather striping so as to effectively preserve the electrical continuity and air tightness of the building. Doors shall have the same fire resistance rating as the wall of which it is an integral part.

10.11.5.2 Type II "Sandwich" insulated metal panels

Framework : Similar to Type 1

Wall panel : Factory insulated composite wall panels with insulation of a closed cell isocyanurate foam core or mineral fibre

External surface finish of Polyvinylidenflouride (PVF2) or approved equivalent, internal surface to be galvanized

Internal cladding (if any) is to be provided it shall be RFI / Screen / Vertically mounted trapezoidal corrugated galvanized sheet metal panels.

	Roof panels	:	Top of roof deck shall be provided with trapezoidal corrugated galvanized steel sheet metal panels with a surface finish of PVF2 or approved equivalent Insulation of mineral fibre board, fibre glass or approved equivalent Protective membrane against wind penetration Vapor barrier of plastic foil, UV-resistant, having a minimum ply thickness of 0.2 mm Bottom of roof deck shall be provided with trapezoidal corrugated galvanized steel sheet metal panels or aluminium panels
	Mastic chaulking	:	Similar to Type I
	Sealing foam	:	Sealing foam shall be the polyurethane foam (PU) type
	Closure strips	:	Similar to Type I
	Flashings	:	Similar to Type I
	Screws	:	Similar to Type I
	Rivets	:	Similar to Type I
	Doors	:	Similar to Type I

The roof and wall cladding shall be tested in accordance with relevant Code.

10.11.6 Roofs

10.11.6.1 Steel Roof Decking

Refer to relevant clauses of Section 10.8

10.11.6.2 Concrete Roof

Refer to relevant Clauses of Section 10.6

10.11.6.3 Design Requirements

All roofs shall have a minimum sound absorbing index of 20 dB(A) or more where required for sound abatement and a maximum heat transmission coefficient of 0.45 $W/m^2.K$. Appropriate insulation materials satisfying the above requirements shall be used.

The roofs shall be designed and constructed so as to effectively prevent water, moisture, dust, birds and vermin from penetrating the building's envelope.

The sound and thermal insulation indices shall comply with ASCE specifications. The type of construction used shall take into account the individual conditions prevailing in the building.

10.11.6.4 Materials

Roofing felts shall comply with American Standards.

Fibre insulating materials and expanded plastics shall conform American Code.

All metal sections for wall connection joints as well as hoods and sleeves are to be adequately protected against the effects of weather.

10.11.6.5 Roof construction

The roof construction is to be such that, due allowance for the climatic conditions and any air conditioning Plant installed in the rooms, the intended use of the rooms taken into account. It shall be ensured that no dampness will penetrate the roofing materials. All roofs must have a minimum sound absorbing index of 20 dB (A) and a maximum heat transmission coefficient of 0.45 W/m^2 °C. Appropriate insulation materials satisfying the above requirements shall be used.

The sequence of placing layers if roof and their dimensioning shall be correlated with the type of substructure and the intended use of the building concerned.

Roof surfaces are in principle to be designed with a slope. Sloping layers below the vapour barrier must not be constructed of lightweight concrete.

All roof penetrations are to be made with metal surrounds and bonded flanges and are to be sealed.

Roof covering and roof sealing works shall comply with American Code.

10.11.7 Plaster Finish

The type of plaster employed and its method of application shall be approved by Engineer.

The plastering surface must be free from dust and shall be clean. Strongly absorbent surfaces shall be thoroughly damped before plastering. The plastering shall be securely bonded to the blockwork and shall be free from crazing and efflorescence. Approved pre-mixed plaster systems should be used for which only water need be added. In case of gas or aerated concrete the instruction of manufacturers shall be strictly complied with.

Plastering to internal walls shall be in two coats totalling 15 mm thick. The rendering coat is to be 12 mm thick and the setting coat 3 mm thick. The rendering coats shall be consist of one part portland cement to three parts fine sand to one tenth part gypsum lime (1:3:1/10) by volume. The setting coat shall be a premixed gypsum lime plaster applied in accordance with the manufactuer's instructions by specialist applicators.

10.11.8 External Rendering

All rendering materials shall be measured in a proper gauge box and shall be mixed in a clean container, on a clean board or in an approved machine and all rendering materials shall be used within one hour of the addition of cement; parly set or dried material shall be discarded.

All rendering work shall be protected from direct sunlight and the drying effects of winds during execution and 7 days curing with water.

The contractor shall ensure that all surroundings building work and paving is protected from cement splashes.

All water pipes, electrical conduits and other services, soil, waste and anti-syphonage pipes shall be fixed in position, and when necessary securely fixed in chases and recessed, before the execution of any rendering or other similar work. Metal pipe fixings or untreated steel are to be suitably protected from contact with the cement rendering, either by painting with bitumen or by an approved wrapping.

All blockwork wall surfaces shall be brushed down with stiff dry brush to remove the efflorescence and loose dirt.

Low spot and areas shall be dubbed out and sufficient time shall be allowed for the dubbing to dry out before the rendering is applied.

10.11.9 Cement Wash

The cement wash to fair-faced blockwork shall be well rubbed or bagged into the surface of the blocks in order to produce an overall smooth surface.

10.11.10 Painting

All paint coat shall be applied properly depending on the material concerned.

Base preparation shall be done for all surfaces to be painted. Paints which are not subjected to chalking only shall be used. The shades as decided by owner shall be used. In toilet rooms mild due paints shall be used.

10.11.11 Concrete Flooring

The concrete flooring shall conform to the following requirements :

a. To be wearing, and divided into sufficiently small bays of maximum 5 x 5 metres to prevent shrinkage cracking.

b. All pre-treatment of base, e.g. application of damp – proof membrane or insulating coats and adherent coatings, shall be carried out to prevent any deficiencies or damages.

c. To be made non-slip

To edge openings and railings with suitable sections

e. To be dust - proofed

f. To be resistant to oil and grease

Floor shall be constructed with desired slopes or shall be made totally level.

Building joints and settlement joints shall be covered with suitable elastic joining sections.

The type of finish and method of laying is to be approved by the Engineer

10.11.11.1 Preparation of Flooring

Before laying any flooring or screeding the surface of the concrete screed shall be thoroughly cleaned to remove all loose material, dust, oil and grease.

10.11.11.2 Cement / Sand Screed

Cement / sand screeds are required only over areas where strict adherence to level tolerances for plant erection is required. To avoid cracks, provision of joints of adequate size has to be made at suitable locations. The contractor shall take all measures to avoid over drying of screed.

Where a cement / sand screed is to be placed, the surface of the old concrete shall be thoroughly scabbled to remove all laitance, scrubbed and cleaned to expose the aggregate, thoroughly wetted and then covered with an approved bonding agent well brused into the roughened immediately prior to screeding. The thickness of screed layer as per Engineers instructions shall be laid by the contractor.

Where so directed by the Engineer, the Contractor shall add approved compounds to the materials before mixing to give a concrete with improved dust-proof and oil resistant qualities. Such compounds shall be added in accordance with the instruction of the manufacturer. Edgings are to be made with properly fixed steel angles.

The screed shall be placed in panels not exceeding 3 m square. Contraction joints shall be provided around the perimeter of each panel and shall be of approved materials.

Cement / Sand screed shall comprise one part cement and two parts sand or other mix as approved by the Engineer. It shall be steel floated to a smooth hard finish before final set.

After laying it shall be kept wet with sand or sawdust or ponded for at least seven days and then allowed to dry.

The screed shall be true and level free from any bumps or hollows that would affect the finished surface of vinyl thermoplastic flooring.

The Contractor shall provide chases, battens, box outs, etc., to support plates and channels, etc., for plant erection.

All necessary grooves for door channels, duct channels etc., shall be provided and later grouted in.

10.11.12 Tiling

10.11.12.1 Ceramic Floor Tiles

Ceramic floor tiles and tiling to relevant codes shall be fully vitrified, a minimum 10 mm thick non slip type laid strictly in accordance with manufacturers recommendations. In general they shall be provided with covered skirtings 100 mm high covered tile bases at all walls, and all exposed edges shall be rounded. Grout shall be epoxy resin based.

The floor areas shall be dived into bays with approved brass dividing strips. The top of the strips shall be truly level with the finished surface.

Tiles shall conform in size, shape, pattern and colour with the samples previously submitted to the Engineer for his approval.

Brass dividing strips shall be provided in the floor finishes under all doors.

10.11.12.2 Terrazzo Tiles

Terrazzo tiles shall be true to shape, free of flaws, cracks and pitting, of smooth surface and of an approved type, make, colour and texture. They shall consist of a facing of cement and chippings (1:2.5 nominal mix) using either white cement, with or without pigment added, or coloured cement. The facing shall be wear resistant and of a finished thickness not less than 6 mm. Backing shall consist of ordinary Portland cement and sand (1:5 nominal mix).

All terrazzo tiles shall be supplied polished.

Terrazzo tiles shall be cured by total immersion, after initial set, in clean potable water for at least 24 hours, before grinding, filling and polishing.

Terrazzo skirtings shall be produced in the same manner as for tiles.

Terrazzo tiles shall be laid and bedded direct onto a concrete sub-floor using a cement and sand screed (1:4 nominal mix). The minimum thickness of the screed shall be 18 mm. The total thickness of cement/sand screed and tiles shall not exceed 50 mm. All tiles shall be laid with square joints and finished to a true flat surface.

All tiling shall be grouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a colour to match the tiling or of white cement. Any surplus grout shall be immediately cleaned off the face of the tiling and surrounding surfaces and all tiling work shall be carefully cleaned.

All terrazzo surfaces shall be polished on completion. Large areas such as floors shall be wet polished by means of approved machines using carborundum abrasive. Any surface too small for convenient machine polishing may be polished by hand using carborundum stone and clean potable water. Care shall be taken during polishing operations not to damage any angles or arises.

Terrazzo tiles, skirtings etc. shall generally be applied in accordance with the foregoing, except that the chamfered edge of the skirting shall bed against the finished wall surface.

10.11.12.3 Cast Stone

Floors and steps of cast stone shall be constructed according to relevant American Codes. Only standard cement and tested aggregate shall be used. Section "Concrete Works" specified herein shall be observed. The surfaces shall be silicated.

10.11.12.4 PVC Tiles

PVC tiles shall be made from mineral fibres and fillers, pigments and natural or synthetic resinous or asphaltic binders by an approved manufacturer. Tiles shall generally be 300 mm square x minimum 3 mm thick.

Samples of colours of all tiles to be used shall be submitted to the Engineer for his approval.

The tiles shall be sealed and polished upon commissioning of the plant, prior to this the tiles shall be protected with plywood.

10.11.12.5 Acid / Alkali Resisting Ceramic Tiles

Acid / alkali resisting tiles shall be fully vitrified 20 mm thick non slip type bedded and jointed with acid/ alkali resisting materials. All top edges and corners, etc., shall be rounded and ordered with the standard tiles. Grout shall be epoxy resin based.

Tiled upstands shall be provided under all doors at interfaces with non-chemical finished areas.

The surface of the floor slab shall be hacked to remove the laitance. It shall be degreased, swept clean, washed and time given for the water to penetrate the slab. Excess moisture shall be brushed off and neat cement grout brushed into the surface prior to the laying of the mortar bed.

The tiles shall be bedded and jointed in (1:2) cement/sand mortar having a minimum thickness of 20 mm. The width of the joints shall be uniform and shall not exceed 6 mm. While the mortar is still green, the joints shall be raked out to a minimum depth of 8 mm. The grout shall be strictly in accordance with the manufacturer's instructions. The joint surface shall be clean as well as free of grease, dust and other foreign matter. Immediately after application, any surplus grout on the tiles shall be removed with a clean dry rag. The finished joint shall be allowed to cure for at least 7 days before traffic is allowed on the floor.

Laying

Unless otherwise specified, tiles shall be bedded in 20 mm thick cement mortar (1:3) to an approved pattern and jointed and pointed in cement mortar tinted to match the colour of the tiles. They shall be firmly bonded in place with finished surfaces truly level. All joints shall be straight, uniform in width and solidly filled. The completed work shall be free of loose, cracked or defective tiles.

Only first quality tiles shall be used. Tiles in wet rooms shall be non-slip. Where acid/alkali resisting tiles shall be fixed on tanking membranes and/or epoxy coating the fixing an adhesive mortar compatible with the underground shall be employed.

10.11.13 Synthetic Rubber and PVC Floors

The subfloor shall be free of dust and dirt, treated with two-component epoxy primer and so constituted that the covering will withstand the heaviest loads without damage. The flooring material used shall be properly laid and any gaps in the PVC floorings shall be welded. In switchgear rooms it is important that the flooring have adequate insulating properties. All floor coverings shall be non-inflammable and oil resistant. American codes / standard recommendations shall be followed.

10.11.13.1 Textile Flooring

Textile flooring shall in all cases be laid on subfloors, pre-coated and treated with levelling compound. Only 100% all-synthetic coverings are permissible. In terms of resistance to abrasion, puckering, fastness to water, fastness to dry cleaning and mechanical loading they shall meet the most exacting requirements; they shall be absolutely safe against wheel chair movements. For all types of textile flooring, the material for the pile shall be dyed before the carpet is manufactured. Suitable additions of conductive substances shall be added as a protection against electrostatic charging. The hygiene requirements shall be upheld throughout the lifetime of the flooring with maximum antimicrobial, bactericidal and fungicidial effectiveness.

10.11.13.2 Acid- and Alkali-proof Coverings

In the construction of resin compound coatings, the instructions and processing rules of the manufacturer shall be strictly observed. Coatings shall only be applied on sand-blasted surfaces. The coverings shall be designed and constructed according to the particular needs, either absolutely flat or with a fall, and they shall be free of projections, pores, cracks and gaps. The materials used shall be of the very highest standards. Rubber linings shall be applied free of blisters onto a sand-blasted and clean ground.

Joints in the structure and settlement joints shall be so sealed that they are permanently elastic and matched in their chemical behaviour to the surfaces concerned.

10.11.14 Floor Expansion Joints

Expansion joints are to be formed with an approved preformed movement control joint system satisfactory to accommodate stresses for high transient loading.

10.11.15 Raised Modular Flooring

The sub-structure of raised floors shall be self-supporting with individually removable bearer sections. Columns shall be adjustable for height and provided with hinged base plates for uniform load transmission; they shall be mounted on sound-insulating underlay. The requirements of the switch gear cubicles shall be taken into account.

All steel parts shall be galvanized and painted.

The non-distorting floor slabs shall be insulated all round against damp, fire and rot.

Electrostatic charges on the final floorings shall be dissipated to the main grounding system in such a way that the requirements as regards installed instrumentation and control equipment are met.

No horizontal displacement of the floor shall occur if one or more slabs are removed.

The floor covering shall be not less than 2 mm thick.

The construction height shall suit the requirements of the control cubicles and buildings.

Sub-floor penetrations shall be bridged. The load-bearing capacity of intermediate floors shall allow for the installation of the switchgear cubicles.

The floor tiles shall be fire-resistant, the flooring shall be self-extinguishing.

The Contractor shall provide all necessary test data and certification to substantiate his material / design on load bearing, fire and anti - static classifications.

The Contractor shall provide a full set of detail construction drawings for all floors within the contact. Drawings shall be submitted to the Engineer for approval prior to fabrication and / or construction taking place.

The Contractor shall ensure that all his drawings have been fully checked prior to submission for approval.

The Contractor shall include for the supply and delivery to site of the complete floor system suitably packed / crated, and installation by skilled team of craftsmen.

10.11.15.1 Accessories

The Contractors shall provide as part of his supply the following :

Cutting and forming openings within the floor and supply of proprietary edging strips and PVC seals.

Supply and fixing of his standard adjustable air grilles to a specified manufacture.

Four (4 no.) lifting devices to enable the floor panels to be lifted. These will be passed to the owner upon project completion or building completion whichever is the sooner.

Spare panels will be dependent upon either the number of individual area or the total floor area. The number of panels will be specified on the enquiry documents, but in general the number of spare panels will be less than five (5) percent minimum. All spare panels shall be complete with the floor finish applied and ready for installation when required.

Ramps, stairs, handrails etc., shall be included and will be as shown on the contract drawings.

10.11.16 Suspended Ceilings

In principle all ceiling panels shall be removable offering to access to the ceiling void for routine inspection and maintenance of services. Sheet and panel joints shall be accurately aligned.

Where removal of equipment such as valves, dampers, etc., is required locakble hinged hatchways shall be provided.

The proprietary suspended acoustic ceilings shall be fitted around light fittings, ventilation ducts, etc., and shall conform to the following requirements

a. Shall be non-combustible

b. Shall not allow the spread of flames

c. Shall be hard enough to withstand accidental knocks or abrasion

d. Shall be vermin proof

e. Shall easily be cleaned or redecorated

f. Shall be so designed as to allow the easy replacement of panels

g. Shall provide the following minimum sound absorption co-efficients

0.47 at 500 Hz
0.70 at 1000 Hz
0.90 at 4000 Hz

The hangers for suspended ceilings shall be non corrosive materials and shall be adjustable.

The choice of ceiling is to be approved by the Engineer, and unless otherwise approved by the Engineer. Panels in any room shall be of uniform size and pattern. The contractor

shall submit a drawing giving the details of proposal to the owner for approval before commencing the work.

10.11.17 Acoustic Ceilings

Acoustic ceilings shall exhibit adequate sound-absorbing properties in the required frequency ranges. When perforated or slotted sheets or panels are used, any top mounted sound absorbing material shall be prevented from falling out. Asbestos materials shall not be used.

10.11.18 Metalwork

All metalwork shall be designed, fabricated and fixed to the satisfaction of the engineer and shall comply with this specification.

10.11.18.1 Aluminium Windows and Louvers

10.11.18.2 Windows

The window frames are to be of anodised aluminium allow with polyurethane colour coat finish as approved by the owner. Supplied complete with hinges and pivot pins, fixing lugs, handles and stays, glazing clips, etc., Gaskets shall be of vinyl glazing channel in gasket shall be designed in accordance with per American Standards. Opening windows shall be provided with insect screens comprising aluminium frames with Nylon or other corrosion resistant material screens of size 1 mm x 1 mm apertures. The Windows shall be designed and constructed to enable cleaning and glass replacement to be carried out from inside.

Windows to air conditioned rooms other than offices and permanently occupied rooms shall be of a non opening type but with facilities for removal from the inside for cleaning and maintenance.

Weathering and glazing splines shall be neoprene or ethylene propylene.

Sun shields shall be provided over and to the sides of window frames.

Double glazed windows shall be provided for HVAC rooms and shall be to the approval of the Engineer.

Aluminium windows shall be framed in extruded aluminium bars and glazing sections which shall be anodised to match the windows. The aluminium shall be of a type comparable to the appropriate National Standard described as a heat - treated material in the solution - treated and naturally aged condition and as a material in the air quenched and precipitation treated conditions. The frames shall exhibit adequate rigidity. They must be provided with rebar for glazing and a lip to bear against the structure.

Each casement has two stays, an operating rod and a handle of anodized light metal. On the inside at the bottom is a condensate channel with caps at the ends. Cavities between window frames and the walls are to be fully insulated with mineral wool and sealed with permanent elastic sealant. Externally at the bottom an aluminium sill cover with a corresponding developed shape is to be fitted.

The sill cover is to be made of 3.0 mm thick aluminium sheet and is to run unbroken for the entire length of strip windows. Where joints occur, these are to be sealed with a permanently elastic mastic on a multi-component thiokol base.

As a finish to each end of the strip window, an aluminium angle with the same height as the window provided with bonded-on insulation on the rear is to be fixed to the frame.

Where window controls are positioned above a height of 1800 mm from floor level, then these windows are to be provided with rod and level or enclosed cable operating gear.

The windows units are to be divided into uniformly large sections by piers at suitable intervals. Top hinged vents shall be attached to the frame by a pair of window hinges and stainless steel pin shall be provided. The windows are to be glazed with glass of an appropriate thickness to suit the opening. Generally polished plate glass will be needed, sometime wired, but alos rough cast glass may be used in certain cases. Blast resistant laminated glass shall be provided in the windows between local control rooms and turbine halls.

The glazing of wired glass is to be fitted with aluminium glazed beads retained by stainless steel screws. Internal and external sealing in multi-component thickol basis to be provided.

The whole design and detailing of the windows is to be the approval of the engineer.

10.11.18.3 Louvres

Ventilation louvres are to be constructed with an enclosing frame and fixed weatherproof lamellas. On the inside a bird guard is to be fitted. Fixing is to be effected as described under clause "Windows" above. The material used shall be aluminium, the description as under "Windows" shall apply analogically.

10.11.19 Wire Screens

Stainless steel wire screens are to be mounted outside lower windows for security where necessary and where ordered. The details shall be to the approval of the Engineer.

10.11.20 Doors and Frames

All door material shall have sufficient thickness, stiffening, sub construction etc., all fire and safety and sound insulation requirements. Doors and door frames shall generally be of galvanised double skin pressed metal with a wood or light weight core supplied by a specialist manufacturer to the approval of the Engineer. All doors except folding shutter type, over 2100 mm high shall be provided with removable transoms.

All doors and frames and ironmongery shall be manufactured by a company specialising only in door manufacturing, the door installations must be manufactured complete including accessories and catches.

Where air locks are required they shall be provided with two sets of double doors with removable transoms of sufficient size to suit all plant access and removal.

All doors shall be complete with all necessary and appropriate fixing lugs, hinges, threshold strips, vision panels of polished wire glass, hard wearing ironmongery, kick plates, push plates, automatic closures with hold-open facility, locks and where necessary panic bars and bolts.

All external doors and frames shall be fitted with approved weather seals.

For external doors, automatic closures are to be fitted internally.

Instruments fire seals are to be inserted into grooves in the edges of all fire resistant doors.

All glass shall comply with an appropriate European Standards or equivalent National Standard. Where required all flush timber doors shall be solid cored and shall be covered on both sides with external quality plywood finished ready for painting. The doors shall be lipped and edged hardwood strips.

10.11.20.1 Locks and Door Furniture

Samples of all door furniture which is to be of a very high quality and heavy duty are to be submitted to the Engineer for his approval. All locks shall be provided with three keys, which on completion of the work shall be clearly and securely labelled in suitable cabinets. The key cylinders are to be submitted with legally protected profile with protection certificate, to guard against unauthorised entry attempts and duplication of keys. The locks, roses and lock sets must suit the lock cylinders. The cylinders are to be matched with the door leaf thickness.

10.11.21 Timber

Timber used in the permanent works shall be thoroughly seasoned and matured, sound, straight, free from warp, sapwood, signs of rot, shakes, large and loose knots, worm holes, wanes, cracks and other defects and shall be sawn or wrought die square and true on all four sides. Timber shall conform to the appropriate National Standard approved by the Engineer.

Timber for concealed work shall be an approved hardwood.

All timber for exposed joinery shall be approved selected Iroko or approved equivalent. Such timber may contain sound or tight knots on any surface provided that the mean diameter of any one knot does not exceed 20 mm the knot nowhere occupies more than one sixth of the width of the surface.

The Engineer will have the right to reject any timber not confirming to the "Selected" standard.

All timber shall be well seasoned with a minimum appropriate moisture content.

Where timber work is required wrought it shall be supplied machine dressed. All joints, mortices, tennons, housings and the like shall be perfectly formed and fitted. All faces of timber in direct contact with blockwork, concrete or rendering shall be protected by an approved primer before fixing.

All timber incorporated in the permanent works is to be pressure impreganated to give full protection from insect and fungal attack. The treatment is to include protection against termites. The type of preservative used and method of treatment are to be to the approved by the Engineer.

The Contractor shall provide and maintain all temporary covering, and shall box - in and protect all work liable to damage.

10.11.21.1 Painting of Woodwork and Timber

Where possible the moisture content of joinery timber at the time of painting should not be more than 15%.

All wrought woodwork shall be prepared and primed in the joiner's shop. Large resinous knots and pitch pockets shall be cut out and replaced by sound wood. (Small knots and pitch streaks shall then be given two coats of knotting.

As soon as the knotting is thoroughly dry the whole of the joinery shal be give a coat of priming paint, care being taken to work the primer into all quirks, crevices and nail holes. End gain shall be given two coats of primer. Spraying will not be permitted.

All joints shall be thoroughly primed before assembly.

After erection on site any primer which has been damaged in any way shall be touched up or re-coated. Any part of the work coming into contact with blockwork, window frames, etc., or otherwise covered up, shall be given an additional coat of aluminium wood primer.

The priming paint for woodwork intended for external work and for internal window sills, frames, ledges, sashes, etc., shall be good quality white lead linseed oil primer containing about 10% red lead. For general interior work a leadless linseed oil grey primer shall be used.

Hardwood joinery which is to be painted shall be primed with aluminium wood primer or hardwood or teak priming varnish. The backs of hardwood joinery not painted on exposed faces shall be similarly treated.

When the primer is dry, and before applying the undercoats, all cracks, nail holes, etc., shall be stopped with a suitable, stopper. Woodwork which has been primed for some time shall be wiped down and rubbed with damp abrasive, leathered off and allowed to dry before applying the undercoats.

The joinery shall then be given two coats of the undercoating paint recommended and supplied by the manufacturer of the finishing paint.

All exterior and interior wood work shall be given one top coat of alkyd resin enamel paint.

All structural timber that does not require to be painted, e.g., timber joints, flooring, staircase and the like, shall be treated with two coats exterior grade approved timber preservative.

10.11.21.2 Oiling Hardwood

Hardwood described as being oiled in indoor locations shall be treated with two coats of raw linseed oil.

Hardwood described as being twice oiled and varnished shall be treated with two coats of raw linseed oil followed by one coat of clear marine varnish.

10.11.21.3 Wood Screws

Wood screws shall be of brass conforming to approved National Standards. Where aluminium components are fixed to joinery work, aluminium screws and washers shall be used.

10.11.22 Handrailing and Baulstrading

Architecturally designed ornamental steel handrailing and balustrading shall be provided in the control building. The balustrading shall be of high quality and samples shall be submitted to the Engineer for approval, together with drawings, before commencement of work.

Handrailing shall be provided on roofs locally for safety where maintenance work has to be carried out.

10.11.23 Access Ladders

Ladders are to be provided so that access is obtainable from ground level to all parts of roofs.

The whole is to be constructed in mild steel to be galvanised and painted after fabrication. Ladders sections may be joined with galvanised steel bolts. The ladders shall be secured to steel work or reinforced concrete work in the main structure or as approved by the Engineer, and the foot of each ladder will normally be required to bed properly on a prepared foundation unless the wall fixing brackets are designed to cater for all possible loading.

10.11.24 Ground Moisture Insulation

All horizontal and vertical water proofing for walls and membranes for floors to seal against ground moisture are to be laid without gaps and so joined that moisture shall not penetrate by capillary action.

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CONTENTS

10.12 Drinking Water Supply System

10.12.1 Scope

This specification covers the requirement in respect of materials, workmanship, and quality for water supply system for drinking water purposes for the maximum demand for human needs.

The water supply system required includes, but is not limited to all pipelines, branch lines, valve pits, inspection chambers, home connections and all necessary associated work not specifically mentioned.

The Contractor has to verify the design, a detailed tabulation of the demand of each installed consumer and the personnel for operation, maintenance and repair, which shall form the basis for the diameters chosen, for approval by the purchaser.

Related work described elsewhere is :

Earthwork - Subsection 10.5
Concrete Works - Subsection 10.6

10.12.2 Codes and Standards

Unless specifically noted otherwise all relevant Americanh Standards, in their latest editions, local regulations shall govern in respect of design, workmanship, quality, properties of materials and methods of testing.

10.12.3 Quality Assurance

The quality shall comply with, but not limited to the requirement of applicable codes and standards.

10.12.4 Qualifications of Installers

A number of competent supervisors as required in the execution of this portion of the work shall be employed by the contractor to ensure proper and adequate installation throughout the work.

10.12.5 Submittals

The Contractor shall submit for review and approval a list of the names of all manufacturers of equipment and materials proposed for the work, and work programme including method of installation of drinking water supply system.

All materials and equipment shall be a standard catalogue product of established, reputed and locally accepted manufacturers.

The Contractor shall furnish samples of materials to the Owner if requested.

10.12.6 Material Handling

The Contractor shall adapt all steps necessary to protect the work and materials of this work before, during and after installation.

The Contractor shall ensure that the Pipe lengths during transportation and off-loading shall not be thrown haphazardly or dropped violently in the absence of adequate man or machine power. Transportation shall also be arranged in a way such that ends of the tubing shall not get damaged by dragging along the ground. The pipe supporting surfaces of site vehicles used for handling shall have no sharp projections and shall provide maximum uniform support for the pipe lengths.

Pipes shall not overhang a transporting vehicle by more than 1 metre and shall be firmly secured during transit.

Handling shall be carried out using only rope or web slings.

Under no circumstances shall pipes be lifted by means of slings, chains or other lifting devices passed through or into the bore of the pipes, and at no time during storage, handling or laying shall pipes be allowed to rest on their ends.

Pipes shall be stacked on a flat surface previously cleared or debris with side supports having a minimum bearing width of 7.5 cm placed at maximum intervals of 1.5 m centres. Pipes shall be supported either continuously along their length or on transverse bearers of 7.5 cm width or widely spaced at maximum intervals or 1 m centres.

Pipes of different size type and thickness shall be separately stacked, but if this is not practicable then the larger diameters and / or thick walled pipes shall be stacked at the bottom of the stack.

The bottom layer of sockets shall be prevented from making direct contact with the ground either by shallow excavation under the socket area or by the use of transverse support as detailed previously.

Succeeding pipe layers shall have sockets protruding at alternate ends of the stack so that the pipe barrels are evenly supported by one another along their entire length.

Pipe stacks in no case shall exceed seven layers or 2 m in height whichever is the greater.

The Contractor shall also provide necessary sunshades to protect pipes being exposed to sun where pipes are to be stored for longer periods (more than two days).

Valves, hydrants and fittings shall be stored tidily in a location clear of mud and free from risk of accidental damage from vehicles or Plant.

The Contractor shall take special steps to protect the internal lining and protective wrappings of the pipework, valves and fittings. Any damage occurring to the wrappings or lining shall be made good to the satisfaction of the Owner at his expense before installation of valves and fittings.

In the event of damage, the contractor shall carry out immediately, all repairs and replacements necessary at no additional cost to the Owner.

10.12.7 Materials

10.12.7.1 Pipes of nominal bore 80 mm and above

The pipes shall be of ductile iron. Pipes and fittings shall be coated internally with a mixture of sulphate resisting Portland cement and sand. The outside sleeving shall be polyethylene film of tubular (lay-flat) form. The film shall have a nominal density of not less than 915 Kg/m and not greater than 930 Kg/m. The film shall have a melt flow index of not more than 2.5 g/10 minutes. The film shall be free of pinholes, and substantially free from gels, undispersed raw materials and particles of foreign matter.

10.12.7.2 Pipes of nominal bore 65 mm and below

The material of this pipe shall be GI. Pipes shall be supplied to site in standard 6 metre or 9 metre lengths and shall be marked at 1 metre intervals in the Appropriate colour coding, the nominal size and pressure classification.

10.12.8 Joints

10.12.8.1 Ductile iron pipework

Jointings of piping work shall be by spigot and socket methods using flexible rubber compression seal of approved make. The joint shall be capable of withstanding 4 degree reflection in any direction together with thermal axial movement and shall be capable of withstanding a 30 bar hydraulic pressure.

10.12.8.2 UPVC Pipework

Jointing of the pipe work shall be done by the spigot and socket or coupling methods, confirming to Codes. In each case the joints shall incorporate a triple compression rubber seal, which shall be seated and locked into position during manufacture. Each joint shall be selected suitable for the working pressure stated for that class of pipe listed under the preceding clauses.

10.12.9 Fittings

Dimensional requirements for flanges and bolting, valves shall be in accordance with Code. Joint rings for flanged joints shall be insertion rings 3 mm thick in accordance with Code.

Bolts, nuts and washers for flanged joints shall comply with Code. The bolts, nuts and washers shall be of the correct diameter and length for the flanges concerned. Washers shall be used under every nut.

10.12.10 Insulating gaskets, bolt sleeves and washers

Insulating gaskets, bolt sleeves and washers shall be supplied and fitted to flanged joints on ductile iron pipework where ever necessary. Insulating bolt sleeves shall be of insulating sleeves or similar of the correct length, diameter and thickness for use with ductile iron flanges bolting confirming to Code. Insulating washers for bolts shall be phenolic laminate material and shall cater for any bolting system. Insulating washers shall be backed with suitable steel washers, cadmium plated.

10.12.11 Isolating valves

Isolation valves shall be supplied and installed in valve pits in the positions as required. The valves in pipes of 5 cm NB and over shall be of the cast iron sluice type with non-rising stem, inside screw with bronze. Suitable for the working and test pressure of the system.

Valves in pipes of 4 cm nb and below shall be of the bronze gate valve type, lock shield pattern in accordance with Code. The valve construction shall be of bronze throughout with solid wedge disc and integral seats. Valves shall have non-rising stems with bonnets and sealed with graphited asbestos packing. Valves shall be designed for working and test pressures of the system.

Isolating valves installed in below ground applications shall be installed in valve pits. Each valve shall be supported individually to ensure no weights transferred to the distribution mains.

10.12.11.1 Check Valves

Check valves shall be supplied and installed in the positions as required. The valves shall be of cast iron constructions, swing pattern, with bronze trim and nitrile rubber disc. Valves shall be coated internally and externally with bitumastic paint.

10.12.11.2 Air-relief Valves

Air relief valves shall be designed on the kinetic principle suitable for operation at the working pressure and temperature of the system & shall confirm to Code.

10.12.12 Execution

10.12.12.1 Installation

Pipework shall be installed generally in accordance with Code

10.12.12.2 Lining of ductile iron pipes

The pipe bore before lining shall be free from loose foreign matter and substantially uniform. Pipes and fittings shall be lined suitably at the manufacturers work place. Pipes shall be lined by centrifugal means and fittings shall be lined by a process which produces liners having a surface finish, comparable with that of pipes.

The process of applying the concrete shall be so controlled that continuous layer of concrete is produced over the pipe bore, with minimal sand segregation and a surface substantially free from laitance. The socket shall be free from concrete and excessive amounts of seal coat.

Curing shall be conducted in such a manner as to produce a properly hydrated concrete lining that is hard and durable. It may be effected by the application of a bituminous seal coat applied to the lining by spraying or brushing, at the manufacturers option, whilst the lining is still moist. Alternatively where a seal coat is not applied, curing shall be carried out under controlled conditions.

The means thickness of linings shall be 5 mm for pipes and 6.5 mm for fittings. Maximum negative tolerance is 1.5 mm. For testing thicknesses by "spear measurement", the lining shall be pierced using a hardened steel point not larger than 1.5 mm diameter immediately after the lining has been placed in the pipe or fitting and before the concrete has set.

The lining shall be substantially smooth. Fine crazing that occurs on cement rich surface is permitted. The seal coat shall adhere to the lining at all points and shall form a continuous covering over the whole area of the lining. After seal coat has dried for at least 48 hours, it should not impart colour, taste or odour to potable water.

For identification purposes, the socket end of the barrel of seal coated concrete lined pipes shall be stencilled "CONCRETE LINED". In addition the ductile iron pipework and fittings shall be coated externally with a black bitumen coating solution at the manufacturer's work complying with the requirements of Code. In addition the ductile iron pipework and fittings shall be further protected externally by polyethylene sleeving.

10.12.13 Laying of Pipes

All tubes shall be of uniform thickness within the manufacturing tolerances as stated in the Code and shall have a concentric bore throughout. The supplier shall ensure that all tubes are free from internal obstructions. All cases where prefabricated pipework is used this shall be water tested at the works.

All pipework shall be installed with a continuous gradient to facilitate air venting and drainage. Levels to be approved by the purchaser on site. at all high points air relief valves shall be provided and at all deep points drainage valves, all arranged in covered accessible chambers. The Contractor shall take special care to prevent dirt or rubbish entering the open ends of the pipework during storage and erection. Plastic caps shall be used for this purpose. Should any stoppage in the circulation occur after the various systems have been put into operation owing to non-compliance with this clause, the Contractor shall attend and rectify the same at his own expense.

Any pipework which, in the opinion of the Engineer is not in accordance with this section shall be removed and refixed at the expense of the Contractor.

When the trench is ready in all respects pipes shall be brought to the side of the trench. This shall be carefully achieved to preserve the external finish. Each pipe shall be cleared internally of all sand and any foreign matter by the use of long handled brushes.

The external coating and internal lining of all valves and pipework shall be inspected and any defects in the coating or lining shall be made good using materials equal to the original coating or lining. At the end of each days laying and wherever a length of jointed pipeline is to be left for any period the ends shall be closed by means of suitable caps or plugs to keep out all dirt and debris. The caps or plugs shall be of special fitting designed to fit the pipe in use and to stay properly in place.

Bends, junctions and tees shall be installed in the pipeline as necessary and as indicated on the drawings. When used in water mains each bend, whether used singly or together with further bends, junctions and tees shall be anchored.

The pipework shall be arranged so that the cutting of pipes is avoided as far as possible. Such cuts as are unavoidable shall be carried out with approved equipment. Cut ends shall be finished as necessary to suit the joint involved. Branch connections shall be taken from the top of the main. The minimum cover levels of all mains shall be 120 cm unless otherwise specified by the Owner.

10.12.14 Joint assembly

Assembly of joints shall be as follows :

The Contractor shall ensure that the mating areas of the joint are thoroughly clean.The full socket depth shall be assessed by measurement and the spigot marked accordingly. A lubricant supplied by the pipework manufacturer shall be applied to the chamfered spigot and to the triple sealing section of the rubber gasket.

The Contractor shall ensure accurate axial alignment of spigot and socket prior to jointing. The spigot shall then be hand fed into the rubber casket until resistance from the inner sealing section is felt.

The joint shall be completed by applying leverage to the following socket and using a timber block to prevent damage. Alternatively purpose made pipe jointing clamps supplied by the pipework manufacturer could be used in lieu of hand feedage and levering.

Where pipes are cut on site, the Contractor shall ensure that the spigot ends are cut square with a fine toothed saw, and the end shall be rechamfered to half pipe thickness with a coarse file or surform dressing tool before jointing.

Proprietary flanged flexible joints shall be installed and jointed in accordance with the manufacturer's instructions. Approved non-corroding nuts and bolts shall be inserted from the same side of the joints and all bolts shall be lightly tightened before any force is applied to the bolts. Thereafter the bolts shall be tightened evenly all around the flange by stages, diametrically opposed bolts being done up alternatively until all bolts are as tight as possible with the use of a ½ metre long spanner. Flanged joints and flexible couplings shall be protected after completion by wrapping as specified elsewhere.

10.12.15 Protection of Valves and Joints

Valves and flanged joints shall be protected with an approved wrapping tape where in an underground as applicable. The tape shall be rubber based tape or cotton tape impregnated and coated with saturated petroleum hydrocarbons with inert siliceous filler. The cotton or rubber based tape shall be overwrapped with non-woven synthetic fibre tape impregnated plasticised bitumen. The tapes shall be of an approved type. The primers and filler to be used with them shall be in strict accordance with the manufacturer's requirements.

10.12.16 Valve Pits

Valve pits shall be constructed by the Contractor in the positions as required. The Contractor shall include for all materials and excavation of the valve pits. The exact position of each pit shall be as approved by the Owner before commencement of construction.

Cast iron surface boxes, covers and frames shall be set that the top of the cover shall be flush and true to the levels and falls of the footpath, verge carriageways, paved areas or surrounding ground as the case may be. Any adjustment of the cover and frame which may prove necessary due to the subsidence of the surrounding ground shall be carried out by the supplier.

Valve pits for air release valves shall be vented and all covers stamped as follows :

Isolating valves	IVW
Air vents	AVW

10.12.17 Thrust Blocks

Wherever changes of direction, end caps, valves, hydrants, air vents etc. occur concrete thrust blocks shall be provided. These shall be designed by the Contractor and approved by the Engineer.

The Contractor shall carry out the necessary excavation, provide materials and construct anchor blocks. Individual dimensions should be agreed with the purchaser to suit particular circumstances on the site at the time of installation.

The design of the thrust blocks shall be such that the largest possible area of contact between the thrust block and fitting is achieved whilst not allowing the thrust block to encase the fitting. Several layers of heavy duty polyethylene film shall be wrapped around the fitting over the thrust block area prior to concreting to provide freedom of expansion movement and protection from abrasion. The concrete to form thrust blocks shall enclose the pipe by a minimum cover of 150 mm on all sides.

10.12.18 Field Testing of Water Pipes

10.12.18.1 General

The Contractor shall test the pipeline as the work proceeds in lengths agreed with the Engineer to a pressure at the lowest point of each length tested of equivalent 1.5 times working pressure.

Such tests are described hereinafter as "initial" tests. On completion of all pipelaying the Contractor shall also subject each entire length of the pipeline to a final test hereinafter described as the "overall" test. The test medium shall be potable water. The supplier shall make his own arrangements to procure the water for testing and convey it to each section of pipeline.

10.12.18.2 Equipment

The Contractor shall provide all the equipment necessary for carrying out the tests including pumps, test pumps, blank flanges, gauges, tubing etc. The Contractor shall submit his proposal regarding the proposed equipment to be used to the Owner for approval before any equipment is brought to the site.

The gauges the Contractor intends to use for the testing of the mains shall be dead weight tested immediately prior to use and recalibrated as necessary to give accurate registration. A test certificate for each gauge to be used shall be submitted to the Owner prior to its use, upon request.

No pipe testing gauge shall be less than 23 cm in diameter.

10.12.18.3 Procedure

The Contractor shall seal off the ends of the length to be tested by means of plugs, caps, a blank flange attached to a blank spigot or blank flange attached to a flange installed as part of the permanent pipeline. The ends thus sealed off shall be securely strutted against a suitable grillage so that the end thrust when the line is under pressure imposes no longitudinal strain on the pipeline joints.

The pipeline shall be tested in lengths sufficient to utilise building connections as an inlet connection. The supplier shall arrange for connection of test pumps upto to this stopcock, which shall also incorporate a test gauge.

The proposal of filling the mains with water shall be submitted by the Contractor to the Engineer for approval. Special care shall be taken to ensure that all air is displaced from the length being filled.

After the pipeline has been filled with water, the pressure in the line shall be brought upto a pressure of 1.5 times working pressure but the final increase to the specified test pressure shall be achieved by means of a hand operated test pump. The rate of increase of pressure shall not exceed 1 bar per minute.

Wherever the test pressure is reached the stopcock or the test pump connection shall be closed and test length left for a period of four hours or such greater time as is necessary to make a visual inspection of all joints in the test section.

At the end of this period the stopcock shall be opened and water pumped into the line until the test pressure is again reached. When the test pressure is reached, the stopcock on the test pump connection shall be again closed and the test length left for one hour. At the end of this period the stopcock shall be opened and any drop in pressure noted. More water shall then the pumped into the line by means of the hand test pump until the pressure is again equivalent to the specified test pressure. The quantity of water required to achieve this shall be measured and the test shall be considered successful if the quantity does not exceed 0.93 litres per 25 mm diameter per 1000 m length per 1 bar pressure per 24 hours.

When the quantity of water required to restore the test pressure exceed that specified, the Contractor shall locate and repair all leaks to the satisfaction of the owner.

The Contractor shall repeat the test procedure until such time as the portion of pipe under test has been passed as satisfactory by the purchaser.

Wherever the Contractor shall be responsible for pumping water from the pipeline to waste he shall make all necessary arrangements and shall ensure that the discharge of water into drains or waterways causes no flooding, erosion or other damage or nuisance. Wherever possible the water shall be conserved by pumping it from one test length to the next.

10.12.18.4 Backfilling and completion of testing

Before any test pressure is applied to buried pipework the length to be tested shall be backfilled and carefully consolidated as specified to the full height of the trench leaving a minimum opening over each joint to facilitate detection of leaks. On no account shall the openings left over the joints be increased beyond the minimum necessary. After successful testing the backfilling over the pipe joints shall be completed in the manner specified for the pipe.

In order to reduce to a minimum the period during which trenches are left incompletely backfilled, each length shall be tested immediately the pipelaying is completed.

10.12.18.5 Overall tests

On completion of the pipeline each complete pipeline shall be subjected to a test over the entire length, the test pressure being 1.5 times working pressure as before at the lowest point and the procedure being as previously specified.

The purpose of the overall test is to test those portions of pipeline between the lengths tested as pipe laying proceeds. The restrictions on backfilling referred to above shall not apply to lengths awaiting the overall test provided that they have successfully passed the initial test.

10.12.18.6 Submittals for Swabbing

The Contractor shall submit his detailed proposals for carrying out the testing to the Owner for approval not less than seven days before the date on which he proposes to begin testing.

The Contractor's proposals shall comply with all requirements of this specification and shall in addition give details of his proposals for obtaining water and for transferred works and any other relevant information.

10.12.18.7 Flushing and sterilising of water mains

After successful pressure testing of the pipeline the Contractor shall swab the pipeline in sections as agreed with the Owner.

The swabbing shall be carried out using treated potable water and a hard polyurethane swab. The sections to be swabbed shall be maintained as long as practicable.

The swab shall be inserted at the upstream end of the section of pipe-line to be swabbed, with the section full of water and all outlets closed.

The upstream side of the swab shall be pressurised and the water shall be discharged from the nearest outlet to the point of insertion of the swab, and as the swab travels nearer to the outlet of next point of discharge shall be opened, the first outlet being shut and so on to the last outlet at the end of the section where the swab shall be recovered. This process shall be repeated until all section of the pipeline have been swabbed.

The Contractor shall ensure that there is water in front as well as behind the swab during the whole process.

Swabs showing signs of wear or contamination shall be replaced at the discretion of the Owner by a new swab at his own expense.

The Contractor shall make his own arrangements to procure the water, for discharging the water, removing the swab from each section and inserting into the next section and the provision of any temporary connections required. He shall also make his own satisfactory arrangements for disposing the water.

After successful swabbing the Contractor shall continue on to flush the main water being admitted at one end and discharged at each junction in succession at the highest flows possible until all sections of the pipeline have been flushed.

The Contractor shall make his own arrangements for the flushing operating for an adequate water supply, and any connection required and the discharge of the water.

When the pipeline has been flushed it shall be drained down and refilled using a mixture consisting of :

6 litres of sodium hypochlorite solution (containing not less than 10 percent of chlorine) per 5000 litres of clean water.

The mixture shall have chlorine residual of not less than 12 ppm. When a chlorine residual has been detached at all permanent outlets the line shall remain full of the mixture for a period of not less than 24 hours. After this period and when repeated sampling at the permanent outlet shows constant residual chlorine at each individual outlet, the pipeline shall be emptied.

The Contractor shall make satisfactory arrangements for disposing of the water.

The Contractor shall provide the sodium hypochlorite and suitable chlorination equipment with all necessary pumps, piping cocks, gauges and other apparatus for injecting the requisite dose of chlorinated water into the pipelines. The equipment used and the method of operation shall be such as to ensure the complete sterilisation of the whole of the pipeline to the approval of the Owner.

10.12.18.8 Bacteriological sampling after sterilisation

Immediately after sterilisation the pipeline shall be flushed through with clean water. It shall then be left full of clean water for 24 hours. At the end of this period, samples shall be taken by the Contractor at intervals along the pipeline as directed by the Owner.

Specially sterilised bottles of one litre capacity shall be used for collecting the samples, one bottle per sample. Each bottle shall be labelled and titled. The label shall show the location and date of the sample.

The bottles containing the samples shall be delivered to the Owner for analysis. Following examination of the samples, the decision of Owner in deciding the suitability of pipeline for service purposes is binding.

If the pipeline not be considered suitable, the Contractor shall carry out further flushing and sterilising until satisfactory samples are obtained. If necessary, the pipeline shall be opened up and source of the contamination traced and removed at no expense to the Owner.

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10.13 Security Fencing and Gates

10.13.1 Scope

This specification covers the requirement of materials workmanship and quality of the work security fencing and gates. The Contractor shall supply and erected the required length of fencing material as per the specifications for temporary fencing, including all necessary straining wires, corner braces, barbed wire topping and the like.

The Contractor shall at his own expense suitable and approved temporary fencing to enclose such areas of the Works to be carried out and all areas of land occupied by the Contractor within the Site as may be necessary to implement his obligations under the Conditions of Contract to the satisfaction of the Engineer.

Temporary fences shall be removed on Completion of the Contract.

The whole Power Station shall be surrounded by perimeter security fencing and gates. The width of the entrance gate shall be at least 6.5 m.

Internal fencing and gates shall also be provided. The general requirements of the internal fences and gates shall be the same as for the perimeter security fencing and gates. However, internal fencing shall be without barbed wire on top.

10.13.2 Codes and Standards

Unless specifically mentioned otherwise American Codes & Standards in their latest editions, local regulations, shall govern in respect of workmanship, quality etc.

10.13.3 Quality Assurance

The Contractor shall comply with, but not limited to the requirement of applicable codes and standards.

10.13.4 Fences

The positions of the fencing and gates are shown in the general layout drawings.

The fences shall be of chain link type and shall be constructed of plastic coated galvanised steel wire and shall be of such manufacture that when any one segment is cut remaining segments within the pattern retain their rigidity.

Overall height of the fencing shall be 2.4 metres above ground level, excluding barbed wire. A further 300 mm depth shall be buried in the ground, but where conditions prevent this, the bottom of the fence shall be fixed down with staples to a continuous concrete sill, or to rocky ground.

All mesh shall be of plastic coated galvanised steel wire. Line wires shall be of plastic coated galvanised steel wire of the same gauge to adequately support the mesh rigidly. Line wires shall be provided at the top and bottom of the mesh and at two evenly spaced intermediate levels. The line wires shall be attached to the concrete supporting posts. The top wire shall be doubled, making five line wires in all. Mesh and line wires shall comply with Code.

Supporting posts and struts shall be of reinforced concrete to the same approved standard as above, unless otherwise approved by the Engineer. The posts shall be set in concrete in the ground. The posts shall have cranked tops set at 45° to the posts, to which shall be attached three strands of galvanised barbed wire. Droppers shall be fitted at the centre of each bay of fencing, to prevent the wires being bunched together. Intermediate posts shall be provided at centres not exceeding 3 metres. Corner posts and struts shall be provided at all changes in direction.

10.13.5 Gates

Gates shall comply with Code and shall be constructed of plastic coated galvanised chain link mesh on a plastic coated galvanised RHS or tubular steel frame, with three strands of barbed wire across the top on cranked galvanised extension arms.

The gates shall be fitted with a vertical drop bolt on each leaf, a sliding bar lock with padlock eyes and a padlock to prevent movement of the sliding bar lock. All these fittings shall be galvanised and plastic coated. The vertical drop bolts shall drop into galvanised steel tubes cast into the road, to secure the gates when in both closed and open positions.

Gate posts shall be made of plastic coated galvanised RHS section and set in concrete in the ground. Gate hinges (pivots) shall be heavily galvanised and plastic coated.

10.13.6 Extension Arms

Extension arms on the gates, for supporting three strands of barbed wire, shall be made of plastic coated galvanised steel of approved section and firmly fixed to the top of each gate leaf, with the cranked tops at 45 degrees outwards from the posts.

10.13.7 Galvanised barbed wire

Galvanised barbed wire shall conform to Code.

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10.14 Sanitary Sewerage System

10.14.1 Scope

This specification covers the requirement in respect of materials, workmanship and quality for drainage works required for the power station and solar fields. The scope shall include separate drainage system for sewage water to be installed inside the non plant buildings or any other buildings where ever sanitary installations are required including all necessary accessories such as gutters, pipe work, gullies, traps, catchpits, manholes. The contractor shall submit samples of sanitary fittings and equipments to the engineer for approval.

10.14.2 Codes and standards

Unless specifically mentioned otherwise American codes and standards in their latest editions and local regulations shall govern in respect of workmanship quality, properties of materials and testing.

10.14.3 Sewage System

The sewage system is designed for the sanitary sewage water (i.e. all run off from toilets, showers, kitchens, etc.).

The sewage water shall be drained by pipes to the septic tank.

10.14.3.1 Sanitary Sewage and Water Drainage

The arrangement of the sewers shall be dictated by the levels of the buildings to be connected. The gradients of the sewers shall correspond to the most favourable hydraulic conditions.

The basis used for determining the sewage quantities is min. 350 l/person and day.

Manholes shall be provided at all inlets, changes in direction and at points where the sewers cross, as well as approximately every 50 m along straight sections. Between manholes, the sewer must run in a straight line.

Allowance must be made for the other services in the roadway such as cable routes and building works.

The following limit values shall be observed:

- Flow speed: V_{min} = 0.4 m/s;
  V_{max} = 1.1 to 1.3 m/s;
- Filling level: h_{min} = 3 cm;
- Drag force for stoneware pipes: S_{min} = 0.25 kg/m^2.

The most favourable slope shall be fixed for a mean flow velocity of approximately 0.8 m/s.

- Pipe material : vitrified clay

If terminal manholes are equipped with automatic drain flushes, the flushing capacity shall be related to the pipe diameter. This flushing capacity must be at least 25 l/s to prevent the deposit of sewage. Flushing manholes shall not be located inside the paved areas of the roads.

The sewage water shall be discharged by pipes to the septic tank.

The septic tank shall be constructed in an agreed position at least 20 metres from any building. The design shall be to American standards and approved by the Owner's Engineer. The tank shall have separate fresh air inlet and outlet pipes and be provided with access openings. The effluent from the tank shall discharge, depending on the type of subsoil and location, into aerobic treatment plant. The treated water along with treated effluents from the plant is discharged into a common solar evaporation pond of RCC construction, capable of drying all the effluents.

In impermeable types of soil, where a soakaway will not function efficiently, either evaportranspiration beds or an upflow filter shall be provided for effluent disposal from the tank.

10.14.4 Sanitary Installation

10.14.4.1 Materials

Items of equipment made of grey cast iron shall be enamelled internally and asphalted or painted externally. Enamel shall be applied in at least two layers and stoved in the same number of operations. Enamelled acid-resisting items shall be protected with yellow tile ename. Low grade ceramic (cheapest grade of ceramic material, porous, containing clays, kaolin-earth, quartz and felspar with small additions of flux, fired in a single operation and with waterproof glaze; has medium strength and tends to form hair cracks) is not permitted.

Sanitary porcelain ware shall be porcelain, which has been fired to the sintering limit, is completely free of cracks and has a white or coloured glaze.

Fireclay shall be ceramic product made from clay and chamotte with walls 20 to 40 mm thick. It is coated with a thick white or coloured englobe and covered with a white or clear acid-resistant glazing.

Earthenware shall be fired from a fire-resistant, very early sintering clay and chamotte or sand. Clay body and glazing obtained by sprinkling ordinary salt during firing are completely acid- and temperature-resistant.

Plastic materials (thermoplastics) are not acceptable.

10.14.4.2 Equipment

The sanitary equipment shall of corrosion-resistant materials and shall be easy to clean.

10.14.4.3 Pedestal-type WC

This type of WC shall consist of a glazed vitreous china closet with 'S' or 'P' trap, seat lugs, solid plastic seat with seat cover, hinges, buffers and necessary flushing facilities. A toilet roll holder shall be provided. Flushing facilities shall be capable of delivering a minimum of eight litres of water per flush, in not more than six seconds.

10.14.4.4 Urinals

Urinals shall consist of a glazed vitreous china well-type urinal with flushing rim, complete with flushing facilities and trap. Where urinals are installed in multiple units, each unit shall be separated by partitions. Flushing facilities shall be capable of discharging five litres of water per flush per urinal.

For multiple units of urinals automatic flushing facilities may be provided, maintaining the above capacity.

10.14.4.5 Hand-wash Basins

Material shall be glazed vitreous china. Basins shall be provided with chromium-plated, easy-clean, screw-down type pillar taps or, if hot water is also provided, mixing valves shall be installed. Wastewater shall be led through a sealed trap to the waste water system. An overflow slot and a device for retaining the water in the basin shall be provided, e.g. rubber plug and chain. Each hand wash basin shall be provided with a mirror.

10.14.4.6 Sinks

Material shall be vitreous glazed fire clay, or, if with draining boards, stainless steel. Chromium-plated bib taps for cold water shall be installed. Where hot water facilities are provided, a chromium-plated mixing valve with swivel spout shall be installed. Wastewater fittings shall be as specified for hand-wash basins. The sink in the cleaners' cupboard shall be provided with a chromium-plated bucket grating with hinges. Taps shall be installed at such a height as to facilitate easy filling of buckets.

10.14.4.7 Wash Troughs

These shall be made of stainless steel and shall be provided with chromium-plated mixing valves. Mirrors shall be provided, one set for every two mixing valves. Wastewater fittings shall be as for hand-wash basins.

10.14.4.8 Showers

Shower basins shall be recessed in the floor, made of stainless steel and be provided with a seal trap connected to the sanitary sewage water drainage system. The shower rose shall be connected to a hot and cold water-mixing valve. Each shower shall be provided with a seat and a recessed soap holder.

10.14.4.9 Emergency Showers and Eye-baths

Emergency showers and eye-baths shall be provided in laboratories, battery rooms and in other areas where people can come into contact with dangerous products. For connection of these showers, the instructions of the manufacturer shall be followed.

10.14.4.10 Changing Facilities

The equipment shall be sufficiently protected against corrosion or shall be made of non-rusting metals in view of the fact that it shall be used in humid and wet areas.

10.14.4.11 Changing Lockers

The lockers shall be in the form of single or double row steel cupboards. Inside there shall be a hat shelf, a hanging rail and additional clothes hooks. The dimensions shall be 0.60 m wide, 1.60 m high and 0.50 m deep. The lockers must stand on feet about 0.40 m high and shall have ventilation openings at the bottom. The air outlet at the top is connected to an outlet duct. This shall be made of the same material as the lockers and must lead to the open air. Benches 0.30 m wide made of non-splintering hot-water-resistant hardwood

slabs shall be provided in front of the lockers. The lock installation with cylinder safety locks shall be in the form of a general master-key installation. The keys shall have metal tags bearing the same number as the number embossed on the corresponding locker.

10.14.4.12 Cloakrooms at Showers

The cloakrooms shall be provided with two non-rusting double cloakroom hooks and a hot-water-resistant easy-clean bench. A spray water shield panel of suitable width shall be provided between the hooks and the shower. There shall be a non-slip duckboard on the floor.

10.14.5 Partitions

Partitions shall be made of panels coated on both sides with plastic, with plastic coated frames all round. Ground clearance 50 cm. Height 2.20 m above floor. Shower cabin walls shall be of non-translucent plastic up to the shower cup. Hygienic requirements shall be taken into account.

10.14.6 Floor Inlets

Floor inlets shall have a drain trap and a cleaning opening. They shall be enamelled on the inside. Where installed in a cellar they shall have means of preventing reverse flow and a dirt trap. The inlet sieves shall be of cast iron, stainless steel or enamelled, depending on application.

Floor inlets in toilet installations shall be made with a bell trap. Acid-resistant inlets shall be of plastic or high-grade steel.

10.14.7 Water

The water supplied by the drinking fountains inside and outside the buildings shall be cooled to a temperature adjustable down to 10°C. It shall be set to 14°C.

10.14.8 Domestic Refuse Bins

The domestic refuse bins shall be made of galvanised steel with a tight-fitting lid and with locking by means of the carrying handle.

10.14.9 Medical Equipment

Medical equipment shall be of materials which are entirely satisfactory as regards hygienic maintenance and which meet the high health standards required. The highest technical and medical standards shall be applied.

10.14.10 Kitchens

In the design of the kitchen equipment special attention shall be given to ease of upkeep and to hygiene requirements. All connections shall be sealed with suitable sealing strips. Work surfaces and preparation areas shall be heatproof. Non-rigid plastics extrusions shall be fitted to all floor edges and vertical struts. Cupboards and drawers must close dust-tight and silently and shall be capable of being withdrawn to the full extent. (Telescopic rails).

The equipment shall consist of:
low level and high level cabinets, tall cabinet for cleaning materials, refrigerator, electric cooker, oven, sink with waste disintegrator unit and extractor hood.

10.14.10.1 Cabinets

The low level cabinets shall be about 60 cm deep and have a well inset dark-coloured plinth. The low-level cabinets shall be divided into units approx. 60 cm wide and fitted with hinged doors with conveniently shaped metal rails as pulls. Above the doors with magnetic catches are drawers similarly provided with metal rails as pulls. The opening direction of the doors shall be clearly identified. The door hinges shall be designed for subsequent door alignment.

The low level cabinet under the sink shall be provided with a compartment for the chrome-plated waste bin which shall also open when the door is opened, also a divided compartment for pans and on top of this a drawer with cutlery tray.

Corner cabinets are to have a turntable with two decks. The cabinet below the built-in hotplate unit shall contain an adjustable shelf and a drawer in the plinth. The controls shall be mounted on the front.

The high level cabinets shall be about 35 cm deep and match the low-level cabinets. The tall broom cupboard shall have suitable fittings and, like the storage cupboard with shelves and baskets, is to fit into the general scheme of the equipment.

Store cupboards shall have a ventilation opening at the bottom and a ventilation opening at the top with an outlet connection.

10.14.10.2 Refrigerator

The refrigerator with a capacity to be approved by the Engineer shall be built in with its base level with the preparation surface. The front of the refrigerator is to match the scheme as a whole.

10.14.10.3 Oven

The oven and grill compartment shall be closed by tinted glass door or flaps. The top and bottom heating elements shall be separately controllable. An electric clock with timer shall be built into the operating panel.

10.14.10.4 Sink

The stainless steel sink with either one or two bowls (according to kitchen size) and drainer shall be fitted with a waste disintegrator unit.

10.14.10.5 Extractor hood

Above the four-hotplate unit, which includes a high-speed hotplate, an extractor hood with activated charcoal filter shall be fired and the hood shall discharge externally and be fitted with a low-noise three-speed fan. Above the working surface a fluorescent lamp rated at about 60 W with a screen shall be fitted below the wall cupboard.

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10.15 Drainage System

10.15.1 Scope

This specification covers the requirement in respect of materials, workmanship and quality for drainage works required for the power station and solar fields. The scope shall include separate drainage system for storm water and sewage water to be installed including all necessary accessories such as gutters, pipe work, gullies, traps, catchpits, manholes.

10.15.2 Codes and standards

Unless specifically mentioned otherwise American codes and standards in their latest editions and local regulations shall govern in respect of workmanship quality, properties of materials and testing.

10.15.3 Drainage system

All drainage system shall be designed with a objective of draining water by gravity along a shortest possible route pumping stations shall be provided wherever possible. If pumping stations cannot be provided alternatively pumps shall be provided with stand by pumps of 100% capacity pumps shall be submersible type, resistant to chemical attack and provided with automatic level switches, provisions shall be made to ensure functioning even after a long dry period.

10.15.3.1 Storm water drainage

The arrangement of the storm water pipes and channels is dictated by the levels of the area to be drained as well as by the road levels. The gradients of the pipes shall correspond to the most favourable hydraulic conditions, varying between 1 : 200 and 1 : 500. The number of runs and outfalls and the pipe sizings shall be sufficient to cope with the severest precipitation, with a factor of safety of 1.2.

Embankments and cuttings shall have drainage facilities at their top or bottom. Provision shall be made for the disposal of surface water from roads and hardstandings. Surface water from roofs of buildings shall be drained to downpipes which connect with the site drainage system.

In principle following types of drains shall be provided:

- Drainage of stone paved areas;
- Drainage for roads and hardstandings;
- Collecting channels.
- Ditches.

All drains shall be provided with adequate sand and sediment traps.

10.15.3.2 Drainage of Stone Paved Areas

The stone paved areas shall be drained by perforated pipes bedded below the stone chipping. These pipes shall be placed with a gradient of 0.3% in a diameter of 150 to 300 mm depending on the area to be drained. The perforated drain pipes shall be surrounded by adequate filter material.

10.15.3.3 Power plant drainage system

One independent and complete drainage system for waste water originating from operation maintenance and accidental release from the power plant and related equipment shall be constructed. The water shall be collected underground and suitably drained. The contractor shall submit a detailed report including hydraulic calculations and drain sizing and layout for the design discharge for approval by owner before commencement of work. The ground floor of turbine/control building shall be provided with floor taps in order to collect normal and accidental drain water and finally discharging the same into the drainage system.

10.15.3.4 Industrial Waste Water Drainage

Solid materials, light mineral liquids, water containing acid and alkaline waste shall not be drained without adequate treatment to the sewage system.

For this reason, sand and sediment traps, separators and neutralisation pits shall be placed at the appropriate points of occurrence and these shall be easily accessible as well as simple to maintain and to empty.

All parts of the separators shall consist of a durable material. Separators made of concrete must be impervious to water. The inner faces of all separators shall be given a protective coating and/or protective tiles against all relevant fluids.

No sediment must accumulate at the bottom of the separators. It will therefore be necessary to arrange adequately dimensioned sediment traps upstream of the separators. An odour seal shall be arranged on the input side of the oil separator. The size of the oil separator to be used depends on the amount of fluid waste.

10.15.3.5 Drainage of Roads and Hardstandings

The area around roads and hardstandings shall be drained by drainage pipes.

The cross section shape of drains shall be determined the most favourable possible hydraulic qualities so as to discharge the drain water in a proper manner.

The following limit values shall be considered :

- Flow speed for pipes and channels : V_{min} = 0.75 m/s;
  V_{max} = 2.5 to 3.0 m/s;
- Drag force for concrete pipes : S_{min} = 0.35 kg/m^2.

The most favourable slope shall be fixed for a mean flow velocity of approximately 0.8 m/s.

- Pipe material : concrete
- Street gullies : approx. every 30 m but at least one for every 400 m^2 of paved area

10.15.3.6 Collecting Channels and Ditches

The whole Power Station areas shall be surrounded by precast reinforced concrete channels which collect the rainwater from the above-mentioned pipes. Where possible the channels shall remain uncovered. Where this is not possible (e.g. road areas or depths greater than 1.00 m) the channels shall be covered by adequate precast concrete covers

which shall be placed only after the base units have been laid and approved by the Engineer.

The collecting channels and ditches shall carry the water by the shortest route outside the Power Station compounds to an area approved by the Engineer.

10.15.4 Pipework

The Contractor shall construct pipelines, drains, and the like to the lines and levels required. He shall provide the materials in accordance with the specification given below. The types of pipes proposed for each drainage systems shall be approved by the Engineer. All pipework shall be installed strictly in accordance with the manufacturer's instructions.

Pipework passing through floor slabs and fire walls shall have an approved proprietary fire protection 'collar' fitted.

10.15.4.1 Steel Pipes (Associated with Civil Works)

Steel pipes shall comply with an appropriate National Standard approved by the Engineer. Pipes shall be welded or lap-welded as specified. Welded pipes shall be made from not more than two plates with two longitudinal welds and no circumferential welds will be permitted except for large diameter pipes, built-up bends and flanges. Each pipe barrel when welded up shall be truly cylindrical and circular in cross section and shall comply with the tolerances laid down in the Standards mentioned above. Unless directed otherwise, internal coatings and linings for steel cast iron pipes and special shall comply in all respects with the requirements of the appropriate National Standard.

Mild steel pipes, bends and Tees manufactured for installation in the drinking water main shall generally be flanged except where joined to fibre cement pipes when the ends shall be built-up as necessary. The lining of the pipework shall be in every way suitably for carrying potable water.

Steel pipes shall be coated with epoxy fusion bonded by immersion in fluidised bed of epoxy powder and suitably wrapped. The contractor shall protect coatings, coverings and linings during and after erection to minimise such damage from whatever cause.

10.15.4.2 Concrete Pipes

Concrete pipes are to be made by an approved manufacturer using sulphate resisting cement. The pipes and specials shall comply with Code.

High alumina cement shall not be used in the manufacturer of the concrete pipes. The ends of concrete pipes shall be truly square to the centre line. Any bituminous painting which may be specified shall be kept from contaminating the contact surfaces of rubber rings where these are used. If the pipes are to be rigidly jointed they shall be laid on the sound undisturbed bottom of a trench on rigid pedestals or on a continuous bed of concrete with suitable depressions prepared for the joints, according to the design. Unless otherwise specified, the joints shall be made with 2 : 1 sand - cement mortar. Whether it is a spigot and socket joint or ogee joint, the mortar shall be packed from outside against a seal of tarred rope or yarn, and the inside of the pipe shall be left clean of mortar; in large pipes the inside of the joint shall be pointed flush. The ends of the pipes shall be wetted before the mortar is packed into the joint.

Concrete pipes are to be flexibly jointed shall, unless otherwise specified, be firmly laid on a bed of compacted granular spoil which shall be free from all stones larger than 25 mm and in which depressions shall be hollowed out to receive the sockets and allow the proper execution of the joints, unless some other patent joint is specified or permitted. The joint shall be made with rubber to produce a watertight joint.

10.15.4.3 Pit Fibre Pipes

Pitch fibre pipes used in the works are to comply with and to be laid in accordance with the requirements of Code and they shall be obtained from approved manufacturers.

10.15.4.4 Vitrified Clay Pipes

Vitrified clay pipes shall be used for oil / water system drainage and shall comply with Code. The glazing on the pipes is to be either glass or ceramic and not a salt glaze. The type of joint used on the pipes is to suit the effluent being carried and is to be to the Engineer's approval. Particular attention is to be paid to the packing, handling and transportation of clay pipes to avoid damage.

10.15.4.5 Fibre Cement Pipes

Fibre cement pipes shall comply with Code. Where the use of rubber rings is ordered or approved for jointing they shall also comply with the requirements of Code. Pipes shall be jointed in accordance with the manufacturer's instructions. These pipes may only be used with the express permission of the Engineer in writing.

10.15.4.6 PVC Pipes

PVC pipes shall confirm with Code and shall be laid and jointed in accordance with the manufacturer's instructions. Other types of pipelines, where ordered by the Engineer, shall be laid and jointed in accordance with the manufacture's instructions.

10.15.5 Acid / Alkali Resisting Drain

Drainage from battery rooms, chemical areas and boilers shall be led to neutralisation pits by means of approved acid resisting pipework. Jointing materials appropriate to the various effluents in the pipes must be used. All manholes and structures leading to the neutralisation pits shall be coated with acid / alkali resistant epoxy lining (minimum 5 mm thick).

10.15.6 Testing

All water mains shall be pressure tested to 1.5 times the working pressure; all foul drains shall be tested for water tightness. The contractor shall provide all equipment, anchors and the like necessary for testing and shall carry out all tests to the satisfaction of the Engineer. If any defects are observed the contractor shall carry out rectification at his own expense.

10.15.7 Sterlization

All mains and services to be used for potable water shall be sterlized before being bought into use, in accordance with the appropriate National Code of Practice approved by the Engineer.

10.15.8 Soakaway Pit

Properly designed soak away pit shall be provided with a cover slab of concrete.

10.15.9 Laying and Jointing Pipes

10.15.9.1 General

All piping systems shall be laid to true and even falls and to the lines and levels required. The Contractor shall supply and fix in all pipe runs, all necessary bends, tees, tapers, valves, hydrants and other specials and shall carry out all necessary cutting, coring, drilling holes, jointing and connecting to new and existing work. All joints shall be made in accordance with the manufacturer's instructions and recommendations of Code. Surplus joint material shall be removed from inside and outside pipes where necessary.

10.15.10 Bedding and Surrounding Pipes

Pipes generally, unless bedded on concrete, shall be bedded on a layer or sand 100 mm thick under the barrel of the pipe. Where indicated or ordered, pipes shall be bedded and surrounded with concrete 150 mm thick. Concrete surrounds in the vicinity of joints shall not be placed until the pipes have been tested and approved by the Engineer. Pipe laying shall not comm

10.15.11 Backfilling

Backfilling shall not be commenced until the relevant length of pipe has been approved by the Engineer. Where pipes are not surrounded by concrete, they shall be backfilled with approved sand to a thickness of 100 mm over the pipe barrel and then with approved material which shall exclude sharp or excessively heavy material. Backfill to pipes that are surrounded by concrete shall be of approved material devoid of heavy stones.

All backfill shall be thoroughly compacted in layers to a density appropriate to the material through which the pipeline runs, and all surplus excavated material shall be disposed of as directed.

10.15.12 Manholes Gullies and Valve Pits

Manholes shall be provided at every change of alignment or gradient at the head of all sewers or branches at every junction of two or more sewers and wherever there is a change, in size of sewer.

Manholes and inspection chamber shall be constructed of approved precast concrete sections in accordance with BS or of concrete cast in-situ. Foundations shall be of concrete, the channels being finished smooth in concrete, or by using performed half circle channels, haunched up to the manhole sides in neat cement. All manholes and inspection chambers shall be watertight on completion. Frames for manholes covers shall be set in cement mortar. For depths greater than 1 m, step irons as specified shall be provided, spaced 300 mm alternatively vertically and 250 mm horizontally. Gullies shall be approved precast units of concrete with gratings and frames. Precast manholes and gullies shall be surrounded with atleast 150 mm of concrete brought upto the underside of the frames. All oil / water and sanitary drain systems shall be trapped and sealed at every drain point and manhole.

Surface water road drainage manholes shall be identical to the existing manholes. Valve pits shall be suitably sized to allow removal of valves without the use of special tools. Chemical gullies, pits and manholes from battery rooms and chemical areas are to be coated internally with an approved epoxy resin liner of 5 mm minimum thickness.

10.15.13 Covers, Gully Gratings and Frames

All covers, gratings and frames shall be of Ductile Iron heavy duty. Covers shall all be double sealed and sewage manholes shall additionally incorporate an internal GRP cover seal. Road drainage manholes shall incorporate GRP covers identical to the existing covers.

10.15.14 Step - Irons

Step - irons, shall be galvanised, painted & shall be built into walls of manholes, chambers and pits in a manner approved by the Engineer.

In in-situ concrete works the step-irons shall be built in as work proceeds. In the case of manholes constructed with precast concrete rings step-irons shall be inserted into the rings by the Manufacturer and shall be positioned as required.

10.15.15 Rodding Drainage Pipelines

Provision is to be made for rodding all pipelines. For this purpose manholes for buried pipelines shall be greater than 75 m apart. Pipelines above grounds level shall have access plates on each bend or junction. Each rain water down pipe shall have an access plate 750 mm above ground level.