

SECTION 25 – CIVIL WORKS

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1 GENERAL (SCOPE OF SPECIFICATION)

All civil works are required to be executed on a Turnkey basis in connection with the installation of all buildings, equipment and services.

The works generally comprise site survey, soil investigation, and services as required, design & detailed engineering and complete execution of all works, to complete the Substation works as described in Mechanical, Electrical, and Civil specifications and the scope of work.

The works involved are described in the subsequent sections of this Specification but shall not be limited to these. The Contractor shall be fully responsible for providing all the required works and services necessary for the satisfactory completion and operation of the project.

OETC/Engineer shall mean the Oman Electricity Transmission Company or its nominated representative(s) on site.

2 APPLICABLE STANDARDS

This Civil specification shall be read in conjunction with the General Conditions of Contract, General Requirements, Drawings and other parts of these Tender Documents.

Works shall generally be in accordance with the Sultanate of Oman general construction standards and the main technical standards for the works listed below, but the list is not exhaustive. In the case of any conflict between the technical standards and this specification, this specification will take precedence.

Subject	Standard
Accuracy	BS 5606
Access Ways	BS 5395, BS 4211
Aggregates	BS EN 13043
Aluminium	BS EN 612
Aluminium Doors	BS 1470, BS 1471, BS 1474, DIN 18360
Aluminium Door Frames and Fittings	BS 3987, BS 1470
Concrete	BS 8110, DIN 1048, DIN 4030, BS EN 206-1, BS 8500

Subject	Standard
Concrete Finishes	BS EN 13670
Design Checks	BS 5975
Doors, Frames and Fittings	BS 6510, BS 4787, BS EN 14220, BS EN 14221, BS 1245, BS EN 12209, BS EN 1154, BS EN 1125, BS 179, BS EN 12217, BS EN 13501, BS 476
Drainage	BS EN 752-1, 2, 3 and 4
Drawing Standard	BS 8888
Earthworks	BS 6031
Earth Retaining Structures	BS 8002
Fire Protection	NFPA 850
Floors (Raised Access Floors)	Property Services Agency's 'Performance Specification PF2 PS/SPU', and UK National Building Standard K41.
Formwork	'A Guide to Good Practice' by The Concrete Society 2012.
Foundations	BS 8004
Galvanising	BS EN 1461
Galvanised Steel Pipes	BS 3868
Isolating Membranes	BS 8218
Kerbs	BS EN 1340
Ladders	BS 5395, BS 4211
Loads	BS 6399
Masonry	BS 5628
Oil Separators	BS EN 858
Paint and Painting	BS EN ISO 150, BS 245, BS EN ISO 12944, BS 5493, BS 6150
Plumbing	BS 8558, BS EN 806

Subject	Standard
Pressed Steel	BS EN 1462
PVC-U	BS EN 607, BS EN 1462, BS EN 12200
Quality Systems	ISO 9001
Record Drawings	BS 8888
Reinforcement	BS 8666, BS 4449, BS 4461, BS 4482, BS 4483, DIN 488, BS EN 10080
Rendering & Plastering	BS EN 13914, BS 5262, BS EN 520, BS 8481
Road Markings	BS 1436
Screed	BS 8204
Security Fencing	BS 1722
Setting Out	BS 5964
Signage	BS 12899, BS 5499
Site Investigations	BS 5930
Soils	BS 1377
Structural Steel	BS 5950, BS EN 1090-2
Surveys	BS 5606
Suspended Ceilings	BS EN 13964, BS 476 Parts 6, 7 and 22
Temporary Works	BS 5975
Testing Concrete	BS 1881
Testing Surveying Equipment	BS7334, BS EN ISO 10012
Timber	BS 5268
Water Proofing	BS 8000, ASTMs D 5, D 36, D 146, D 570 & G 53, UEAtc
Water Retaining Concrete	BS 8007
Water Supply	BS 4504, BS 3974, BS 3505, BS EN 1057, BS 5163, BS 5154, BS 1010, BS 5152, BS 5153, BS 750, BS 12 12, BS

Subject	Standard
	2456, BS 2879, BS 1710.

3 CONTRACTOR'S RESPONSIBILITIES

Civil Engineering shall consist of the detailed design, preparation of drawings, construction, completion and correction of any defects to the plant or installation during the Guarantee Period of Warranty as defined in the General Conditions of Contract.

The Tender shall cover all the requirements of the Tender documents and all associated works, whether specifically mentioned or not, which in the opinion of OETC/Engineer are necessary for the satisfactory design, construction, completion, reinstatement and maintenance of the entire Civil works, and for the satisfactory operation of plant and equipment being supplied under the Contract.

No additional costs will be considered for any items which have been overlooked but which are essential in the opinion of OETC/Engineer for the proper completion of the project in every respect.

The Contractor shall be responsible for ascertaining and complying with the local regulations and procedures which may affect the design, construction and completion of the civil works and shall allow for this in his Tender in order to meet the specified completion dates.

All works shall be executed by skilled workers in a workmanlike manner. Prior to the start of execution the Contractor shall verify that all conditions are suitable for the timely and effective carrying out of the work

The Contractor shall ensure that he is fully conversant with the requirements of all memoranda issued by OETC/Engineer pertaining to the execution of the Works and that his Tender covers all the requirements of these memoranda.

All Civil engineering works and associated building services shall be designed and constructed in accordance with the Contract drawings, specifications and design data included in them.

Failure by the Contractor to submit drawings showing his structure sizes and arrangements with his Tender shall be taken to mean that the Tender Price is based on OETC/Engineer's Contract Drawings. Modifications or alterations in structure dimensions and arrangements which are found to be necessary subsequent to the contract award, and any increased costs arising as a result, shall be the sole responsibility of the Contractor.

4 CIVIL SUBCONTRACTORS

The Contractor is required to appoint a Civil/Structural/Architectural design consultant(s) who shall be a subcontractor(s). Appointment of such consultants shall be subject to the prior approval of OETC/Engineer.

When submitting his Tender, the Tenderer shall provide details of the proposed Civil subcontractor(s) he intends to use for the Works, together with a summary of works of a similar nature for which the subcontractor(s) has had full responsibility in Oman, and CVs of key personnel.

The Contractor shall take full responsibility for all actions or inactions by the subcontractors he employs in undertaking the Works.

The Contractor shall comply fully with OETC HSE requirements for Contractors as specified in section 1.13 of the General Requirements specification. The Contractor shall be fully responsible for ensuring that he and all subcontractors fully comply with these requirements.

The Tenderer shall allow in his Tender for the adequate number of his staff to supervise the subcontractor's work.

The Contractor shall insert appropriate provisions in all Subcontracts relative to the Works, to empower himself to fully manage the Civil Subcontractor in all respects.

The Civil subcontractor shall be Omani and on the current OETC Approved List of Civil Contractors.

The subcontractor shall demonstrate that he has relevant and sufficient experience in the field as required, should be registered with concerned Authorities such as Tender Board, OETC etc., and should have sufficient number of qualified Engineers, supervisors, and technicians for design, supply, installation, commissioning, testing, and maintenance to the satisfaction of

the OETC/Engineer.

The Contractor shall propose three specialist subcontractors with adequate staff/infrastructure for OETC selection.

The Contractor shall submit details of a subcontractor, for approval, for each of the specialised works, and provide the following information,

- The company's name and other details
- Details of work executed
- Certificates from relevant authorities
- List of makes of major items to be used
- Project organisational chart
- C.V. of all field and office personnel assigned for the project.
- Project Quality Plan.
- A confirmation statement from the proposed subcontractor that they have read and understood the specification, drawings and other contract details and have no queries.

Contractor shall nominate a coordination Engineer to coordinate between Contractor and all their Sub-Contractors. Both the Contractor and the subcontractor(s) (nominated or otherwise) shall be responsible for the contract. Where mentioned here after either Contractor or subcontractor(s) shall mean both Contractor and relevant subcontractor(s) (nominated or otherwise).

5 SCOPE AND NATURE OF THE WORK

The Civil Engineering works and associated building services and Architectural design comprise the design, preparation of working drawings, provision of all plant, labour and materials and the construction and maintenance of the new substations.

Construction of buildings for various switchgears, control and relay buildings, basement, compound walls, approach roads, guard room, necessary modifications in various existing substations, steel gates, necessary modifications to complete the overall cable termination works in existing substation and all related Civil works etc., and all site development with associated services are to be constructed.

Reference should be made to the integrated security system in section 24 and the indicative

Civil drawings included in Annex 3 of this Specification, the information provided here shall form a reference for the general requirements for the Works. Indicative site layout drawings including civil features are:

- a) 400/220/33 kV General Layout drawing
- b) Typical Section Through 400 kV OHL Gantry and Switchgear Room
- c) 220 kV Building Sections
- d) 33 kV Building Sections
- e) 132/33 kV Substation Ground Floor Plan 2 Storey Example in Limited Plot Size
- f) 132/33 kV Substation First Floor Plan 2 Storey Example in Limited Plot Size
- g) 132/33 kV Substation Sections

The Contractor shall be responsible for the Civil/Building/Structural design and construction of a fully operational substation, which shall include but not be limited to the following:

- Site surveys and soils investigation work,
- Collection and accuracy of all data and information required for detailed design and construction, including liaising and coordination with the various third parties Government Departments in locating obstructions and connecting into existing cables, drains, water mains and other services
- Identifying the relevant Authorities, determining their requirements and complying with those requirements
- Testing of soils, water and materials to be used
- Complete civil design of substation, based on site investigations, flood risk assessment, and requirements of the Royal Oman Police (ROP), Municipality and other appropriate Authorities
- Earthworks, grading and landscaping
- Soil chemical treatments etc
- Earth cutting/filling to achieve the finished levels.
- Site surfacing within boundary wall
- Basement constructions as per requirements of Royal Omani Police (ROP) and other appropriate Authorities
- Switchgear rooms according to scope of works
- Control / relay buildings

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- Switchgear and control / relay buildings according to scope of works
 - Access roads
 - Road works within substation including maintenance road for HVAC units.
 - Permanent access road to substation from public road
 - Foul and storm water drainage system and connection to holding tank and soakaway system or to trunk sewer and drainage system
 - All necessary HV / EHV cable road crossing ducts and troughs for proposed and future cables within substation and ducts below boundary wall
 - Cable trough construction within boundary wall
 - Future HV/EHV cable entry ducts below boundary wall
 - Adequate number of built in pipes in basement wall for proposed and future HV / EHV cable entry
 - All necessary ducts for future cables
 - Permanent water supply to buildings
 - Storage water tank at ground and roof levels, pumps, including standby.
 - Boundary wall and galvanized steel gates, as specified, all with an OETC/Engineer approved electric pulse fence above.
 - Wall foundation and anti-burrow beam.
 - Plant support structures
 - Foundations
 - Cable ways, troughs and ducts
 - Site lighting system, including security lighting
 - Small power and lighting installations
 - Air-conditioning systems
 - Construction of fire water tank and pump house, etc.
 - Fire detection, alarm and protection installations in buildings
 - Transformer compounds and all associated works and features, including oil containment and fire fighting
 - Sun shades for main transformers to protect from direct sun
 - Necessary modification works and reinstatement of existing substations
 - Temporary works

- Design, preparation of detailed construction drawings and bending schedules completion and maintenance of works
- All necessary associated works for substations
- Dewatering
- Preparation of as-built documentation (electronic and hard copies)

The new primary substations are within the areas subject to planning and development.

Site boundaries, location of access roads to the substations from the public highway (whether existing or to be constructed at a later date by others), site and road levels and orientation of the substation buildings to enable cables to enter / exit in the most convenient location and direction, have all been agreed with the appropriate Ministerial and Planning Authorities in Oman and are shown in the Tender drawings as appropriate.

The Contractor shall submit his proposed architectural view of buildings prepared by architectural consultants approved by OETC/Engineer.

6 SITE CONDITIONS

General

The Contractor, prior to tendering, shall visit each site and examine for himself the existing site conditions under which the Contract will be executed.

The Contractor shall acquaint himself fully of the local conditions and constraints, soil conditions and underground installations and no claim related to these conditions shall be considered nor approved.

Soil Conditions

The Contractor shall carry out his own soil investigation in all work areas before he commences detailed design and working drawings for finding out the allowable bearing pressure, expected settlements, type of foundations, chemical analysis, recommendations etc. The No. and locations of boreholes shall be decided by the Engineer prior to the commencement of soil testing. The Soil Investigation Report then, shall be submitted to the Engineer for approval. Approval by the Engineer shall

in no way relieve the Contractor of his sole responsibility with regard to stability and safety of his design.

The Contractor will be responsible, under his scope, for necessary filling & compaction, including replacement of unsuitable materials if so required, before placing any foundation or structures. Unsatisfactory or soft material encountered under any foundations, shall be excavated down to sound bearing strata and backfilled with appropriate fill or lean concrete as directed by the Engineer.

The type of foundations for all major structures, depending on the type of load bearing strata encountered, shall be selected so as to cater for the performance and serviceability requirements.

7 DESIGN CRITERIA CIVIL, STRUCTURAL AND ARCHITECTURAL WORKS

In addition to the requirements of various British Standards specified under General Technical Specification, the main buildings should be designed for a service life of at least 40 years having a fire rating of at least 2 hours and shall also cater for the loads and details specified herein.

Refer Section-13: Fire Protection Works to determine the spatial separation distances, requirement of fire walls / fire barrier and/or active fire protection.

7.1 Loads

General

Design of buildings, equipment foundations and other structures shall be based on the worst combination of dead loads, live loads, equipment loads, and impact effect, vibrations generated from equipment as applicable, thermal loads, wind load, seismic load, earth pressures and construction loads. Different categories of these loads are mentioned below. Live loads in equipment areas are equivalent to vertical loads covering the weight of equipment. However, the design of structures shall also be checked for actual load of the equipment plus a general vertical live load of 3.00 kN/m²

(applied on free area around installed equipment) and the worst condition adopted for the design.

Dead Loads

This will include the loads due to the self-weight of all permanent structural and non-structural components such as walls, both exterior and interior, finishes, partitions, beams, floor slabs, columns, foundations etc.

Additional loads for suspended ceiling, pipes, and AC ducts 1.00kN/m²

Live Loads

Switchgear/Control Building

Ground floor - 10.00 kN/m² (in case of unknown equipment loads)

Roof - 1.50 kN/m²

Equipment Loads on Roof

All roofs shall be designed for specified live loads plus loads due to other equipment supported on the roof areas. Due provision for the dynamic effects shall be made.

Stairs and Platforms 4.00 kN/ m²

Trenches and Pits

Surcharge for earth Pressure 10.00 kN/ m²

Outdoor & Indoor Precast concrete covers 5.00 kN/ m²

Indoor chequered plate and grating covers 5.00 kN/ m²

Tunnels and Road Crossing HS 20 of AASHTO/11.4 t Axle load

Equipment Loads

Foundations for equipment shall be designed for the equipment loads furnished by the manufacturers. Impact and vibration effects shall be considered as recommended by the manufacturer.

Actual load of the equipment plus a general vertical live load of 3.00 kN/m² (applied on free area around installed equipment) and the worst condition adopted for the design.

Wind Loads

The basic wind velocity, $v_{b,0}=33\text{m/s}$, is the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10 m above ground level in open country terrain with low vegetation such as grass and isolated obstacles with separations of at least 20 obstacle heights, shall be considered for determining of its effect on buildings and structures. Wind pressure, shape factor and other related criteria shall be based on latest BS EN 1991-1-4.

Seismic Loads

Seismic Loads on buildings and structures shall be based on the effect corresponding to Seismic Zone 2A for Muscat Region Areas and Zone 1A for the remaining regions as per Uniform Building Code and the horizontal lateral force shall not be less than 5 % of the total vertical load. The vertical load for seismic load calculation shall include dead load, equipment loads, pipe and cable tray loads, and 25 % of the live load. In the absence of detail equipment, pipe and cable tray loads, the seismic load shall be calculated for 100 % of live load. However it is recommended by Muscat Municipality (MM) using zone 2A as the seismic zone for Muscat, seismic force calculation should be done accordingly for grid stations in Muscat region.

Thermal Loads

Thermal loads shall be considered in the design of structures assuming $\pm 15^{\circ}\text{C}$ at all members above ground level and 15°C difference between inside and outside of the

building.

Thermal loads shall be incorporated in all design load combinations.

Earth Pressure

Value of soil friction shall be as determined from Soil Investigation, but in no case shall it be taken more than 30 degrees for earth pressure calculation and 45 degrees for rock.

7.2 Method of Design

Design of steel and concrete structures shall be based on the following standards or their equivalent:

- BS EN 1991 - Eurocode 1. Actions on structures
- BS EN 1992 - Eurocode 2. Design of concrete structures
- BS EN 1993 - Eurocode 3. Design of steel structures
- BS EN 1996 - Eurocode 6. Design of masonry structures
- BS EN 1997 - Eurocode 7. Geotechnical design
- Uniform Building Code
- AASHTO Specifications

The latest additions and addenda of the Codes and Standards referred to in this specification shall be used. The Contractor may be permitted to use other international codes and standards if found equivalent and approved by the Engineer. The Contractor shall submit an English translation of these codes for approval and an additional copy to the Employer.

Requirements

The works shall generally include, but not be limited to, the following for the substation.

-
- 1) Site Survey
 - 2) Soil Investigation
 - 3) Clearing, backfill, grading
 - 4) Plumbing and Drainage
 - 5) Storm water drainage
 - 6) Roads, Parking Areas and Pavements
 - 7) Cable and Pipe trenches, pits and tunnels
 - 8) Foundations for building, equipment and other structures
 - 9) Buildings
 - 10) Compound wall.

7.3 Site Survey

Survey of the proposed site shall be conducted.

Grid intervals for measurement shall be 5 m (five meters) or less depending on topography to produce contour maps of 0.25 m intervals. The scale of the contour maps shall be 1:500. The contour maps shall show all the existing structures (if any) at and near the areas surveyed.

7.4 Soil Investigation

Complete soil investigation shall be carried out by the Contractor along with laboratory testing, in sufficient depth and numbers as necessary for complete determination of subsoil conditions as approved by the Engineer. As a minimum 4 boreholes (BH's) 15 meter deep and minimum 2 trial pits 2.5 x 2.5 x 3.0 shall be executed. For 400 kV, 220 kV & 132 kV OHL routes the Contractor shall submit his proposal for soil investigation for approval before commencement of soil investigation works.

Based on his investigation, the Contractor shall establish Geotechnical design criteria comprising of, but not be limited to the following:

- Definition of design soil profiles under all structures and facilities, including geotechnical properties
- Determining bearing capacities, performance of structure stability and settlement analysis, selection of fill material, bearing stratum and foundation system
- Determination of design earth pressures
- Assessment of ground water conditions and their probable effect on construction; determination of ground water level, if encountered
- Identification of corrective measures required for the improvement of sub-surface conditions (e.g. removal of poor material, in-situ compaction, grouting, etc.)
- Definition of any measures required for erosion control
- Definition of measures against the corrosion of underground concrete, if any
- Identification of any other potential Geotechnical problems and recommended solutions

The required geotechnical test are:

a) Classification Tests

Water content determination

Bulk density and dry density determination

Specific gravity of soil grains

Particle size distribution by sieve analysis

Particle size distribution by hydrometer analysis

Atterberg limit tests

Relative density determination for granular soils

b) Chemical Test

Determination of pH value in soil

Determination of total and water soluble sulphate content in soil

Determination of chloride content in soil

Determination of carbonate content in soil

Determination of organic matter in soil

Determination of sulphate content of ground water

Determination of chloride content of ground water

c) Triaxial Tests on Soil

Triaxial Tests on Soil

Unconsolidated undrained tests

Consolidated undrained tests with pore pressure measurement

Multi-state consolidated undrained tests with pore pressure measurement

Consolidated drained tests

d) Direct Shear Tests on Soil

Consolidated drained tests

Consolidated constant volume shear tests

Strength tests on rock or cemented material cores

e) Strength tests on rock or cemented material cores

Point load tests

Unconfined compression tests

f) Compressibility Tests

Consolidation tests

7.5 Clearing, Backfill and Grading

Clearing

The Contractor shall be responsible for site clearance and station area grading of all

areas within the plot area. The necessary slope for area drainage shall be provided. Embankment slopes shall not exceed 1 vertical to 1.5 horizontal and shall be protected against erosion.

Filling, where required, shall be done with improved fill material compacted as per specifications including compacting/making good existing soft ground and replacement of unsuitable materials, if encountered.

Grading

During implementation of the project, this initial grading work will be disturbed and the Contractor shall restore the ground to the initial grade levels. The final grading will, therefore, involve mainly levelling and compacting of the station area to smooth profiles at the specified grade levels for the surface drainage and complete clean-up of the whole area. The final grading will include 10 centimetres of crushed stone surfacing in areas not covered by structures and pavements. Final ground level (FGL) shall be subject to Engineer's approval.

Along 400 kV, 220 kV & 132 kV cable route ground surface shall be restored to original state and quality as it was before excavation works started.

7.6 Plumbing and Drainage

General

The work shall be carried out in accordance with Codes and Regulations of Oman and British Codes as applicable.

All places where there is a possibility of oil collection, an oil trap shall be provided in the drain line.

Indoor Potable Water, Storm Drain and Sanitary Sewer Systems shall be in accordance with the Plumbing Specifications.

Two water tanks including sun protection shades (plastic) shall be installed for 220kV

building and one for gate house.

Water shall be supplied from the existing water network.

Outdoor Sewer System piping shall be designed for gravity flow through buried pipes totally independent of storm water drainage system.

The Sanitary system within the buildings will be developed by the Contractor as per standards referred to in the specification and continued into the general outdoor sanitary sewer system and finally to the holding tank and connected to the existing system.

The treatment of sanitary sewage will be through a watertight holding tank adequately designed for capacity specified in Vol. 2, section 5.23. Effluent disposal shall be done by existing network in Sohar Industrial Zone.

7.7 Storm Water Drainage

Rainwater drainage system will comprise of any or combination of the following:

Rainwater from the station area will be collected by open concrete drains and taken to the natural drainage channels or connected to the existing system wherever feasible.

For built up paved areas and roof drains, rainfall shall be guided to suitably located and adequately designed soak pits/drains. Oil and water separators shall be provided before water is discharged into the soak pits.

The outdoor drainage system shall consist of buried pipes and the slope shall not be less than 1 vertical in 200 horizontal. If required calculations shall be provided for the slopes adopted. Manholes shall be provided at all levels and intersections and on

straight line at every 50m distance. All pipes crossing the road shall be designed for HS-20 as per AASHTO standards/145 kN axle load.

7.8 Roads, Parking Areas and Pavements

Layout of roads, parking areas and pavement shall be as indicated on the Tender Drawings. The layout is to be suitably adjusted according to the finally approved plot plan layout. The widths of roads shall be as per functional requirements and subject to approval. Lighting and road markings and signs shall be provided for the roads and parking areas as per requirements and specifications. Priority of road construction shall be according to the program as approved by the Engineer. During the construction phase of the project, roads shall be built without the bituminous wearing course, which will be laid in the completion stage of the project.

7.9 Cable & Pipe Trenches, Pits & Tunnels

All trenches and tunnels shall be provided with a minimum clear walkway space of 600 mm (width) and all tunnels shall have minimum clear height of 2.0 m throughout unless otherwise agreed in writing by the Engineer. For tunnels adequate ventilation and lighting shall be provided.

All trenches, tunnels and pits shall have sufficient drainage slope and adequate arrangements shall be provided for drainage. Removable covers shall be provided for all cable and pipe trenches and pits.

All trenches, tunnels and pits shall be provided with minimum 150 mm wide PVC water stops at all construction joints below Ground water table.

All outdoor trenches and pits shall be 300 mm above adjacent ground level to avoid flow of surface water into the trenches.

Adequate drainage shall be provided for all trenches and tunnels.

All concrete work for trenches and tunnels shall be of grade 35 N/mm². Concrete surfaces in contact with soil/water shall be protected in accordance with standard

drawings for concrete protection details, taking into account sulphate and chlorine content in the soil and underground water.

7.10 Foundations for Buildings, Equipment and Other Structures

The foundations shall be designed based on the recommendations and geotechnical data from the Soil Investigation report and stress resultants as obtained from analysis of the worst combination of loads.

OHL Tower Foundations

For OHL towers, foundations shall be casted on a pre-applied membrane, which mechanically bonds to pored concrete, remaining in place if settlement of substrate occurs. The complex cell mesh bonded to a polyethylene membrane allows poured concrete to interlock with the membrane forming a tenacious mechanical bond. The membrane shall incorporate a peel-off seldedge strip to ensure sealed lap.

The membrane shall provide long-term protection to reinforced concrete in the Middle East climatic and environmental conditions and basement waterproofing protection to grades 2, 3 and 4, as specified in BS8102.

All waterproofing materials including membranes, rubberised bituminous mastics, primers, adhesives, fillets, armour tape, protection board and flashings etc. shall be compatible with each other and shall be from a manufacturer operating the BS:EN:ISO9001 or 9002 quality assurance scheme.

All materials are to be applied strictly in accordance with the manufacturer's instructions and must be capable of being applied both horizontally and vertically using one grade of membrane, and laps between rolls must not encroach into concrete cover.

The self-adhesive membrane shall have a coefficient of friction not less than (0.4) with concrete surfaces and min. thickness of 4mm.

Equipment Foundations

For all major equipment, the foundation shall be cast in continuous single pour with no cold joints. This is strictly applicable to equipment foundations subject to vibration. All precautions for limiting and isolating vibration shall be taken as per the relevant Codes and Standards. All foundations located at/near the oil spillage areas shall be given three coats of oil resistant epoxy paint.

Transformer Foundations

The transformer compound shall be made for catchment of oil spillage from the transformer resulting from mechanical or electrical failure. To achieve that the outline of the oil containing part in the transformer will be at least 2.4m inside the walls of the oil pit. Precautions shall be provided to prevent pollution of ground water, irrigation ditches and other watercourses by leaking of oil. This can be achieved by providing proper water stop or other means at all construction joints.

Transformer foundation shall be not less than 300 mm above the surrounding level and shall be surrounded by a low watertight reinforced concrete pit enclosing an area in which the 110% of the oil content of the transformer can be retained in the event of a major leak.

Concrete surfaces inside the pit shall be protected by an approved oil resistant paint.

A layer of stone (38 mm single size stone chipping) shall be placed 150 mm below the top of the transformer pit wall. The layer shall be 300 mm thick and set on galvanized grille (grating). A sump shall be provided and shall be readily accessible through a manhole, which will be fitted with galvanized grating cover. Petrol motor driven mobile pump of adequate capacity for drainage of transformer pit shall be supplied under the Scope of Works.

Between adjacent transformers the protective reinforced concrete fire wall shall be provided. The fire wall shall be 1 ft higher than the highest point in the transformer (i.e. conservator tank). The fire wall shall be extended by 600 mm after the edge of

containment of the transformer.

Refer Section-13: Fire Protection Works to determine the spatial separation distances, requirement of fire walls / fire barrier and/or active fire protection systems.

7.11 Buildings

The basic building parameters are given in the respective Drawings. Generally the following requirements shall apply to the buildings:

i) Buildings

All buildings shall be planned and laid out according to their respective functional requirement and use. Office space can be provided if requested by OETC only otherwise it shall not be provided. The buildings shall be air conditioned.

The Contractor shall employ a qualified architect for the administration building to design and detail the building in order to achieve the best possible visual effects. The design of the building shall be suitably incorporated in the ambient of the substation area.

Minimum requirements for each building in respect of office space, furnishings, equipment, finishes, HVAC, lighting, fixtures, toilet requirements, etc., shall be as shown in the drawing and/or schedule or as specified in this document. The Contractor shall ascertain the final requirement, taking into consideration adequate space, access for ease of operation, maintenance, safety, etc. and provide for this in his Tender. Structural framing, floors, roof, cladding, etc. for the different buildings shall be as shown on the drawings or as specified. Details of the facilities, finishes, doors, windows, furnishings, office equipment, etc. shall be in accordance with specifications.

Control & relay rooms shall have heavy duty raised floors without interference with cable trays.

The buildings shall be of framed reinforced concrete structure with reinforced concrete

floor and roof slab. The external walls not facing transformers shall be of cavity insulated construction minimum 350mm thick consisting of a 100mm solid blockwork external leaf, 50mm insulation, and 200mm hollow blockwork inner leaf, While external wall facing transformers shall be of solid insulated construction minimum 350mm thick consisting of a 100mm solid blockwork external leaf, 50mm insulation and 200mm solid blockwork inner leaf. Alternatively, the exterior cladding may be of calcium silicate bricks. Interior walls shall be of hollow concrete blocks. The blockwork walls shall be rendered and painted with oil bound paints of approved shades as per specifications.

The floor shall be of reinforced concrete 45 mm topped with floor hardener and epoxy screed 5 mm with PVC wall skirting for GIS building, switchgear room. In the Relay & Control Room as well as Telecommunication room, a raised floor for heavy load shall be provided without interference with cable trays. For the battery room area anti acid/anti alkali tiles shall be provided.

Corridor and office floors shall be finished with granite or marble tile approved by OETC/Engineer.

Skirting shall be provided in all rooms made from a material matching the floor finish material.

The walls for all rooms shall be smoothly rendered and painted with 2 coats of oil based paint up to 2.2m above floor level, while for battery room acid/alkali resistant tiles up to 2.2m above floor level shall be applied. The walls above 2.2m will be smoothly rendered and painted with 2 coats of emulsion paint.

Suspended ceiling shall be provided for the buildings as described in the Scope of Works - Section 2 hereof.

The windows shall be of anodized aluminium with glazing as per Specification.

An access ladder shall be provided to the building roof.

Waterproofing of the roof shall be done as per Specifications.

Foundation for the building shall be designed for the worst combination of various loads.

Grade beams shall be required to transfer the horizontal thrust. Structural analysis shall be carried out to find axial forces, shears, and bending moment, as well as lateral displacements. The architectural treatment and finishes shall be as applicable and as outlined on the respective drawings and specifications. The partition materials for the offices shall have a fire rating of 2 hrs.

The steel doors provided for the buildings shall have a fire rating of 2 hours, all steel doors shall be designed according to the integrated security system (Section 24).

All masonry walls from ground floor shall be placed on Damp Proof Course on reinforced concrete grade beams.

All ground floor slabs carrying heavy equipment (Switchgear ...etc.) shall be connected to the surrounding grade beams.

All exposed concrete structural members shall be painted with thermal protective paints.

All buildings shall have minimum plinth height of 300 mm from adjacent ground or as shown in the drawings.

Buildings shall be provided with minimum 1.0 m wide reinforced concrete paving all-round. Paving shall be sloped to provide a rapid run-off of rainwater away from the building. All electrical, A/C, plumbing and sanitary services etc. shall be provided for in the buildings.

The Buildings shall be provided with slope and roof drainage systems, cold and hot water supply, floor drains for wet areas, sanitary fittings, gully traps, manholes, holding tank, etc. complete with all associated works and in compliance with the relevant sections of the specification, and as approved by Engineer. Each basin and sink is to

be provided with both hot (except battery room) and cold water.

If Office rooms are requested, then each office shall be provided with the following furniture:

- a) 1 (one) office table and suitable chairs
- b) 2 (two) lockable cupboards

The Control Rooms shall be equipped with the furniture to accommodate SCS equipment, three working places and one additional office table with suitable chair.

Stores shall be equipped with prefabricated still shelves sized for spare equipment and maintenance tools and materials for substation and are subject to approval. One heavy duty workshop table shall be supplied.

ii) Concrete Work

All concrete works below ground level shall be of OPC or sulphate resistant portland cement based on the requirements stated in the standard drawings for concrete protection details and shall not have a water-cement ratio more than 0.45, the minimum cement content shall be in accordance to CIRIA guide recommendations

All concrete works below ground floor level shall be of minimum grade 35 N/mm² grade (28 days cube strength)

All concrete works above ground floor level shall be of minimum grade 35 N/mm² grade (28 days cube strength)

All equipment foundations shall be of minimum grade 35 N/mm² (28 days cube strength).

The paint or tanking membrane shall be applied / performed as per manufacturer's instructions.

A blinding concrete of minimum grade 15 N/mm² of minimum 75 mm thickness shall be provided under foundations, trenches, pits, grade beams, ground floor slabs, etc.

All steel reinforcement shall comply with the requirements of BS 4449 Grade B500B.

iii) Structural Steelworks

Rolled Steel Parts, flats, plates, bolt and nut bars shall consist of mild or high yield steel which shall not be inferior in strength and quality to Grades S275, S355JR and S460N as specified in BS EN 10025 “Hot rolled products of structural steels”. The steelwork shall be hot dip galvanized unless otherwise accepted by the Engineer. Galvanizing shall be done to BS EN ISO 1461 with a minimum galvanizing thickness of 127 microns. All bolts & nuts shall be provided with locking device i.e. galvanized spring washers.

7.12 Compound Wall

A high security compound wall, 2.5m height shall be provided in accordance with the Specification of Integrated Security System (Section 24) and other related Specifications as well as Royal Oman Police requirements and subject to ROP approval.

8 TENDERER TO VISIT SITES

The Tenderer shall visit site before preparing his Tender for the purpose of examining the extent and nature of the work, to familiarise himself with local and site conditions under which the work is to be carried out and to ascertain the availability of all labour, plant and materials for the satisfactory execution of the works within the overall programme for the respective commissioning dates.

The Tender shall be deemed to include for all local conditions and restrictions.

9 CIVIL WORKS PROGRAMME

The Tenderer shall submit with his Tender an outline civil programme based on the overall project programme showing how the works are to be completed in the time available.

Within one month after receipt of the OETC/Engineer order to commence works, the Contractor shall submit his detailed construction programme for approval to OETC/Engineer,

in the approved format and based on the above outline programme.

10 KEY SUBMISSIONS

The Contractor is required to submit various documents at different times during the execution of the contracted works. Such submissions are listed below with the time of submission along with the relevant section of this specification where the nature of the document requirements is detailed. However, the full text in the specification must be referred to. The Contractor shall include key submissions in the detailed project programme. Other submissions required are noted in the text of the specification. Where a time based target has not been stated the target date shall be agreed with OETC/Engineer based on the approved project construction programme.

Document	Submission Date – no later than (convert to actual dates after contract award)	Specification Section
Civil subcontractors	To suit programme	4
Architectural views	To suit programme	5
Full construction programme	Award date + 1 month	7
Civil Quality Plan	Award date + 1 month	9
Quality Inspection Plan	Award date + 2 weeks	9
RAMS	At least 10 days before activity	9
Building permit	To suit programme	10
Staff CVs	To suit programme	12
Supplier names and details	To suit programme	17
Site establishment layout	To suit programme	20

Document	Submission Date – no later than (convert to actual dates after contract award)	Specification Section
Safety & Env Report	Weekly	21
SI report	To suit programme	28
QA Programme	Award date + 2 weeks	29
Alternative Codes & Stds	Tender	29
Fire Risks and Strategy Report	To suit programme	29
Drawing Register	Award date + 2 weeks	29
Computer Programme Certs	Award date + 4 weeks	29
Checked civil/structural/building designs	To suit programme	29
Site preparation drawings	Award date + 4 weeks	30
Plant proposals	Award date + 4 weeks	30
Buildings – roof waterproofing	To suit programme	34
Concrete mix proposals	To suit programme	35
Door fixtures and fittings	To suit programme	47
Security walls and gates	To suit programme	52
Termite treatment	To suit programme	63
Handover documents (drafts)	12 weeks before commissioning	66
Handover documents (finals)	4 weeks after commissioning	66

11 QUALITY CONTROL, ACCEPTANCE AND INSPECTION

11.1 General

The Contractor shall maintain a quality control system which guarantees the monitoring of the quality of the entire Contract. The Contractor shall guarantee compliance with the following conditions.

A Civil Quality Plan, including organization chart and field control procedures shall be submitted by the Contractor for approval by OETC/Engineer.

The Civil Quality Plan shall be prepared in line with ISO 9001 'Quality Management Systems – Requirements'. In particular, Sections 4, 7 and 8 of ISO 9001 shall be developed within the Civil Quality Plan.

The Contractor shall identify appropriate 'Hold Points' in the Quality Plan. As a minimum, hold points shall occur when it is required that the Contractor seeks approval from OETC/Engineer before proceeding to the next stage of a design, construction or supply.

The Contractor shall guarantee compliance with the requirements arising from the quality control system and the corresponding records. He shall ensure that on the basis of his experience he is familiar with the scope, methods and risks of all tests and is in the position to perform such tests.

OETC/Engineer shall have the right to request information from the Contractor as to the status of the works and quality control. For this purpose OETC/Engineer shall be allowed access to the production centres as well as drawings and documents which are necessary for assessing the works.

The Contractor's suppliers shall also be subject to such obligations. OETC/Engineer reserves the right to carry out an inspection in the presence of the Contractor after completion of individual works. The Contractor shall provide safe access to all locations, including lighting and appropriate checking tools etc. required by OETC/Engineer for checking the works.

11.2 Risk Assessments and Method Statements (RAMS)

Before commencing any permanent or temporary work, including but not limited to:

- Excavations
- Working at height
- Working in confined spaces
- Cranage and lifting
- Concrete placement
- Heavy vehicle movements
- Dewatering
- Temporary works,

the Contractor shall submit risk assessments and method statements (RAMS) which shall include a detailed description of the proposed works and procedures, checked calculations, drawings, sketches, lists and details of equipment to be used etc. The work shall be in accordance with the Health, Safety and Environment (HSE) Plan, and shall commence only after acceptance of the RAMS by OETC/Engineer.

Documents for approval shall be submitted allowing appropriate time and at least thirty (30) days prior to the commencement of the relevant work for which the documents are submitted, for review, amendments and subsequent reviews leading to approval by OETC/Engineer. At least fifteen (15) working days shall be allowed for the review process, from submission by Contractor to OETC/Engineer leading to approval. The Contractor shall take full responsibility for approvals delayed due to circumstances within his control such as late submission, size or complexity of submission (submission date must allow for this), or submissions that are incomplete or sub-standard etc.

When works are to be carried out within or directly adjacent to an operating substation, particular care shall be taken to avoid excessive dust propagation and other disturbances to the System plant. Close co-ordination with the substation operators shall be established.

11.3 Contractor's Approval of Civil Work at Site

The Contractor shall establish on site a team of experienced and appropriately qualified Civil Engineers dedicated to the review and detail checking of civil designs and drawings.

The checking team leader shall be a Chartered Civil Engineer from the home office organisation of the Contractor and shall have a minimum of 15 years relevant experience. He shall be responsible for the correctness of design and its conformity with the specifications.

Each element of the detailed Civil, Structural and Building Engineering permanent works on completion of the design shall be subjected to a full and independent design check. This shall be carried out by a chartered member of an appropriate professional body e.g. ICE, IStruct E, who has been independent of the design team responsible for the production of the particular calculations and drawings. This checker may be employed by the same organisation.

The independent design check shall ensure that the calculations, drawings and all supporting documentation conforms to all relevant standards, documentation, reports etc., and is, within that context, fit for purpose. This independent check shall confirm that the design assumptions are valid and that the concepts are sound.

In order to demonstrate compliance with this clause an approved Civil/Structural/Building Engineering Design Check Certificate shall be completed by the individual responsible for the independent design check. A template of the certificate is included in Annex 4 of this specification.

The first formal issue of a drawing or drawings representing Civil/Structural/Building Engineering design shall be accompanied by the appropriate Civil/Structural/Building Engineering Design Check Certificate. Design details without such supporting documentation shall not be incorporated into the any part of the Works. Design check certificates for subsequent revisions to drawings shall only be required where significant change to the design philosophy and/or construction methods has been made or where specifically requested by OETC/Engineer.

OETC/Engineer shall determine the significance of the change and therefor the need for formal rechecking.

The above checking procedure shall also apply to temporary works, but where applicable and agreed with OETC/Engineer, the requirements of BS 5975:2011 Section 9.2 including Table 1 shall take precedence in respect of category of check and independence of the checker.

Documents and drawings shall be forwarded to OETC/Engineer for approval only after they

have been reviewed and signed off by the checking team leader.

Prior to OETC/Engineer approval to pour concrete, the Contractor shall check the setting out of his subcontractor's work including formwork, reinforcement and embedded items and services etc. As part of the approval process the Contractor shall sign an 'Approved for Casting' certificate, which will confirm he is satisfied that the items in the pour for which he is responsible or has an interest in are correct and set correctly. The Contractor shall have overall responsibility for the correct setting out of all aspects of such elements of work. Following this procedure the prepared element shall be inspected by OETC/Engineer for final approval.

11.4 Notification of OETC/Engineer, Inspection and Testing at Site

The Contractor shall notify OETC/Engineer formally of the commencement, interruption or recommencement of any element of the Works.

The Contractor shall submit individual inspection request sheets to the OETC/Engineer 48 hours prior to the commencement of the works such as excavation, backfilling, drainage, concreting and structural steel erection etc. Works shall commence on that element only after OETC/Engineer's approval of the inspection sheet.

The OETC/Engineer's approval shall not relieve the Contractor of any of his obligations under this Contract. The form of the inspection sheet shall be proposed by the Contractor and approved by OETC/Engineer.

It is to be noted that should the Contractor repeatedly fail to notify or inform OETC/Engineer of inspections, sampling or testing (if any) then OETC/Engineer may carry out independent checks without informing the Contractor and reject parts of the works should the results of such inspection or testing require it. OETC/Engineer may instruct the Contractor to re-expose for inspection, work covered up in these circumstances, all at the Contractor's own expense.

As far as is practicable OETC/Engineer shall have free access to the site, fabrication areas and suppliers work at all times without notice. Should OETC/Engineer discover unsatisfactory work, process or procedure then he will invite a formal joint inspection.

Either after such an inspection or if the Contractor declines the invitation OETC/Engineer shall issue instructions with regard to the faults and their reparation.

OETC/Engineer may instruct tests at no cost to him, provided either the overall frequency governed by the specification is not exceeded and the notification given to the Contractor is equal to that currently being provided by the Contractor for his normal testing in formality and warning, or the Engineer has due cause to suspect a change in the quality, such concern having already been advised to the Contractor.

OETC/Engineer may instruct sampling, testing or both which satisfy only some or none of the above criteria.

11.5 Approval Procedures

The Contractor shall prepare a Quality Inspection Plan (QIP).

The Contractor shall guarantee that the fittings and accessories fabricated by him are approved by OETC/Engineer for use in the agreed works.

The Contractor shall guarantee and prove by way of suitable tests that the requirements placed on the fittings and accessories are fulfilled in terms of guaranteeing serviceability and high availability.

The results of tests carried out shall be furnished in writing by means of certificates and/or test reports complying with relevant standards. Normal OETC/Engineer approval is to be a staged process for supplier or source and the material or product.

The Contractor shall supply, as far as is possible, the following information:

In respect of suppliers or subcontractors:

- A review of previous performance in supplying to similar specifications
- Evidence that he can legally supply to Oman
- Capacity of plant
- Other ongoing commitments
- Details of main items of plant and key personnel
- Independent references (if any and preferably unsolicited)
- Test reports on similar products (again preferably independent).

In respect of materials or products:

- All that is necessary and sufficient information to demonstrate conformance with the contract documents.

Approvals previously granted for any materials etc. shall be withdrawn if they are not properly transported, handled or stored and otherwise protected against weather or contaminants, which may adversely affect their properties in service. The Contractor has the option of removing such materials or having them retested for approval.

12 BUILDING PERMIT APPROVAL

All Civil works in Oman require building permit issued by the relevant authorities before construction work commences on site. Drawings showing general arrangements and main constructional features and materials to be used in the building project shall be submitted by the Contractor to the appropriate planning authority for their consideration and approval for building permit.

It is the Tenderer's responsibility to make himself fully conversant prior to Tender with the building permit regulations and requirements and that his Tender includes all costs incurred in preparing the required drawings, making application for the building permit and incorporating any amendments recommended by the authorizing body in his drawings prior to receiving building permit approval. A valid building permit must be held by the Contractor before construction work commences on site.

Statutory restrictions on the proximity of excavations to any third party boundary or asset shall be understood by the Contractor and complied with.

13 UNITS OF MEASUREMENT

The units of measurement used in this Contract shall be metric in the International System of units (SI).

14 MATERIALS AND WORKMANSHIP

All materials used in the works are subject to OETC/Engineer's approval.

All materials incorporated in the Works shall be new and of the best quality available to the approval of the OETC/Engineer. The Contractor shall provide during the mobilization period,

a schedule indicating the dates of submission of requests for approval of all materials to be incorporated in the works. The schedule shall also include particulars of approval dates required, placement of order, expected delivery dates, actual delivery to site, etc. The schedule shall be reviewed, updated and adapted from time to time.

In pursuance of Omani contract law, the Contractor shall use his best endeavors to ensure that at least 10 % of the value of the contract (in products or services) is attributable to Omani Small Medium Enterprises (SME).

Also, preference shall be given to Omani products up to a price 10% higher than the imported products provided they comply with the specification.

The Contractor shall furnish in reasonable time a minimum of three (3) No. samples as directed by the OETC/Engineer. Samples shall be furnished in sufficient time, so as not to delay fabrication allowing the OETC/Engineer reasonable time for consideration of the samples submitted.

The OETC/Engineer's approval of materials shall not relieve the Contractor of his responsibility to comply with the specification. The Contractor shall be solely responsible for any delay in the completion of the works, due to his failure to submit and to obtain the requisite approvals from OETC/Engineer, at the appropriate time.

Materials shall be stored in an approved manner and shall be protected from exposure to weather. Damaged/defective materials shall not be incorporated into the Works. They shall be removed away from the site and replaced at the Contract's expense.

All workmanship shall be executed by approved staff. The qualification and experience of working staff shall be submitted in CVs and approved by OETC/Engineer before commencement of any works.

15 SAMPLES

In addition to the special provisions made in this specification for sampling and testing of materials by particular methods, samples of any materials and examples of workmanship proposed to be used in the Works may be called for inspection and or testing at any time during the Contract by OETC/Engineer and shall be provided by the Contractor without delay and at the expense of the Contractor.

Samples when approved shall be regarded as the acceptable standard, and any material or workmanship subsequently not complying with that standard shall be rejected and replaced by those of acceptable standard at the expense of the Contractor. Sample storage boxes, if requested by OETC/Engineer, shall be provided by the Contractor free of cost.

16 TEST/MILL CERTIFICATES

Where specified or requested the Contractor shall obtain from the manufacturer, and send to OETC/Engineer, certificates of test, proof sheets, mill sheets, etc. showing that materials have been tested in accordance with this specification or the relevant British Standard.

Notwithstanding any tests which may be directed to be carried out at a manufacturer's and/or subcontractor's works, OETC/Engineer may carry out any tests or further tests he considers necessary or desirable after delivery of materials to the Site.

OETC/Engineer inspectors may attend the premises of subcontractors to test materials or verify the manufacture of materials or products.

The Contractor shall provide all labour, equipment and facilities necessary for the execution of tests both in works and on Site.

The cost of tests required by this specification shall be deemed to have been included in the Contract Price.

17 LABORATORY

Detailed tests (including all chemical tests) of soil, concrete, steel and other materials shall be performed by appropriate third party specialist companies in laboratories, and at the expense of the Contractor.

Such companies (with their facilities) shall be subject to OETC/Engineer approval as a subcontractor.

As well as the testing, the third party specialist testing laboratory company shall also be responsible for the sampling, handling, and transport to the laboratory, and also the analysing and reporting of the tests. Interpretations and recommendations from the results shall also be included in the reports when requested by OETC/Engineer. All reports shall be submitted

directly to OETC/Engineer.

OETC/Engineer shall have the right to witness testing and to carry out independent testing either using his own resources or those of the third party specialist testing company.

Calibration/service certificates of testing machines/equipment shall be submitted along with particular test reports of material, works etc. All calibrations and service certificates shall be in date and in accordance with the recommendations of the equipment manufacturer.

18 REJECTION OF MATERIALS AND WORKMANSHIP

OETC/Engineer shall at any time have power to reject materials and workmanship which do not comply with the contract specifications or with the approved drawings. Materials so rejected shall be immediately removed from Site and replaced with materials of an approved standard at the expense of the Contractor.

Rejected workmanship shall be removed by the Contractor without delay and at his own expense and replaced by work of an acceptable standard, including the supply of new materials.

19 NAMES OF SUPPLIERS AND COPIES OF ORDERS

Before ordering material of any description, the Contractor shall submit for OETC/Engineer's approval the names of makers or suppliers proposed. Copies of material specifications accompanying orders shall also be submitted if so requested.

OETC/Engineer may at any time withdraw his approval to obtain materials from any maker or supplier should such maker or supplier fail to supply materials of the specified quality or quantity in the requisite time.

Approved samples shall be kept in the OETC/Engineer's office until the end of project. The Contractor shall provide a separate room in OETC/Engineer's office for this purpose.

20 DIMENSIONS, LEVELS, CO-ORDINATES, SETTING OUT

All dimensions, levels and coordinates shown on the drawings shall be verified and checked on Site by the Contractor and confirmed with the appropriate Authority.

Upon entering the Site to commence work, the Contractor shall immediately locate all reference points and fully protect them from damage. He shall be responsible for the correct setting out of the position, levels, dimensions and alignment of all parts of the works in accordance with the approved designs and drawings and he shall fully protect and preserve all benchmarks, pegs and other things used in his setting out.

Before the commencement of the works the Contractor shall survey the site to establish the ground levels over the area of the substation compound plus 20m outside the compound perimeter, unless this area is not accessible due to reasonable third party restrictions. The survey will be on a grid of 5m maximum spacing, and will also identify any significant features and changes in ground level within that grid.

The site survey plan shall be prepared showing the survey results, the levels of all roads existing buildings nearby the site, and the proposed layout of the new works. Copies of this plan shall be sent to OETC/Engineer for approval as "Being an accurate record of the site before the commencement of Works". Based on this record, the Contractor as Designer shall recommend to OETC/Engineer the most suitable finished substation level and ground floor level and give reasons for his recommendations. OETC/Engineer will review the Contractor's recommendations and advise the Contractor of the required finished substation level and ground floor level for the scheme.

OETC/Engineer may provide substation and ground floor levels at contract Tender stage.

All surveys required for construction of the works shall be performed by the Contractor as construction work proceeds.

All other necessary survey lines, points and elevations shall be fixed by the Contractor. In the case of long straight lines the Contractor shall establish survey points fixing locations and elevations at distances of no less than 100m. In the case of curves and bends, these marks shall be provided at distances of 20 to 50m or as requested by OETC/Engineer. Survey points that are lost but which are still required shall be properly reinstalled.

The marks shall be adequately protected during the construction period and handed over to OETC/Engineer upon completion of the works. Any breaks in gradient and direction shall be marked in addition.

In planning substation levels the Contractor shall take due cognisance of any recommendations contained in Flood Risk Assessment Reports by others and made available to the Contractor by OETC/Engineer. Such recommendations may include numerous flood mitigation measures, and these shall also be incorporated into the substation design.

The Contractor shall set out all the works as accurately as possible from appropriate setting out lines. The maximum tolerance permitted for any part of the works shall be as given in BS 5964: Part 1 and BS 5606, unless specified otherwise in this specification.

Within the substation, the tolerances for permanent and temporary setting out points shall be:

- | | |
|---|--------------------------------|
| a) Horizontal distance up to 50 m: | Permitted tolerance ± 3 mm |
| b) Horizontal distances over 50 m: | Pro rata of a) |
| c) Lines between pairs of stations intersecting at 90° : | ± 6 seconds |

Within the substation, the tolerances for temporary bench marks shall be:

- | | |
|---|--------------------------------|
| a) Up to 100 m from a permanent bench mark: | Permitted tolerance ± 3 mm |
| b) Over 100 m from a permanent bench mark: | Pro rata of a) |

Other permitted tolerances of line and level on substations shall be:

- | | |
|--|------------|
| a) Line - Any part of the works including centerline of holes for fixings and inserts from the appropriate setting out line: | ± 5 mm |
| b) Line – Distance between centres of individual holes or inserts within a group: | ± 2 mm |
| c) Level – Foundations, structures and inserts: | ± 6 mm |
| d) Level – Between any part of a single structure or foundation: | ± 3 mm |

If at any time during the progress of the works any error shall appear or arise in the position, levels, dimensions or alignment of any part or the works the Contractor shall, at his own expense, rectify such error to the satisfaction of OETC/Engineer.

OETC/Engineer may at any time check the lines and levels set out by the Contractor and the Contractor shall supply all necessary assistance and provide all facilities and equipment required by OETC/Engineer for checking the setting out of the Works.

The checking of any setting out by OETC/Engineer shall not in any way relieve the Contractor

of his responsibility for the correct setting out of the Works.

20.1 Establishing Survey Points

Survey points in rock or solid walls shall be of stainless steel or cast iron. In soil, they shall be securely fixed in concrete of appropriate strength. The concrete block shall be at least 600 mm square, 500 mm in height with 300 mm protruding above ground, and shall be stable.

BS 5606 shall be followed as the standard of accuracy of methods and devices used and the required number of survey points.

20.2 Survey Point Details

Steel or cast iron points shall be fixed firmly and sufficiently deep in rock, walls or concrete and adequately protected. Exposed or buried survey points not in concrete shall be suitably founded and completely stable. Inscriptions identifying the points shall be on brass plates suitably anchored. Underground survey points shall be protected from damage by means of suitable frames with covers. The marks shall be kept free from water and sludge. Subordinate points may be marked by steel pipes or other pegs, subject to OETC/Engineer approval.

All survey point identifying plates and the inscriptions shall be provided and preserved by the Contractor.

20.3 Establishing Setting-out Points

The Contractor shall locate and mark setting out points in a manner so that easy checking and use of them is possible at any time.

20.4 Protection and Preservation of Survey and Setting Out Points

The Contractor shall at his own expense take all measures required for adequate protection and preservation of all survey and setting out points.

20.5 Avoidance of Damage to Survey and Setting Out Points

The Contractor shall not cause any damage to or arbitrarily remove any survey points, including those of other firms participating in the project.

20.6 Action Required in the Case of Damage to Survey and Setting Out Points

Any damage which the Contractor may have caused to the survey or setting out points shall immediately be brought by him to the attention of the party who provided them and to the attention of the OETC/Engineer. In each case OETC/Engineer will decide whether the Contractor shall comply with the following:

- Provide new point(s)
- Make arrangements to replace the point(s)
- Have the required survey carried out by others
- The survey point(s) in question may be omitted

It is expressly stated that the Contractor shall be responsible for any consequential damage or costs caused by defective survey points.

20.7 Method of Survey

The method of survey proposed by the Contractor shall be submitted to OETC/Engineer for approval and shall be adjusted to the OETC/Engineer's requirements if he deems adjustments are necessary.

20.8 Personnel Employed

The Contractor shall assign surveying and setting out work only to persons who are trained, qualified and have appropriate proven experience to undertake the work. Respective C.V. shall be submitted to OETC/Engineer on request.

20.9 Submittal

The Contractor shall submit a survey report showing all survey results and locations and details of the of survey points to the OETC/Engineer for approval on an appropriate drawing size and in a digital format, acceptable to OETC/Engineer.

20.10 Verification

The Contractor shall apply in reasonable time for the necessary setting out details to be verified by OETC/Engineer, especially on parts which require grouting or welding.

The Contractor shall assist OETC/Engineer at any time when checking bench marks or other points established by the Contractor, or when checking position, shape of construction items or temporary works if this appears necessary.

The Contractor shall keep clear all marks and sight-lines required for this purpose. Checks will usually be made during work breaks, but in case of urgency checks may be made by OETC/Engineer during working hours. If necessary, the Contractor shall restrict or stop affected work without being entitled to extra payment.

Any directions given by OETC/Engineer shall not relieve the Contractor of his full responsibility for the accuracy of structures or parts of them with regard to their positions or dimensions.

These conditions shall also apply to Contractors and/or subcontractors for erection work.

At existing substations, unless directed by OETC/Engineer, the Contractor shall carry out the civil works to the existing lines and levels, and regulate and reinstate the surface levels to match existing prior to laying the gravel site surfacing as specified.

The Contractor should assume in his Tender that new gravel site surfacing will be required in those areas affected by the modification.

21 SURVEYING INSTRUMENTS

The Contractor shall keep on site such modern surveying instruments as necessary for the complete and accurate setting out and construction of the Works.

Instruments for setting out and monitoring shall be tested on site in accordance with the relevant parts of BS 7334: Parts 1 to 8. Any results from these tests showing non-compliance shall be submitted to OETC/Engineer with details of elements where the instrument had been used since the previous tests, and proposals to check work completed using the specific instrument.

All surveying equipment shall be regularly checked and calibrated to BS EN ISO 10012 in accordance with the manufacturer's recommendations or the Contractor's own quality procedures, whichever is more onerous. Calibration tests shall be carried out at least every six months and when the accuracy of the equipment is suspect.

The surveying instruments shall be kept available for use by OETC/Engineer as required.

22 SITE ESTABLISHMENT

22.1 Facilities at site

The Contractor shall provide offices as required by OETC/Engineer's supervisory staff for the duration of the contract. The offices shall be located at a place agreed with the OETC/Engineer prior to the start of works. No permanent work shall be commenced without agreed suitable office(s) being ready for occupation and use as indicated.

The Contractor shall provide 2 No fully furnished, air conditioned, and sound and weather proofed site office blocks. They shall be connected to an additional conference room block, all complete with electrical power and light fittings, plumbing and sanitary systems to the approval of OETC/Engineer.

The office blocks shall be located adjacent to the Works area and as directed or approved by OETC/Engineer. Each office block shall consist of two office rooms and each office room shall have a floor with a floor area of not less than 20m². The floor area of the conference room shall be at least 36m². Toilet facilities shall be attached to each office block.

Toilet and washroom facilities shall include air extraction fans, western style WCs, urinals, washroom and shower and washbasins with hot and cold water. Water and effluent shall discharge into a suitably sized holding tank unless connected to a public sewer system.

The following equipment and furniture shall be supplied to each office block:

- 2 No land-line telephones with international calling facilities
- Fastest possible internet connection
- 2 No latest model PCs complete with standard software packages including MS Office 2013
- 4 No writing desks with swivel arm chairs
- 6 No guest chairs
- 2 No drawing hanger stands
- 2 No bookshelves
- 2 No storage lockers
- Split type AC unit
- Fire extinguishers.

The following equipment shall be shared between both office blocks:

- 1 No photo copier/scanner/printer
- 1 No fax machine
- The kitchen, including 1No hob and oven, refrigerator, water cooler, hot and cold water supply, sink, drainer, microwave oven, cupboards, and worktops.

All equipment shall be proposed by the Contractor for approval by OETC/Engineer before any item is ordered.

All equipment and consumables shall be stocked, maintained and replaced by the Contractor on a regular basis for the duration of the Contract as necessary.

The conference room block shall be sized to accommodate at least 10 persons sitting and be equipped with a conference room table (approx. 4.0 m x 1.5 m) and 12 chairs. A white board shall be provided.

For conference room AC split unit of 2 tons capacity shall be provided.

During the construction period until issuance of a Provisional Acceptance certificate (PAC) and completion of all outstanding items, the Contractor shall provide a daily refuse collection and disposal service to be loaded, transported and dumped at areas where prior permission has been obtained from responsible authorities in order to keep the total offices and construction site areas clean and in safe condition.

Neglect of cleaning by the Contractor may lead to waste removal by others and the removal costs being deducted from payments to the Contractor.

22.2 Access Road and Parking

The Tenderer shall allow in his Tender for constructing and maintaining temporary all-weather access roads as required for the construction, delivery of electrical equipment and maintenance of the works. These temporary roads will be taken from the nearest existing public highway to the substation sites.

The Tenderer shall include in his Tender all coordination work within the various Ministerial departments in the construction of the substations and permanent and temporary roads to the substations.

Diversion or modifications to existing power lines, if approved, will be coordinated with the appropriate division of OETC

The Contractor shall as a minimum provide a temporary sealed and free-draining hard access road to the site office.

Parking areas for OETC/Engineer shall be provided by the Contractor. These areas shall be located close to the working places (site offices and areas of construction) used by OETC/Engineer.

The parking areas and site offices shall be indicated by the Contractor in the layout drawing for Site installation to be submitted for OETC/Engineer approval during mobilisation.

Design of all the works involved, e.g., sheds, drainage, cross section, surfacing marking etc. shall be subject to the approval of OETC/Engineer. Design, construction, maintenance and removal by the Contractor shall be deemed to be included.

22.3 Temporary Lighting, Fencing, Security and Signage

The Contractor shall provide and maintain at his own cost all temporary lighting, fencing and security, complying in all respects to relevant local or national regulations and rules. In particular, such features shall be provided when and where necessary or required by the OETC/Engineer for the protection of the work and for the safety and convenience of the public.

At the entrance to the site, a signboard shall be provided and erected by the Contractor. The signboard shall comply with the regulations of the concerned authorities and shall show as a minimum the names and contact numbers of the Contractor and OETC/Engineer, and a contact number in case of an emergency.

22.4 Removal of the Temporary Site Establishment

As soon as the work is completed and before the issue of the Hand Over Certificate, the Contractor with prior approval of OETC/Engineer shall remove and clear away from the OETC's property all temporary offices installations and temporary facilities erected above and below ground, such as foundations, holding tanks etc. The Contractor shall fill resultant voids in the ground with appropriate and compacted fill approved by OETC/Engineer, leaving the terrain completely clean and with a tidy appearance. The Contractor shall also treat the

excavations executed for his own convenience, such as temporary roads, in a way acceptable to the OETC/Engineer.

23 SAFETY AND ENVIRONMENTAL PRECAUTIONS

Under the contract, the Contractor shall be responsible to OETC/Engineer for all safety and environmental related issues and actions for the Works, including those of his subcontractors. Reference shall be made to the OETC HSE Guidelines included in Annex 1 of these specifications.

Environmental issues include but are not limited to the elimination, reduction or management as appropriate of noise, dust, waste, vehicle movement and general nuisances.

The elimination, reduction or management of the effects of the Works on flora and fauna by the Contractor or his subcontractors will also be the responsibility of the Contractor. Any Environmental working restrictions imposed on the Contractor or his subcontractors by lawful Authorities or OETC/Engineer shall be strictly observed.

The Contractor shall provide a HSE Plan and comply with the requirements and reporting procedures defined in the OETC procedure OETC-HSE-O-SOP-M-002 'Contractor's HSE Requirements'.

The Contractor shall demonstrate his effective management of the subcontractor's attitude and approach to HSE by proposing and operating appropriate training and supervision of them, to the satisfaction of OETC/Engineer.

As the works are to be constructed in the vicinity of existing facilities (such as pipelines, power cable or any other underground equipment) the Contractor shall be responsible for ascertaining safety measures and precautions to be observed from the relevant Authority responsible for such facilities and/or equipment. The Contractor shall strictly comply with these precautions and safety measures.

A full time dedicated HSE Officer shall be appointed for each site. Where more than one site is involved a full time Senior HSE Officer/Manager shall be appointed with responsibility for HSE Management across all sites and for supervision of the full time HSE Officers at each site. OETC/Engineer shall have the right to add more safety Engineers at the Contractor's cost to ensure compliance with OETC/Engineer's safety regulations.

A weekly safety and environment report shall be submitted to OETC/Engineer.

The Contractor shall be responsible for all necessary safety measures in order to comply with any Statutory and contractual requirements. From the commencement of the work until acceptance, the Contractor shall strictly follow the safety requirements and recommendations for accident prevention.

Scaffolding shall be designed to appropriate standards and be subject to a checking, and approval by OETC/Engineer. The ground supporting the scaffolding shall be proven to have adequate allowable bearing capacity. Scaffolding shall be installed with all appropriate safety features including, but not limited to:

- Toe boards
- Hand rails
- Clamped walking boards
- Self-closing gates at ladder tops
- Access/egress methods.

Appropriately designed strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risk of slides, etc., shall be provided by the Contractor and included in the Contract prices. Designed physical support shall be mandatory for all material greater than 1.5 m. Any material proposed to be unsupported at any time shall be justified as stable by analysis and calculation.

In the event of soil slides occurring during earth and rock work, all damage, clearing away and making good will be at the expense of the Contractor.

Excavation below existing building foundations shall not be carried out until appropriate underpinning and shoring has been completed by the Contractor. All existing structures, foundations, pipes and cables which are to be incorporated into the final work, shall be adequately protected or replaced by the Contractor.

When excavation is to be carried out adjacent to and lower than any existing structure, the Contractor shall submit a method statement for supporting the existing works.

24 WATER, ELECTRICITY AND OTHER POWER

The Contractor shall be responsible for supplying all water, electricity and other power required for the Works and for any other purpose in connection with the Works. He should give notice and pay all fees as required by the respective water, electricity and other Authorities concerned with such supplies and services. There is no obligation on the part of OETC/Engineer to supply these services.

25 PREVENTION OF DAMAGE

The Contractor shall take all necessary and reasonable precautions during the period of the Works to prevent damage to land, walls, fences, channels, roads, building, services and the like on or adjacent to the Site and site accesses of OETC or third parties. When such items are to be removed or modified under the Contract, the method of removal or modification shall be agreed with OETC/Engineer.

26 INCLEMENT WEATHER

Programme extensions only will be considered by OETC/Engineer in the event of extreme weather conditions which prevent safe working. Programme extensions shall not be granted for public and official holidays including Ramadan and Eid, all of which shall be included and shown by the contractor in the programme.

27 APPROVED DRAWINGS

Drawings referred to in the sections of this specification which follow shall be understood to mean drawings prepared and submitted by the Contractor and approved by OETC/Engineer.

28 CLEANLINESS OF SITE

The Contractor shall at all times maintain the Site in a clean condition. All rubbish, debris and the like shall be collected as it accumulates and final clearance shall be carried out within 14 days of OETC/Engineer issue of the certificate of completion of the Works. All subcontractors shall maintain their plant, materials, stores and equipment in an efficient and workmanlike manner at all times, under the overall responsibility of the Contractor.

29 CIRCULARS AND MEMORANDA

The Contractor shall comply with the requirements of all Ministerial Circulars and Memoranda and statutory regulations, which shall be considered as forming part of this specification.

30 SITE SURVEY AND SOILS INVESTIGATIONS

30.1 General

Notwithstanding any preliminary site survey and soil investigation reports, which may be supplied with these Tender Documents for information purposes, the Contractor shall be responsible for arranging his own site survey and soils investigation using an approved independent subcontractor specializing in soil mechanics and foundation engineering in order to assess for himself the sub-surface conditions on site and to produce suitable foundation designs.

The specialist subcontractor shall be approved by OETC/Engineer prior to commencement of any soils investigation work.

The soils investigation should consist of a combination of trial pits and boreholes or other methods deemed necessary, and be carried out in accordance with this specification. The location of boreholes and trial pits shall be agreed with OETC/Engineer at the commencement of the Works.

All site survey and soils investigation work shall be carried out at the Contractor's cost and deemed to be included in the Tender Price.

The Contractor shall submit a report to OETC/Engineer, within the time stated in the Tender, on the geotechnical investigation setting out the complete logs and test results together with a discussion on foundation design and verification and justification of his chosen design.

The location map drawing provided is for the Contractor's guidance only and to assist him in preparing his own survey and site investigation. The provision of this data in no way relieves the Contractor of his responsibility to establish and verify for himself the features and ground conditions on site.

The geological and geotechnical site investigations should aim to, but not necessarily be

limited to, identifying the following properties and characteristics:

- a) Geological and geotechnical features of formations.
- b) In situ geotechnical properties.
- c) Ground water table, including any seasonal variations.
- d) Chemical composition of soils and ground water, with emphasis on the soluble salts (sulphate) and (chloride) content.

Particular attention shall be paid to the following:

- a) Design life of the facility
- b) Bearing pressure of the footings shall be considered in relation to the settlements that can be absorbed by the structures without structural and/or functional or serviceability damage.
- c) In chemically aggressive environments, foundations shall be constructed in dry conditions to enable the appropriate application of concrete protection, as necessary.
- d) If the foundation is required to be excavated into fine granular material below the water table, adequate dewatering must be provided. Well-point dewatering shall be considered.
- e) Long term protection piled concrete foundations.
- f) Protection or design against the effects of sink-holes or similar formations.

30.2 Location of Site

The location of the site is shown in the project Tender Documents.

30.3 Extent of the Site Survey and Soils Investigation Works

The works will include the sinking of boreholes and excavation of trial pits. Also included will be in-situ and laboratory testing.

The extent of the soils investigation and interpretations should be such as to provide comprehensive and representative information on sub-soil conditions to enable suitable foundation designs to be produced for all the works, including roads and hard standings.

The Tender Price shall be deemed to include for all the necessary soils investigation work including mobilisation costs.

30.4 Drawings

The Contractor shall carefully examine the drawings provided with this Tender and acquaint himself fully with the details and requirements of each site insofar as site investigations will be required.

He shall allow such sums as he considers necessary in his Tender to cover any special conditions required in the carrying out of the Works.

30.5 Site Access

The Contractor will be deemed to have satisfied himself as to the means of access to the Site and of transport of all labour, material and plant to and from and within the Site, paying due respect to all existing and proposed features.

The Contractor shall use, as far as practicable, existing road, tracks and hard standings in gaining access to the Site and individual trial pits and boreholes and test locations. The permission of OETC/Engineer must be obtained before entering the Site for any investigation purposes.

The Contractor shall provide and maintain all temporary roads and hard standings that he may require at the Site and clear them away on completion. The Contractor will be held responsible for repairing any damage he may cause in gaining access to or on the Site to the satisfaction of OETC/Engineer and the cost of repairs will be borne by the Contractor.

Approved type hoarding around the site shall be provided by the Contractor until completion of project.

30.6 Damage to Property

The Contractor shall carry out the Works with as little damage as possible to property, crops or existing features.

Where, in order to carry out the Works, it is necessary to remove walls or fencing, the Contractor shall provide temporary barriers or fences and take all precautions to ensure that such property, crops and existing features are maintained in a secure state.

Any damage to property, crops walls etc., shall be the responsibility of the Contractor who

shall make good any damage caused and reinstate removed items at his own expense.

30.7 Contractor's Area

Any huts or temporary buildings that the Contractor may require for his purposes shall be located in areas agreed with OETC/Engineer. The Contractor shall reinstate these areas on completion of work, to the satisfaction of OETC/Engineer.

30.8 Use of the Site

The Contractor shall at any time move any vehicle, wagon or any other obstruction within his control that may be required by OETC/Engineer to be moved. This shall be done promptly and at the Contractor's own cost, unless agreed otherwise with OETC/Engineer.

The Contractor shall be required at his own cost to fence, board over or otherwise protect all excavations throughout the duration of the Contract.

30.9 Drains, Streams Etc

All watercourses cut through or disturbed by the execution of the Works are to be restored so that water shall continue to flow in them in as full and free a manner as prior to the disturbance.

The Contractor shall at all times keep all water courses, the site and adjoining properties clean and free from pollution from any cause arising from his operations, and he shall indemnify OETC/Engineer against all claims arising from any such pollution.

30.10 Wayleaves

Where the Contractor needs to enter onto land subject to OETC/Engineer's wayleaves, he shall apply in writing for OETC/Engineer consent to such entry not less than fourteen days prior to his proposed date of entering such land and he shall observe any conditions imposed by OETC/Engineer.

30.11 Trespassing

The Contractor shall prevent his workforce from trespassing on any adjoining property for any purpose whatsoever.

30.12 Existing Services

The Contractor shall undertake such searches for services as may be necessary for their identification, safe avoidance or diversion (with the agreement of the third party). He shall take all reasonable precautions to avoid damage to any pipes, sewers, cables, telephones, water mains, gas lines and the like which he may encounter in carrying out the Works, and must adequately support and protect them to the satisfaction of OETC/Engineer.

The Contractor shall arrange indemnity against any damage caused to such services of OETC or third parties.

30.13 Site Working Conditions

Throughout the period of the Works, the Contractor shall arrange and maintain the whole of his operating area(s) in a clean, tidy and safe condition. All rubbish, waste material, debris etc. shall be systematically cleared away as it accumulates.

30.14 Cleanliness of Site

On completion of the works the Contractor shall clear and remove from the site all plant, rubbish and temporary works of every kind, except for protective measures such as fences, covers and the like and timbering which OETC/Engineer may order to be left in place. The site shall be left in a clean and tidy condition to the satisfaction of OETC/Engineer. Boreholes, trial pits and test sites shall be backfilled with excavated material thoroughly compacted, and the surplus of excavated material removed.

30.15 Regulations and Bye-Laws

The Contractor shall conform to all by-laws, regulations and requirements of the Local or any other Authority.

The Contractor shall also comply at all times with the requirements of OETC/Engineer regarding site security and the security clearance of all personnel entering the Site.

30.16 Levels, Setting Out and Supervision

The setting out of the boreholes, trial pits and test locations shall be carried out by the Contractor in accordance with the Contract drawings, or as otherwise instructed by

OETC/Engineer. All levels shall be referred to the national datum, or agreed local datum as indicated on the survey drawings.

The Contractor will appoint and employ in charge of each boring rig or test, an experienced Engineer capable of acting on instructions issued by OETC/Engineer at the Site.

30.17 Nature of Ground

The Contractor shall form his own opinion of the nature of the ground to be excavated or penetrated and no responsibility is assumed by OETC/Engineer as to the conditions which may be met during the progress of works.

The Contractor's Tender shall be inclusive of all classes of material which may be encountered whether hard or soft, rock, clay, sand etc. or whether it is in thin or thick beds stable or unstable.

30.18 Soil Samples and Testing

a) Trial Pits

At agreed locations shown on drawings, or as directed by OETC/Engineer, the Contractor shall excavate trial pits to a depth not exceeding three metres (or to rock head if at a lesser depth) and subsequently backfill and consolidate and leave in a safe, clean, and tidy state. The Contractor shall be responsible for the stability of the sides of the excavations and shall provide and install at his own expense all timbering and shoring necessary to ensure stability. Such works shall be designed, checked and approved as temporary works in accordance with this specification.

The exact position of each pit is to be recorded on the site survey plan provided with the Tender drawings.

Trial pit log sheets shall be plotted giving adjacent ground levels, depths, and descriptions of the various soil types encountered, depth at which ground water is encountered and the standing water level recorded after 24 hours. Representative jar samples shall be taken from each stratum as required for identification, classification and tests. Jars shall be airtight and clearly marked and labelled in accordance with BS 5930.

Where cohesive soils are encountered, undisturbed clay samples shall be taken from the

bottom of the excavated trial pits, coated with paraffin wax, securely packed and dispatched to the laboratory for determination of shear strength parameters. A plate bearing test may also be required to be carried out at the bottom of trial pit excavations in non-cohesive soils.

b) Boreholes

The Contractor shall sink boreholes in the agreed positions indicated on the drawings or as directed by OETC/Engineer. The depth of boreholes shall not be less than 10m unless otherwise instructed by OETC/Engineer. The boreholes shall be of such minimum diameter as is necessary to sink in the strata encountered to the specified depths and facilitate the tests and extraction of samples as required to provide data for the Site Investigation Report and appropriate interpretation for the design.

Full borehole logs shall be prepared recording the reduced level of the ground at the top of the borehole, details of strata penetrated indicating the depth from the surface of each change, the depth at which water is encountered and the standing water level after 24 hours. Rock core records should specify total core recovery, solid core recovery and quality of the rock cored.

Samples of soil shall be obtained in accordance with BS 5930 from all soil strata or at 1.5 metre intervals in a single stratum and tested to determine physical and chemical properties particularly with respect to substances which would react with concrete or buried metals. Depths of all jar samples and undisturbed samples for laboratory testing shall be recorded on the borehole logs.

In situ soil test shall be applied to all soil strata or at 1.5 metre intervals in a single stratum. These shall be: Standard Penetration Tests in **cohesive and** non-cohesive soils and weathered bedrock; undisturbed samples in cohesive soils and, if so directed by OETC/Engineer; shear vane tests in sensitive cohesive soils.

c) Soil Testing

All laboratory tests on disturbed and undisturbed samples shall be carried out at a laboratory approved by OETC/Engineer. The result of each test is to be made known to OETC/Engineer as soon as possible after the test is complete. The Contractor is required to make sufficient arrangements to ensure that no undue delay is experienced between obtaining of samples, testing, and communicating the results of the test to OETC/Engineer.

The sulphate and chloride content of ground water and soil shall be determined from samples from each trial pit and borehole.

Laboratory tests shall be carried out for the identification and classification of the various strata encountered in the works and to enable recommendations of foundation type and allowable bearing capacity to be made. Soil testing shall be carried out in accordance with BS 1377. The Contractor shall allow in his Tender for all other samples and tests and for all other field and laboratory tests he may require to provide a comprehensive set of results and recommendations.

30.19 Site Investigation Report

The Contractor is required to prepare and submit a factual and interpretative report with foundation recommendations which should include as a minimum an outline of the geology of the sites and the following:

- a) A detailed log of each trial pit and borehole together with the results of all site and laboratory tests - SPT or equivalent, index properties, particle size distribution, tri-axial tests, swell and shrinkage, sulphate content of soil and water, electrical resistivity and any other information as specified and as necessary for the proper design of the foundations and earthing system.
- b) An allowable bearing capacity of the sub-soil at various depths and an estimation of the corresponding settlement.
- c) Recommendations for the design of all foundations generally, including consideration of designing for earthquake resistance.
- d) Recommendations for protection against foundation failure due to sinkholes if they may be present.
- e) Recommendation for type of cement and concrete protection required for the soil conditions, including concrete cover to reinforcement.
- f) Coloured photographs of good quality of all borehole logs and trial pit excavations, clearly labelled.

Any site information or advice provided to the Contractor by OETC/Engineer is provided in good faith. It is the Contractor's responsibility to assess this information and take full responsibility for it if used in the design. Also, OETC/Engineer takes no responsibility for any

soils information found or realised and used by the Contractor during the contract.

31 CIVIL WORKS DESIGN

31.1 General

The Contractor shall use the drawings indicated in his accepted Tender as the basis for preparing his detailed designs and working drawings for all the civil works. Detailed designs and working drawings for all the civil works shall be submitted to OETC/Engineer for approval in accordance with the requirements below.

The civil works shall be designed on the basis of this Civil Works specification and in accordance with any relevant British and American Standards and Codes of Practice referred to therein and throughout the specification. The absence of any relevant American Society for Testing and Materials (ASTM), British Standard (BS) or Code of Practice (CP) from the text shall not relieve the Contractor of his obligation to comply with such ASTM, BS or CP as required by the specification.

The design life of the Civil and Structural Works shall be 50 years to first major maintenance.

Due regard for the premature deterioration of reinforced concrete through chemical attack shall be taken, particularly in respect of buried concrete. Appropriate concrete mix design and the use of physical barriers shall be used to suit in order to prevent this deterioration and achieve the specified design life.

Unless otherwise instructed in the Contract, other national or international codes, which meet or exceed the requirements of those specified may, at the discretion of OETC/Engineer, be substituted provided a full list of substitute codes complete with an English translation, where appropriate, is submitted with the Tender for OETC/Engineer's consideration. Failure to submit such codes with his Tender shall be taken to mean that the Contractor will observe the requirements of the codes and standards as specified herein.

In case of conflict between the standards OETC/Engineer's opinion will govern.

Unless indicated otherwise, the location of the sites and boundaries and position of entrance roads and access to the substations from the nearest public roads have been agreed with the appropriate planning departments.

The agreed site locations and layouts are shown on the Tender drawings and should be adhered to unless otherwise instructed by OETC/Engineer. The Contractor shall be responsible for clearing, grading and levelling the sites and the entrance road to each substation from the public road. He shall also agree the location and forming the junction with the existing road or planned public road, to the lines shown on the drawings and to the levels specified below.

Where planned road levels surrounding sites are not finalised, Tenderers shall allow in their price for sufficient backfilling to achieve a finished substation level of 150mm above the highest point of the existing or planned external road.

A detailed Fire Risk and Strategy Report shall be submitted by the Contractor. The author shall have appropriate qualifications and experience of the subject. The final report shall be submitted to OETC/Engineer for approval prior to the start of related design work.

The report shall detail all the fire risks and safety systems associated with the Contractor's design of the substation in its entirety. Typical content will include design philosophy, policies, standards and materials to be used in various locations, fire sealant requirements between areas, fire ratings for doors, walls, roller shutters etc. The proposed number, location and type of emergency exits and exit routes, etc., shall be listed and described.

The Fire Risk and Strategy Report for the whole facility including buildings and basements, and shall take cognisance of any Omani statutory requirements, Civil Defense Requirements' employed by the ROP and any firefighting and alarm specifications.

31.2 Design Work after Award of Contract

Immediately on his offer being accepted the Contractor shall commence preparation of the detailed design, working drawings and bending schedules, calculations and structural analyses to enable completion of the civil engineering works.

Within two weeks after award of Contract, the Contractor shall submit to OETC/Engineer a drawing register in an approved format setting out the number, title and proposed date of submission of drawings and calculation sheets for OETC/Engineer's approval. The Contractor shall be responsible for updating the register as necessary.

Copies of all the working drawings and supporting design calculations, where appropriate

shall be submitted to OETC/Engineer for approval before the date required for approval, to permit amendments to be made and to ensure the work they represent is commenced on Site without delay to the construction programme.

The Contractor shall only be authorized to proceed with the work shown on a drawing when a copy is returned to him stamped clearly with the OETC/Engineer's full approval and he shall subsequently provide OETC/Engineer with copies of the approved working drawing. Drawings which are not approved will be revised in line with OETC/Engineer's comments, and resubmitted for approval as above.

Design calculations and structural analyses should take into account the most unfavourable combination of dead, live and wind loading. Methods of computation and magnitude of loads shall be in accordance with the standards and Codes of Practice referred to above.

The Contractor shall refer to the General Requirements Specification Section 1.10 for minimum requirements of load combinations, load factors and factors of safety to be used in aspects of structural designs.

Any computer programmes proposed for design shall be verified as accurate by the provision of ISO 9001:2008 quality assured certification from the developer, or checked hand calculations.

The Contractor shall employ the services of a subcontractor/designer in accordance with the requirements of Section 4 'Civil subcontractors' of this specification. In his tender, the Contractor shall demonstrate how he will manage and take full responsibility for the work of such design subcontractor. OETC/Engineer shall take no responsibility for the work of any subcontractors.

The works shall be constructed in strict compliance with the approved working drawings except where full details of any amendment found to be necessary have been submitted to and approved by OETC/Engineer or where specific instructions in writing have been issued by OETC/Engineer in respect of any alterations, omissions or additions to the working drawings. All such modifications have to be included in 'as-built' drawings.

The Contractor shall be responsible for any discrepancies, errors or omissions in the drawings, calculations and other particulars submitted by him or his subcontractor(s) and

OETC/Engineer's approval of the same will not relieve the Contractor of his responsibility for the correct, proper and safe design and construction of the Works. The Contractor must further ensure that his designs satisfy the requirements of all relevant Local and National Authorities.

The Contractor shall produce reinforcement drawings and bending schedules detailed according to the 'Standard Method of Detailing Reinforced Concrete' published by The Concrete Society, Terminal House Grosvenor Gardens, London SW1W 0AQ. Bending, scheduling, dimensioning and cutting of steel reinforcement for concrete shall be in accordance with BS 8666. The Contractor shall observe the requirements of any revised version of the standard subsequently published.

The dimensions and size of the buildings shall be so selected that an adequate space is available for the equipment housing, easy service and maintenance. Appropriate access for trucks, cars, forklifts etc. required for all maintenance and replacements shall be provided. Hatches, doors, corridors and staircases shall be sized as appropriate so that equipment can be taken in or out as necessary.

The design of the buildings must ensure that the noise, vibration and temperature levels are within the acceptable limits in accordance with the design criteria and safety requirements. The Contractor shall give full details of the measures to be adopted and the materials he proposes to use to achieve these requirements.

The Contractor shall prepare all necessary design and detail drawings in accordance with the above and the Project requirements, whereby the attached Tender Document drawings shall only guide the Tenderer to provide the expected proposals.

The attached Tender Document drawings show the preferred layout arrangements of the substation. The arrangements shown on the drawings with these Tender Documents have been based on typical sizes of equipment and are provided for illustration only. The buildings and roads within the Site and their design and detailing shall comply with and satisfy the fundamental technical, operational, maintenance and removal requirements of the mechanical and electrical plant to be accommodated therein and with the requirements of this specification.

Room sizes shall not be smaller than shown on the drawings of these Tender Documents but may be larger if necessary to meet the requirements of the plant actually being supplied and

identified in the technical schedules by the Contractor. The Contractor should ascertain for himself during the Tender stage that the plant he proposes to supply will be suitable for the arrangements shown on his Tender drawings, and the Contract Price is deemed to include the cost of any enlarged buildings or modified layout to meet OETC/Engineer's design parameters.

Foundations shall be capable of restricting settlements and other movements in service to acceptable limits for the equipment and superstructure they support. All foundations shall be in reinforced concrete. Where the ground is excavated for any reason below the designed underside of the foundations, slab/trench etc. the void shall be filled with 20 N/mm² concrete.

Wet trades are to be avoided in the construction of the Works where technically feasible, if this will shorten the construction programme.

32 SITE PREPARATION

32.1 General

The scope of this work comprises clearing, cutting, grading and filling with suitable material, and supply of additional fill as and where required in order to establish the specified Site levels and the slopes to the adjacent areas. Dumping, spreading, watering, compacting, grading and levelling etc. of the whole site area are included.

Prior to starting any cut and/or filling works the following must be complied with:

- a) Detailed execution drawing for the cut and fill operation, as well as for any associated slopes, temporary works, protection of services, structures and safety considerations shall be prepared and submitted for OETC/Engineer approval.
- b) A detailed execution programme, together with a binding list of equipment the Contractor or his subcontractor intends to use shall be submitted for OETC/Engineer approval.
- c) An adequate number of benchmarks are to be installed at the Work. These shall be established with national grid elevations and co-ordinates.

Filling and compaction to form embankments, raising site levels and other similar works shall be undertaken in accordance with the requirements of the UK Highways Agency's 'Specification for Highway Works' Series 600: Earthworks, and BS 6031 Code of Practice for

Earthworks .

When fill is placed, areas to be filled shall be clear of any topsoil, deleterious material and standing water, unless otherwise specified.

Each layer shall be maintained at all times with a sufficient camber or cross fall and sufficiently even surface to enable surface water to drain readily from it.

Unless specified elsewhere in the above documents, uncompacted layers of fill shall not exceed 250 mm, with compaction carried out in accordance with the specifications.

Areas of general fill and embankments shall be built up with side slopes not greater at any time than that specified for the completed profile.

32.2 Execution of the Work

Filling shall be suitable material from excavation or other approved materials from borrow pits in the area compliant with the specifications and approved by the OETC/Engineer. It shall be free from slurry, mud, organic or other unsuitable materials and capable of compaction by established and conventional means.

Fill shall be placed in 150 mm thick layers, spread, sprinkled with potable water, and be thoroughly compacted and consolidated to its maximum densities with vibration compression machines prior to the placement of the successive layer. Filling with broken concrete blocks, bricks and other similar unsuitable materials shall not be allowed. All filled areas shall be left neat and smooth.

The Contractor shall be responsible for the appropriate reinstatement of any surface or structures which may have moved or otherwise been affected by his work.

Profiles to be done after backfilling shall be taken every 15 metres or less depending on the graded level. The measuring points along the profile will be every 10 metres or less depending on the change in the final filled level.

Filled areas that are to support structures shall be subjected to appropriate soil testing and any geotechnical recommendations are to be followed.

32.3 Compaction and Testing

Each layer of fill shall be adequately compacted throughout its full depth in accordance with the specifications prior to the placement of an additional layer.

Where the fill is to support any structure, including roads, pavements, parking areas and services, the filling material shall be compacted to a dry density not less than 98 % of its maximum dry density, tested in accordance with BS 1377 Part 4 Section 3 Cl 3.5. This minimum figure for dry density may be reduced to 95 % for fill elsewhere.

The Contractor shall submit for approval by OETC/Engineer the methods (plant type and number of passes etc.) with justifications by which he intends to achieve the specified compaction of fill.

The frequency of density testing shall be at least:

- Fill for structures, roads, pavements, parking areas and services: 1 No test per 100 m² per layer.
- General fill: 1 No test per 100 m² alternate layers.

Unless otherwise specified, in smaller areas of works a minimum of five tests shall be undertaken for every layer of roads, pavements, parking areas and services, and every second layer of general fill.

The Contractor shall notify OETC/Engineer when he intends to undertake filling operations.

32.4 Cavities/Over Excavation

If excavation is undertaken beyond the designed and approved lines or levels without OETC/Engineer's prior approval, the Contractor shall backfill with approved concrete at his own expense, the volume of concrete corresponding to the volume of over-excavation.

Cavities or over-excavations at the bottom or at the sides of rock excavations against which concrete is to be placed, whether due to lack of care on the part of the Contractor when making the excavation or due to the removal of materials damaged through an excess of explosives when blasting, or by the use of unsuitable excavation systems, shall be fully backfilled at the Contractor's expense with concrete of the same quality as the concrete of the structure to be erected at this place.

32.5 Stockpiles and Disposal of Excavated/Unsuitable Material

Excavated material from the works selected for re-use should be placed in its final position straight away if possible, otherwise the material may be stockpiled to the approval of OETC/Engineer. Spoil unfit for re-use shall be removed to the locations approved by the relevant Authorities.

The Contractor shall trim and form the edges of spoil heaps to profiles and levels as directed by OETC/Engineer. The Contractor shall ensure the flow of any water courses is not affected by the disposal of spoil material, and he shall observe any relative agreement between the Employer and other persons or Authorities concerned.

All excess excavated waste materials are to be disposed of away from the site by the Contractor at his cost, following regulations of the local Authorities.

The cost of the transportation of materials from the excavations to their final destination whether in the work or in the waste disposal areas, including any necessary and approved temporary stock-piling and the additional loading and transporting operations, shall be included in the Contract price.

32.6 Soil Import and Soil Improvement

The material to be imported shall not contain soluble or swelling components such as chloride or sulphates, clays, or organic matters. In generable sand and gravel mixtures of appropriate grading shall be used for replacement material.

Prior to the commencement of work, at least three samples shall be taken from the proposed borrow area and tested in respect of Proctor density, optimum moisture content, grain size distribution and content of soluble matters.

The samples shall cover the approximate variation of materials to be expected within the borrow area.

The fill material shall be placed in horizontal layers of no more than 250mm un-compacted thickness. The fill moisture content shall be controlled and adjusted in order to achieve a maximum of compaction. Fresh water shall be used for dampening the soils.

The fill material shall be compacted by vibrator roller. The minimum required degree of compaction shall be 98 %, tested according to modified proctor density. The testing location will be indicated by OETC/Engineer.

The results of the tests shall be made available to OETC/Engineer within 24 hours of the tests being performed. Filling work may continue only after all tests performed show satisfactory results.

32.7 Preparation for Foundations

All earth surfaces, against which concrete is to be poured, shall be clean and free of any detritus, impurities, organic matter or other unsuitable material. Immediately after excavation and any necessary soil replacement, all such surfaces shall be wetted and protected by means of a lean concrete layer 100 mm thick or as indicated on the approved construction drawings.

Ground water level shall be reduced to a minimum of 1.20 m below the base of foundation level.

All rock surfaces on which or against which concrete, fills or sealing material are to be poured, shall be carefully cleaned, prepared and roughened as described below.

Rock surfaces shall be free of oil, stagnant or running water, mud, loose rock, residue and impurities or any other improper material. Rock faults, depressions and fractures shall be cleaned, and all breccia and decomposed material shall be thoroughly removed to sound rock. Immediately before concrete or sealing material is placed, all rock surfaces shall be thoroughly cleaned by means of air and water jets, wire brushes, sand jets or by any other devices necessary to clean the foundation and keep it free of water, but the surface shall still be moistened before placing concrete or sealing material.

The Tenderer shall include in his Tender for all such foundation preparation work.

33 CLEARING & GRADING

33.1 GENERAL

The intent of this specification is to define the minimum requirement for Clearing

and Grading.

The Contractor shall execute grading for all areas within the required limits, including excavation from borrow areas and/or disposal of surplus material, spreading in layer with necessary compaction and or filling with approved material from outside the plant area.

33.2 STANDARDS

All works shall be executed to British Standards as applicable.

33.3 CLEARING

Clearing shall consist of clearing the surface of the ground of the designated areas of all undergrowth, debris and any rubbish of any nature, natural obstructions or such material which, in the opinion of the Engineer, is unsuitable for the foundation of the required structure. All spoil materials resulting from the clearing operation shall be disposed of by removing to approved disposal areas designated by the Engineer.

The Contractor is to familiarize himself with the existing condition at the site before quoting to understand the involvement of work.

33.4 ROUGH GRADING

Grading shall be done to the specified grading levels in different areas as indicated on the drawings. Grades not otherwise indicated shall be uniform levels or slopes between points and existing finished grades. The work shall involve partly excavation and partly fill, and materials obtained from excavation shall generally be used for fill if permitted by the Engineer. Lumps larger than 150 mm in size shall be broken down to use in fill if permitted by the Engineer, or otherwise be disposed of along with any organic material obtained from excavation.

Any shortfall in fill is to be obtained from borrow areas to be designated by the Engineer. Sub-base for the roads including shoulders shall be a suitable material

as approved by the Engineer.

Surplus and disposable materials are to be spread in disposal areas, trimmed and leveled in such a manner as not to interfere with the drainage of the area and be acceptable to the Engineer.

Filled areas shall be laid in layers not exceeding 200 mm in loose thickness and shall be compacted by smooth-drum vibratory rollers of 10 ton minimum static weight. The frequency of vibration between 20 to 30 cps is expected to result in desired compaction. Grading under roads and paving shall be carried to the subgrade of the base course, removing all large stones and debris, grading and compacting uniformly to the correct lines and levels for receiving the paving or slab. All areas of unsuitable subgrade material and areas where rock is encountered shall be excavated to a minimum depth of 300 mm below the subgrade, or to such depth as the Engineer may designate. The portion so excavated shall be refilled with suitable selected material as approved by the Engineer in a manner as stated above.

Depending on the percentage of fines, each layer shall be compacted to 80% average relative density (72% minimum) as per BS or 95% of maximum modified dry density. Water shall be added as required to achieve the desired compaction.

Field density test shall be done as per BS 1377. Frequency of the test will be decided upon by the Engineer. Compaction shall be considered as part of grading work.

33.5 COMPACTION OF EXISTING GRADE

Before start of the grading work, the above areas are to be checked for the existing degree of compaction. Where the compaction is below the above specified, the areas are to be compacted. If such areas were filled in the previously done work, the fill materials are to be excavated if required and re-laid in the manner as described above.

33.6 FINISH GRADING

During implementation of the project works, the rough grading is likely to be disturbed. On progressive completion of work in different areas, the final ground levels are to be finished to the final grade levels as shown on the drawings, by minimum 10 cm of crushed aggregate or wadi gravel on areas not covered by buildings or pavements. Additional fill materials, if required, shall be obtained from the previously excavated materials or from borrow areas as directed by the Engineer. Compaction shall be made as specified above.

The finish grading level shall be subject to Engineer's approval.

34 EARTHWORKS

34.1 GENERAL

The intent of this specification is to define the minimum requirement for Earthworks.

Notwithstanding any information contained within any report of a site investigation for this project the Contractor shall judge for himself the nature of the ground and shall be fully responsible for ascertaining all necessary information concerning permanent water table, periods of rainfall, flooding of the site and all matters affecting the excavations and foundation work.

The methods of excavation, which the Contractor desires to use, shall be at the sole discretion of the Contractor. The use of explosives may be permitted with the Engineer's written consent. The Contractor shall take all necessary precautions to ensure the complete safety of all site personnel, including any third party, together with all buildings on site, including buildings completed or partly completed by any third party.

The Contractor shall obtain all necessary licenses and permission covering the purchases and use of explosives, and shall meticulously observe the requirements of the relevant authorities.

The Contractor shall report to the Engineer when excavations are completed and are ready to receive blinding concrete or foundation concrete if blinding is not required, and shall obtain consent before depositing concrete.

In the event of excavations being made larger than the sizes shown on the drawings or as otherwise directed by the Engineer, the Contractor shall fill in the excavated void to the correct profile with selected fill or with mass concrete as described under the specification for Concrete Work hereinafter at his own expense.

The final 150 mm depth of all excavations shall be taken out by hand unless allowed by the Engineer otherwise and the bottom levelled and rammed immediately prior to placing concrete.

Should gypsum or any similar material be encountered at the bottom of any excavation, it shall be removed and the extra depth filled with concrete as directed by the Engineer.

Where shown, the excavation shall be either blinded or filled with concrete (Mix 10/20) and shall be placed as specified as soon as possible after the formation is approved, but not later than 24 hours after the final trimming of the bottom of the excavation, after which time fresh approval shall be sought and obtained from the Engineer before proceeding with this work.

34.2 POOR GROUND

Loose soil, bad ground or cavities met within any part of the excavations for foundations of structures shall be excavated to a solid formation and filled to foundation level with mass concrete as described in the Specification for Concrete Work.

34.3 EXCAVATION IN ROCK AND BOULDER ROCK

The Contractor shall notify the Engineer on each occasion he considers that he is

entitled to payment for excavation in rock and shall not fill any excavation concerned until it has been inspected by the Engineer. No payment for excavation in rock shall be made unless the Engineer has inspected the excavation and certified in writing the quantity involved.

Rock in this context is any material met which is, in the opinion of the Engineer, of such size or position that it can only be removed by means of compressed air or other special plant, or explosives.

34.4 SHORING EXCAVATIONS

The Contractor shall, to the satisfaction of the Engineer, shore the sides of excavations for structures, trenches and pits to prevent them from slipping or falling. Should any slips, falls or settlement nevertheless occur they shall be made good by the Contractor, at his own expense, with selected fill or with mass concrete as may be directed by the Engineer.

In removing shoring from the sides of excavations, care shall be taken to avoid bringing loads onto any concrete until it has hardened sufficiently to carry such loads.

Timber or other materials used for shoring the sides of excavations shall be removed as the work proceeds except when ordered to be left in by the Engineer.

The Contractor shall submit to the Engineer for inspection calculations and working drawings for the proposed scheme of strutting and retaining the sides of the excavations and shall not proceed with the appropriate section of the works until receipt of the Engineer's written consent.

The receipt of such consent shall not relieve the Contractor from any of his duties and responsibilities under the Contract.

The Contractor shall be responsible for the stability of all excavations, and for the maintenance and protection of any adjacent property, structures and roads.

34.5 BACKFILLING

Foundation trenches, column bases and the like are to be backfilled with selected excavated or imported materials as directed by the Engineer, and consolidated by approved methods to the satisfaction of the Engineer in layers not exceeding 150 mm in thickness. The fill material shall comply with the requirements mentioned under Clause 34.10 of this Section.

34.6 DISPOSAL OF SURPLUS EXCAVATED MATERIAL

Surplus excavated material shall be removed from Site by the Contractor to approved locations or as otherwise directed by the Engineer.

34.7 TRIMMING OF SLOPES

The slopes of cuttings and embankments shall be trimmed by hand or by approved mechanical means to uniform batters as shown on the drawings or as directed by the Engineer. A tolerance of plus or minus 100 mm measured at right angles to the batter will be permitted.

Any rock or boulder appearing in the face of a cutting shall be trimmed back to within the tolerance specified above and, in addition, any such rock or boulder which in the opinion of the Engineer is unstable shall be completely removed and the resulting void filled with compacted material to the approval of the Engineer.

34.8 MAKING UP LEVELS UNDER GROUND SLABS

The area shall be trimmed to a clean, properly compacted uniform surface to the lines and levels shown on the drawings. Any soft areas considered unsatisfactory by the Engineer shall be taken out and the extra depth filled with approved compacted fill material.

Compacted fill shall comprise non-plastic granular material, well graded and shall be laid over the foundation in layers as specified on the drawings not exceeding 150 mm thickness after compaction for each layer. It shall be laid properly

compacted by mechanical means with a uniform surface and blinded with approved fine materials to the line and levels shown on the drawings. The density after compaction shall not be less than maximum dry density obtained in Test 13 of BS 1377.

Backfilling and compaction operations to make-up the levels under ground slabs shall proceed at the same time as backfilling to final external levels. The difference in the level of the backfill between inside and outside of walls shall not be permitted to exceed 200 mm unless noted otherwise.

34.9 NON-COMPACTED FILL

Non-compacted fill shall be non-plastic granular material to the approval of the Engineer.

34.10 HARD CORE

The Contractor shall supply non-plastic granular material fill from a source approved by the Engineer.

Fill material shall be not greater than 70 mm diameter, not more than 15 % shall pass the 200 sieve and it shall be free from all debris, organic matter and the like.

The Contractor shall submit to the Company all sieve analysis reports on all fill material.

The method of grading shall comply with BS 1377 and shall be within following limits:

BS Sieve Size	by mass passing
70 mm	100 %
37.5 mm	85-100 %
10 mm	40-70 %
5 mm	25-45 %

600 μm	8-22 %
75 μm	0-10 %

Fine-grained material having moisture content in excess of 4 % of plastic limit shall not be used as fill. The chloride and sulphate contents of the material shall not exceed 0.05% and 1.2 gm/l respectively.

Placing of soil shall not be started until approval by the Engineer has been obtained. It shall be properly laid in layers of not exceeding 150 mm in thickness compacted by mechanical means. The density after compaction shall not be less than maximum dry density obtained in test 13 of BS 1377.

34.11 PROTECTION OF SERVICES

The Contractor shall maintain and protect all permanent mains, services, etc. serving adjacent buildings where affected by the excavations.

34.12 DEWATERING

The Contractor shall be responsible for keeping all excavations free from water from whatever cause arising from whatever means.

The Contractor shall make good at his own expense any damage that may result from his failure to keep the excavations free from water.

Grading in the vicinity of excavation shall be controlled to prevent surface water running into excavated areas. The Contractor shall remove, by pumping or other means as approved by the Engineer, any water inclusive of rainwater and subsoil water, accumulated in excavation and keep the pit dewatered until the construction of foundation structure is complete. Sumps, if made for dewatering, must be kept clear of the foundations.

Method of pumping shall be approved by the Engineer, but in any case the

pumping arrangement shall be such that there shall be no movement of subsoil or blowing in due to differential head of water during pumping.

Dewatering operations shall not be discontinued until allowed by the Engineer.

34.13 POLYTHENE SHEETING

Polythene sheeting where shown on the drawings shall be of 1000 gauge supplied in rolls and laid by rolling over the prepared base at the levels, and in the areas shown on the drawings. Where a joint is necessary at the side or end of a sheet, this shall be a double welt folded joint made by placing the edges together and folding over twice. The joint shall be prevented from opening prior to concreting by blocks at intervals on top of the joints.

The Contractor shall protect the sheets from damage during laying and subsequent operations and shall replace all damaged sheets to the satisfaction of the Engineer.

35 CRUSHED AGGREGATE BASE

35.1 GENERAL

The Contractor shall execute all work pertaining to crushed aggregate base for roads and paving as indicated on the drawings and specified herein.

The work shall consist of a course composed of crushed aggregate placed and compacted on the prepared subgrade in accordance with this specification and in conformity with lines, grades, thickness and typical cross sections shown on the plans.

Aggregate base will be placed to the limits, locations and areas as required or as indicated on the drawings.

35.2 STANDARDS

American Association of State Highway Officials (AASHO) Specifications.

35.3 WORK NOT INCLUDED

Preparation of subgrade for placement of crushed aggregate base is covered under "Clearing and Grading".

Course to be placed on completed crushed aggregate base is specified under "Hot Bituminous Concrete Pavement".

35.4 SITE INVESTIGATION

Before placement of crushed aggregate base, all pipes, conduits, trenches, etc., passing under the proposed work shall be completed and shall have been subjected to required tests where applicable. Backfill material at such crossing shall be checked for compaction, and lines and grades shall be in conformance with adjacent surfaces before placement of base material.

35.5 MATERIALS

Crushed aggregate shall consist of hard, durable particles or fragments of stone, and a filler of sand or other finely divided mineral matter.

Crushed aggregate shall be uniformly graded from coarse to fine and shall conform to the requirements given in Table 1 below. The portion of the material passing a No. 4 sieve shall be known as filler. The materials shall be free from vegetable matter and clay balls.

Coarse aggregate shall have a percentage of wear of not more than 50 for 500 revolutions as determined by AASHO T 96.

For all grading, that portion passing a No. 40 sieve, including blending filler, shall

be non-plastic or shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 as determined by AASHTO T 89 and T 90, respectively.

The material must pass the ASTM soundness test so that the decrease after 5 cycles will be not more than 12% when sodium sulphate is used, or not more than 18% when magnesium sulphate is used.

The grading percentages specified in Table 1 shall apply to the material after it has been processed on the road as well as when tested at the pit or other source of supply.

Table 1:

Grading Requirements for Aggregate

Percentage by Weight Passing Square Mesh Sieve

Sieve Designation	Grading
3 inch (75 mm)	---
2 inch (50 mm)	100
1-1/2 inch (37 mm)	70-100
1 inch (25 mm)	55-85
3/4 inch (20 mm)	50-80
1/2 inch (12 mm)	---
3/8 inch (10 mm)	40-70
No. 4	30-60
No. 10	20-50
No. 40	10-30
No. 200	5-15

Note: The fraction passing the No. 200 sieve shall not be greater than two-thirds the fraction passing the No. 40 sieve.

If fine aggregate or filler in addition to that naturally present in the base course

material is necessary in order to meet the grading requirements, or for satisfactory bonding of the materials, it shall be uniformly blended with the base course materials at the screening and crushing plant or on the road. The material for such purpose shall be obtained from sources approved by the Engineer and shall be free from hard lumps.

35.6 APPROVAL OF MATERIALS

The Contractor shall furnish the Engineer with samples of crushed aggregate base material prior to delivery to the site, and at other times at his request. Final approval of the material by the Engineer for delivery to the site will be given only after these samples have been tested and approved by a Materials Laboratory approved by the Engineer. Testing by the Materials Laboratory shall be continuous, and approval of the material may be withdrawn whenever samples fail to pass the specifications established in this section. Any damage or delays in the work due to the non approval of substandard material shall be the sole responsibility of the Contractor.

35.7 CONSTRUCTION

Subgrade, including shoulders, shall be constructed, prepared, and finished as provided under section "Clearing and Grading".

Base materials shall be placed on the prepared subgrade and compacted in layers of the thickness shown on the plans. Where more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

The placing of material shall begin at the point designated by the Engineer. Placing shall be from spreader boxes or from vehicles especially equipped to distribute the material in a uniform layer or windrow.

The layer or windrow shall be of such size that, when spread and compacted, after making due allowance for any blending material that is to be added on the road, the layer shall have the required thickness.

When hauling is done over previously placed material, hauling equipment shall be routed as uniformly as possible over the entire area of previously constructed layers.

When additional fine aggregate or filler is required and it is to be blended with the material on the road, the blending material shall be uniformly placed with spreader boxes or other approved devices.

After each layer of base course material has been placed, and blending material added when required, it shall be thoroughly mixed to its full depth by means of power graders, travelling mixes, or other mixing equipment. During mixing, water shall be added in the amount necessary to provide the optimum moisture content for compacting. When uniformly mixed, the mixture shall be spread smoothly to a uniform thickness or, in case of the top layer, to the cross section shown on the plans. The Contractor, shall so schedule his operations as to assure completion of spreading within 48 hours after processing. No segregation of the material while mixing and spreading will be allowed.

Immediately following final spreading and smoothing, each layer shall be compacted to the full width by means of smooth-wheel power rollers. Each 100 cubic meters compacted measurement of material placed, shall receive at least 1 h of continuous rolling. Rolling shall progress gradually from the sides to the center, parallel with the centerline of the road, and shall continue until the entire surface has been rolled. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. Along curbs, headers and walls and at all places not accessible to the roller, the base material shall be tamped thoroughly with mechanical tampers. The material shall be both bladed and rolled until a smooth, even surface has been obtained.

The amount of rolling and tamping as required above is estimated as the minimum necessary for adequate compaction.

If, in the opinion of the Engineer, compaction is not adequate, the Contractor shall perform additional rolling or tamping as may be necessary to obtain the desired compaction.

The Engineer may permit compaction with types of equipment other than those specified above, provided he determines that use of the alternative equipment will consistently produce densities of not less than 100 %, determined as provided above. The Engineer's permission for use of alternative compaction equipment shall be given in writing and shall set forth the conditions under which the equipment is to be used.

The thickness of the completed base shall not vary more than 20 mm from the thickness shown on the plans.

Immediately after final compaction of the base, the thickness shall be measured at one or more points in each 500 linear meters of base. Measurements shall be made by means of test holes or other approved methods. The points for measurement shall be selected by the Engineer at random locations within each 50 m section in such manner, as to avoid any regular pattern. Various points on the cross section shall be covered. Whenever a measurement indicates a variation from the thickness shown on the plans of more than the allowable tolerance, additional measurements shall be taken at intervals of approximately 10 m until the measurements indicate that the thickness is within the allowable tolerance. Any area not within the allowable tolerance shall be corrected by removing or adding material as necessary and shaping and compacting as specified at no extra cost to the Employer.

The cutting of test holes and refilling with materials properly compacted shall be done by the Contractor under the supervision of the Engineer at no extra cost to the Employer.

When tested with a crown template conforming to the typical cross section shown on the plans, and a 3 mmeter straightedge applied at right angles and parallel,

respectively, to the centerline of the roadbed, the variation of the surface from each testing edge between any two contacts with the surface, shall, at no point exceed 20 mm for the crown template and 10 mm for the straightedge.

36 HOT BITUMINOUS CONCRETE PAVEMENT

36.1 GENERAL

The intent of this specification is to define the minimum requirement for Hot Bituminous Concrete Pavement work.

The Contractor shall execute all work pertaining to hot bituminous concrete pavement for roads and paving as indicated on the drawings and specified herein.

The work shall consist of laying a wearing course composed of dense graded bituminous concrete construction on a prepared crushed aggregate base course, on roads and pavements, in accordance with this specification and in conformity with lines, grades, thickness and typical cross sections shown on the drawings.

36.2 STANDARDS

American Association of State Highway Officials (AASHO) Specifications.

36.3 WORK EXCLUDED

Preparation of subgrade for placement of crushed aggregate base is specified under section "Clearing and Grading".

Crushed aggregate base to be placed on prepared subgrade prior to placing hot bituminous concrete pavement is specified under specification for "Crushed Aggregate Base".

36.4 SITE INVESTIGATION

Before placement of bituminous concrete pavement, all pipes, conduits, trenches, etc., passing under the proposed work shall be completed and shall have been

subjected to required tests where applicable. Backfill material at such crossing shall be checked for compaction, and lines, grades and thickness of base course shall be in conformance with adjacent areas before placement of base material.

36.5 MATERIALS

The pavement shall be constructed in two layers consisting of a wearing course and a binder course, unless one-course construction is called for on the plans.

The wearing course shall comply with all requirements stipulated in the next paragraph. The binder course shall also comply with all those requirements, except that the percentage of material passing a No. 200 sieve shall be from 0 to 5 % and except that no mineral filler need to be added.

The several mineral constituents for the mixture shall be so sized and graded and shall be combined in such proportion that the resulting blend meets the grading requirements in Table 1 below. The fraction actually retained between any two consecutive sieves shall be not less than 4 percent of the total, and for the wearing course at least one-third of the fraction passing the No. 200 sieve shall be mineral filler. To such blended aggregate (considered as 100 percent), bituminous material shall be added within the percentage limits shown in Table 1.

Table 1:

Grading Requirements for Aggregate

Percentage by Weight Passing Square Mesh Sieve

AASHTO T11 and T27

Sieve Designation	Grading A	Grading B
1 inch (25 mm)	100	---
3/4 inch (20 mm)	70-100	100

1/2 inch (12 mm)	55-90	---
3/8 inch (10 mm)	40-80	---
No. 4	30-55	45-65
No. 8	---	33-53
No. 10	22-47	---
No. 40	16-38	---
No. 40	12-32	10-25
No. 80	8-20	---
No. 200	4-8	3-8

Bitumen (sol. CS2) percent	5.0-8.0	3.5-7.0
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Crushed aggregate shall consist of hard, durable particles of stone having a percentage of wear not more than 40 for 500 revolutions as per AASHO T96.

The materials shall conform to the requirements of the specifications. Asphalt cement shall be of penetration grade 60-70 or 85-100, and tar shall be grade RT-11 or RT-12.

36.6 APPROVAL OF MATERIALS

The Contractor shall furnish the Engineer with samples of crushed aggregate base material prior to delivery to the site, and at other times at his request. Final approval of the material by the Engineer for delivery to the site will be given only after these samples have been tested and approved by a Materials Laboratory approved by the Engineer. Testing by the Materials Laboratory shall be continuous, and approval of the material may be withdrawn whenever samples fail to pass the specifications established in this section. Any damage or delays in the work due to the non approval of substandard material shall be to the sole responsibility of the Contractor.

36.7 CONSTRUCTION

Mixing shall be done in suitable pug mill or continuous mixer. Minimum time of mixing shall be 30 seconds, and mixing shall be sufficient to coat all particles. Transporting shall be done in trucks having insulated, light, clean, oiled bodies. Each truck load shall be tarpaulin covered.

Placing shall be done only when surface is dry and atmospheric temperature is above 5 °C. Placing shall not start until prime coat has set. The contact surfaces of all structures shall be painted with hot bituminous material as used in the mixture. The mixture shall be spread by mechanical spreaders; only in inaccessible locations shall the mixture be spread by hand. Hand placing shall be from a steel dump board by means of hot shovels. Hand spreading shall be done with hot rakes of suitable design.

The mixture, as it will bear the roller without undue displacement or hair cracking, shall be rolled with a 3-wheel roller weighing not less than 10 ton, immediately after spreading. Roller wheels shall be equipped with scraping and sprinkling devices and shall be kept properly moistened without excess of oil or water. Rolling shall start longitudinally at the sides and proceed toward the center. Each trip of the roller shall overlap the previous trip by at least 300 mm. Alternate trips of the roller shall be slightly different lengths. The speed of the roller shall not exceed 5 km per hour.

Where no curb exists, the roller wheel shall overlap the shoulder a sufficient number of times to compact the shoulder firmly against the pavement. Then rolling shall be done diagonally in two directions with a tandem roller weighing not less than 8 tons, the second diagonal crossing the lines of the first. If pavement width permits, rolling shall also be at right angles to the center line. Rolling shall be continued until all creases have been removed and desired consolidation attained. Mechanical tampers shall be used for compacting in locations inaccessible to the roller.

When new mixture is placed against previously placed mixture, the joint shall be cut back to a clean, vertical surface and painted with hot bituminous material as used in the mixture.

The maximum temperature of the asphalt cement as delivered to the mixer shall be that at which it has a Saybolt-Furol viscosity of 75 sec. Asphalt cement shall not be used while foaming nor shall it be heated above 177°C at any time.

Tar shall be delivered to the mixer at a temperature between 80°C and 121°C.

When asphalt cement is used, the temperature of the aggregate as introduced into the mixer shall not exceed that, at which the asphalt cement has a Saybolt-Furol viscosity of 75 seconds. It shall not be lower than is required to obtain a complete coating and uniform distribution of the aggregate particles and to provide a mixture of satisfactory workability.

When tar is used, the temperature of the aggregate as introduced into the mixer, shall be between 60°C and 107°C.

The Engineer will set the job-mix temperature with due consideration of the above factors but in no case shall the specified maximum temperature be exceeded.

The heated ingredients shall be combined in such a manner as to produce a mixture which, when emptied from the mixer, shall be at a temperature between 121°C and 177°C for asphalt mix and between 80°C and 107°C for tar mix and within the allowable tolerance of the temperature set in the job-mix formula. The maximum mixing time shall be limited as directed by the Engineer to avoid undue changes in the characteristics of the bituminous material.

Asphalt recovered from pavement samples as prescribed below shall have a penetration of at least 50 percent of the penetration of the asphalt cement before mixing, and a ductility of at least 40 centimeters when tested in accordance with AASHTO T 49 and T 51, respectively.

The asphalt shall be extracted from the pavement samples in accordance with AASHO T 164. The contained mineral particles in the bitumen solvent solution shall be removed in a centrifuge and the solution shall then be concentrated to approximately 200 ml. This removal of minerals shall be considered satisfactory when the content (by ignition) of the recovered bitumen is not greater than 1 percent by weight. The bitumen shall be recovered from the solution in accordance with AASHO T 170.

The mixture shall be delivered on the road at a temperature between 107°C and 163 °C for asphalt mix and between 66°C and 107°C for tar mix and within the allowable tolerance of the temperature set in the job-mix formula.

The specific gravity of the consolidated pavement shall be not less than 95% of the specific gravity of Laboratory compacted specimen composed of the same materials in like proportions. Laboratory specimens shall consist of 100 mm x 100 mm cylinders of the mixture, molded under a static pressure of 211 kg/mm² for 2 minutes. The double plunger method shall be used and the temperature of the mixture at time of molding shall be approximately 120°C for asphalt mixture and approximately 93°C for tar mixture.

The Contractor shall cut from the finished work samples not less than 220 mm square, for testing by the Engineer. Samples shall be taken of the mixture for the full depth of the course from the locations directed by the Engineer. Number of samples per day shall be as decided by the Engineer. In addition, samples shall be taken whenever a substantial change is made in the job-mix. Where samples have been taken, new material shall be placed and finished satisfactorily at no extra cost to the Owner.

Sections of the newly finished work shall be protected from traffic of any kind until the mixture has become properly hardened by cooling. In no case shall traffic be permitted less than 6 hours after completion of the pavement unless a shorter period is authorized by the Engineer.

The finished surface shall be smooth and the thickness shall not vary by more than 5 mm. The finished profile shall not vary more than 5 mm in 3.0 meters.

37 KERBS AND CARRIAGEWAY MARKING

37.1 KERBS

The intent of this specification is to define the minimum requirement for kerbs and carriageway marking work.

Kerbs shall be precast concrete and shall conform to BS EN 1339 and BS EN 1340 and shall be manufactured by pressing and using sulphate resisting cement complying with BS 4027.

37.2 LAYING AND JOINTING KERBS

Precast raised kerbs shall be laid with a 5 mm gap and pointed with a 1 to 3 cement mortar to road level. One joint in ten shall be left unpointed and a 10 mm compressible insert provided for expansion; a similar coincident joint shall be formed in the haunch.

Hydraulically pressed kerbs with ends consistently square and true may, subject to approval, be laid unpointed with tight butt joints.

Kerbs shall be protected from defacement by bitumen or cement.

37.3 ALIGNMENT OF KERBS

The longitudinal and vertical alignment of kerbs shall not deviate more than + 5 mm from the true line. The rate of deviation from this true line shall not exceed 1 mm/m run of kerbs.

37.4 PAINTING OF KERBS

If kerbs are required to be painted they shall be painted with two coats of an Alkyd Enamel with good gloss, color retention, weather resistance and resistance to salt

water and aliphatic hydrocarbons, thinners in accordance with manufacturers instructions, white black or yellow as instructed. Preparation and painting shall be carried out as follows:

- a) Remove all dust and loose particles from the kerb by rigorous brushing.
- b) Dilute an alkyd enamel with good gloss, color retention, weather resistance and resistance to salt water and aliphatic hydrocarbons with up to 5% by volume of thinner. Thinners shall be in accordance with manufacturers instructions.
- c) Thoroughly mix the paint in the can.
- d) Apply the paint by brush with a complete and uniform coating.

37.5 MARKING MATERIALS

Marking materials shall be in accordance with BS 3262 and shall be suitable for road surface temperatures of up to 80°C.

37.6 APPLICATION OF MARKINGS

Carriageway markings shall only be applied to surfaces which are clean and dry. If the pavement has become polished, a tack coat compatible with the marking material may be required to be applied in accordance with the manufacturer's instructions before marking.

38 FENCING

38.1 GENERAL

The intent of this specification is to define the minimum requirement for furnishing of all services necessary for or incidental to supply, fabrication and installation of the Fencing in accordance with the drawings and as specified herein.

The following work shall be included:

- a) Chain link fences
- b) Gates
- c) Foundations
- d) Padlocks

38.2 Standards

The latest editions and/or addenda thereto, of the following standards and specifications, form a part of this specification.

BS	Specification for anti-intruder fences in chain link and
1722-	welded mesh.
10	

38.3 MATERIALS

Fencing shall be chain link and all parts galvanized.

Fabric shall be chain link type and shall be woven from galvanized wire with an outside diameter of 4.75 mm including the PVC coating. The inner core shall be 3.55 mm to a mesh size of 50 mm. The color shall be dark green.

Line posts shall be made from Standard equal Angles of flange min. 40x40 as per BS EN 10056, or galvanized Circular Hollow Sections as per BS EN 10255 Medium Grade or Heavy Grade in min. diameter of 48.3 mm and shall be spaced 3.0 meters on centers maximum. Posts shall have angle type extension arms at an angle of 40° to 45° to the vertical. All posts shall have concrete footings capable of supporting the posts in a true vertical position and eliminating the possibility of uprooting the posts and footing.

Barbed wire shall consist of three rows of a strand 6 mm² galvanized 4 point thick-set barbed wire secured to the posts with 4 mm² galvanized wire loops.

Steel extension arms shall be GI pipe / mild steel angle and galvanized. Each arm

shall be held to take half hairpin staples of PVC coated GI wire for fixing three lines of barbed wire 150 mm apart and shall be provided with two 9.5 mm diameter galvanized bolts.

Standard braces at corner posts, terminal posts and gate posts shall be provided.

Strainer, corner and end posts shall be made from Standard equal Angles of flange min. 50 x 50 as per BS EN 10056, or galvanized Circular Hollow Sections as per BS EN 10255 Medium Grade or Heavy Grade in min. diameter of 60.3 mm.

Gates shall be the same height as the chain link mesh on the fence. Chainlink infill gates shall be made to match chainlink fence system.

Gates shall have main frame, rod bracing and chain link fabric. Gate frames shall be min. 50x50 angles or min. 60.3 mm Medium or Heavy Galvanized Circular Hollow sections outside diameter. Cross bracings shall be 20 mm diameter adjustable truss rods and the corners shall be welded.

Gate posts shall be made from Heavy duty Circular Hollow Sections of diameter min. 88.9 mm.

All necessary hardware, including bronze cylinder padlock, shall be provided. Padlocks shall not be masterkeyed.

All fittings shall be galvanized.

Cleats, one to each eyebolt, shall be of galvanized not less than 50 x 50 angle 50 mm wide.

Eyebolt strainers shall consist of 10 mm diameter bolt with welded eye sufficiently threaded and fitted with a nut and washer. Two-way eyebolt strainers shall have suitable rings nuts, fitted after the wires have been strained on one side.

Stretcher bars shall consist of mild steel flat 25 mm x 5 mm. They shall be secured to the cleats by 8 mm diameter steel bolts.

Droppers for barbed wire shall be of mild steel not less than 25 x 5 mm thick with 38 x 4.85 mm hair pin staples PVC coated GI wire for fastening the barbed wire to them.

38.4 INSTALLATION

Installation shall be in accordance with manufacturer's instructions. Corners shall be square where required. Posts shall be aligned in the horizontal and vertical directions.

Fabric shall be attached by stretcher bars and tie wires and tension connections shall be spaced at 300 mm.

Posts shall not deflect in any direction thereby causing gates not to close properly.

Hold open and meeting stop shall be provided for all gates, securely anchored into the ground and/or pavement.

Gates shall be hung on a minimum of two galvanized steel hinges not less than 85 mm wide, clamped securely to the gate posts and allowing the gate to swing back against the fence. Hinges shall be designed and so arranged that the gate cannot be removed without mechanically dismantling the hinges.

Gates shall be secured with padlocks and to this end each gate shall be fitted with a latch with padlock eyes of the forked or plunger type, operated from either side of the gate. Double gates shall be fitted with stops and a center rest and catch.

The top lines of the barbed wire shall be fitted with droppers so that they cannot be bunched together.

As far as possible the fence shall run in straight lines. Where changes of direction are required, the angle shall be not less than 130°.

The fence shall be sunk into a concrete channel 150 x 150 mm to prevent burrowing. The channel shall be a minimum of 50 mm below the ground line

(graded).

39 CONCRETE WORK

39.1 GENERAL

The intent of this specification is to define the minimum requirement for the design, supply and storage of materials and consumables, execution, testing, curing and finishing of all concrete work.

39.2 DESIGN REQUIREMENTS AND DRAWINGS

All materials and methods for complete execution of plain and reinforced concrete work shall be in accordance with the relevant requirements of BS EN 1992 "Eurocode 2: Design of concrete structures" and the specifications as referred to therein to ensure a service life of at least 50 years.

The Contractor shall be responsible for setting out the work on site as per the approved drawings necessary for the proper execution of the works. Should the Contractor find any discrepancies on the drawings, he is to refer the matter to the Engineer for decision before proceeding with the part of the work affected.

The whole of the work shall be accurately constructed in accordance with the approved drawings.

39.3 STANDARDS

The latest editions and/or addenda thereto of the following standards and specifications form a part of this specification.

BS EN 1991	Eurocode 1. Actions on structures.
BS EN 1992	Eurocode 2. Design of concrete structures.
BS EN 1993	Eurocode 3. Design of steel structures.

BS EN 1996	Eurocode 6. Design of masonry structures.
BS EN 1997	Eurocode 7. Geotechnical design.
BS EN 197	Cement. Composition, specifications and conformity criteria for common cements
BS EN 1097	Tests for mechanical and physical properties of aggregates.
BS EN 12620	Aggregates for concrete
BS EN 1992-1-1	Eurocode 2. Design of concrete structures. General rules and rules for buildings
BS EN 12350	Testing fresh concrete
BS EN 12390	Testing hardened concrete
BS EN 1015	Methods of test for mortar for masonry
BS EN 1008	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete
BS 4027	Specification for sulphate resisting Portland cement
BS 4449	Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification
BS 8666	Scheduling, dimensioning, bending and cutting of

steel reinforcement for concrete. Specification

BS 4483	Specification for steel fabric for the reinforcement of concrete
BS 4482	Steel wire for the reinforcement of concrete products. Specification
BS EN 196	Methods of testing cement
BS 4551	Mortar. Methods of test for mortar. Chemical analysis and physical testing
BS EN 934-2	Admixtures for concrete, mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labelling
BS EN 480	Admixtures for concrete, mortar and grout
BS EN 13670	Execution of concrete structures
BS 5080	Structural fixings in concrete and masonry
BS EN 206-1	Concrete. Specification, performance, production and conformity
BS 5975	Code of practice for temporary works procedures and the permissible stress design of falsework
BS 6089	Assessment of in-situ compressive strength in structures and precast concrete components

BS 8221-1	Code of practice for cleaning and surface repair of buildings. Cleaning of natural stone, brick, terracotta and concrete
BS 8000	Workmanship on building sites
BS 8204	Screeds, bases and in situ floorings. Concrete wearing surfaces. Code of practice
BS 5930	Code of practice for site investigations
BS 5964, ISO 4463	Building setting out and measurement
BS 6031	Code of Practice for Earthworks
BS EN 752	Drain and sewer systems outside buildings
UBC	Uniform Building Code (USA)
BS 1377	Methods of test for soil for Civil Engineering Purposes
BS 1305	Batch type concrete mixers
BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS 4190	ISO metric black hexagon bolts, screws and nuts
BS EN 10025-1	Hot rolled products of structural steels. General technical delivery conditions

BS 4395	Specification for high strength friction grip bolts and associated nuts and washers for structural engineering.
BS 4592-0	Industrial type flooring and stair treads. Common design requirements and recommendations for installation
BS 5493	Code of practice for protective coating of iron and steel structures against corrosion
BS 4921	Specification for sherardized coatings on iron or steel
BS EN ISO 3690	Welding and allied processes. Determination of hydrogen content in arc weld metal
BS EN ISO 2560	Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels. Classification
BS 2853	Specification for the testing of steel overhead runway beams for hoist blocks
BS EN 1011	Welding. Recommendations for welding of metallic materials.
BS EN 485	Aluminium and aluminium alloys. Sheet, strip and plate.
BS 4868	Specification for profiled aluminium sheet for building
BS EN 124	Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type

testing, marking, quality control

BS EN 752	Drain and sewer systems outside buildings
BS 437	Specification for cast iron drain pipes, fittings and their joints for socketed and socketless systems
BS EN 598	Ductile iron pipes, fittings, accessories and their joints for sewerage applications. Requirements and test methods
BS EN 1916	Concrete pipes and fittings, unreinforced, steel fibre and reinforced
BS EN 1401-1	Plastic piping systems for non-pressure underground drainage and sewerage. Unplasticized poly(vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system
BS 3506	Specification for unplasticized PVC pipe for industrial uses
BS 1196	Specification for clayware field drain pipes and junctions
BS 5391-1	Acrylonitrile-butadiene-styrene (ABS) pressure pipe. Specification
BS 5392-1	Acrylonitrile-butadiene-styrene (ABS) fittings for use with ABS pressure pipe. Specification
BS EN 13101	Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity

BS 1161	Specification for aluminium alloy sections for structural purposes
BS EN ISO 8501	Preparation of steel substrates before application of paints and related products. Visual assessment of surface cleanliness.
BS 4873	Aluminium alloy windows and doorsets. Specification
BS 6180	Barriers in and about buildings. Code of practice
BS 598-1	Sampling and examination of bituminous mixtures for roads and other paved areas. Methods for the measurement of the rate of spread of coated chippings and the temperature of bituminous mixtures using non-contact temperature-measuring devices and for the assessment of the compaction performance of a roller
BS 1707	Specification for hot binder distributors for road surface dressing
BS 1722	Specification for fences
BS EN 10223	Steel wire and wire products for fences.
BS 6319	Testing of resin and polymer/cement compositions for use in construction.

39.4 MATERIALS

Supply, storage, sampling and testing of all materials shall be the responsibility of the Contractor.

Cement

The type of cement to be incorporated into concrete shall be indicated on the drawings and shall be one of the following types complying with the Corresponding British Standard:

Ordinary Portland Cement BS EN 197

Sulphate Resisting Cement BS 4027

The cement shall be obtained from an approved source. The source shall not be changed without the Engineer's approval.

For each source and type of cement, separate storage shall be provided. Intermixing of sources and types shall be scrupulously avoided.

Cement shall be stored at the site in such a manner as to prevent its deterioration, intrusion of moisture and foreign matter. It must be kept dry at all times. Prolonged storage of cement at site is to be avoided. Cement that has partially or fully caked in storage will not be permitted in work and shall be immediately removed from the storage area.

Any bag or package or sample of cement which has been damaged, or re-bagged or in any way has deteriorated shall be rejected either as an individual bag or package or as the whole consignment in which such bag, package or sample is contained.

The Contractor shall keep records of the various consignments of cement in store, giving quantities received and used, and the sections of the work in which the cement has been used, on a daily basis and make a weekly return to the Engineer accordingly. Cement used in the Works shall be free flowing and free from lumps.

Every delivery of cement shall be accompanied by the manufacturer's test certificates. If such certificates are not available, the Contractor shall take representative samples from different bags or containers of each consignment. The samples shall be packed, labelled and sent for testing to an approved testing laboratory, to be tested as per provisions of BS EN 196. The samples tested shall comply with the requirements of BS EN 197 or BS 4027.

Site testing shall be limited to:

Compressive strength	BS EN 196
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Time of setting	BS EN 196
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Sampling and testing of the cement shall be performed on the site at the time of delivery and these when and as directed by the Engineer. The test samples shall be submitted to the Field Control Laboratory within 24 hours after sampling.

Fine Aggregate

Fine aggregate shall consist of natural clean sand, stone screenings or artificial sand or a combination thereof, conforming to the requirements of grading and physical properties in compliance with BS EN 12620 and subject to the Engineer's approval.

The shape of the particles of the aggregate shall be generally spherical or cubical.

Only clean washed sand conforming to BS EN 12620 shall be used for concreting purposes. It shall not contain any deleterious matter either in a form or a sufficient quantity to adversely affect the strength and durability of concrete.

The storage area for the clean washed sand shall be shaded from the direct rays of the sun and shall be screened for protection from dust. The area in the neighbourhood of stockpile / mixing plant shall be watered as necessary, to reduce

as much as possible the rising of dust.

The aggregate shall be stored on a raised platform suitably bundled to prevent contamination and intermixing of aggregates.

Coarse Aggregate

The coarse aggregate shall consist of gravel, crushed gravel or a combination thereof, conforming to the requirements of grading and physical properties in compliance with BS EN 12620 and subject to the Engineer's approval.

The particles of the aggregate shall be generally spherical or cubical.

Only clean, washed aggregate as required and free from deleterious matter shall be used for concreting purposes.

The aggregates shall be stored on raised platform suitably bundled to prevent contamination and intermixing of different sizes. Stockpiles shall be shaded from direct rays of the sun and shall be screened for protection from dust.

Testing of Aggregates

The Contractor shall supply to the Engineer for approval full details of the aggregate he proposes to use prior to any concrete being placed in the Works. Such information shall at least include the source of each aggregate, current certificate of grading of the aggregate, test certificates covering, sulphate, chloride and shell contents and alkali/aggregate relationship. Consequently throughout the Contract, further grading and test certificates shall be supplied to the Engineer at approximately monthly intervals, or at such intervals as the Engineer may direct. The costs of all testing shall be borne for by the Contractor.

The source of the aggregate shall not be changed without the approval of the Engineer.

Aggregates shall be tested as prescribed in BS EN 1097 and particular care shall

be taken regarding presence of deleterious matter for which the following shall apply.

The sodium chloride content of the aggregate shall not exceed the following percentages of dry weight of the aggregates:

Fine aggregate 0.06 %

Coarse aggregate 0.03 %

If the content of either aggregate exceeds these limits, the material shall still be considered acceptable provided that the total sodium chloride content of the aggregates does not exceed 0.32% by weight of the cement in the mix.

The maximum sulphate content expressed as SO₃ (sulphur trioxide) shall not exceed 0.25% of the dry weight of the aggregate, or it shall be such that the maximum sulphate content does no more than double the sulphate content, already in the mix attributable to the sulphate (gypsum) content of the cement.

The allowable shell content, expressed as a percentage by weight of dry aggregate, as calcium carbonate shall not exceed the following:

Allowable Shell Content

Nominal Size of Aggregate	Total	Hollow
40 mm	6.0 %	1.0 %
20 mm	10.0 %	1.0 %
Fine	15.0 %	2.0 %

Where limestone aggregate is used for the coarse aggregate, the Contractor shall satisfy the Engineer, so that the proposed aggregate is compatible with the cement and that its use will not give rise to a chemical reaction between the alkali

in the cement and the aggregate which would affect the durability of the concrete.

Water

Mixing water for concrete and water for spraying aggregate curing and the like purposes shall be from a source approved by the Engineer. The water shall be clean, fresh and free from oil, organic matter and other deleterious substances.

Prior to commencement of concreting and subsequently once every two months the Contractor shall sample and test the water as per BS EN 1008 for the presence of sulphate and chloride salts. The amount of dissolved solids in the water shall also be checked on a weekly basis by conductivity methods during the period for which concrete work is being carried out. Any significant change in the amount of dissolved solids recorded, shall be immediately investigated by further testing for sulphate and chloride salts.

Water for concreting shall not contain more than 1000 ppm of sulphates (SO_3) or more than 500 ppm of chlorides.

If at any time when tested with Universal indicator the water supplied has a pH value outside the limits of 5.5 to 8.5 then the Engineer shall be informed accordingly and the water shall be tested in accordance with the recommendations of BS EN 1008 in order to determine acceptability of the supply for further use. In interpretation of the test results the Engineer's decision shall be final.

Reinforcement

Reinforcement shall be from an approved source. All steel reinforcement shall comply with the requirements of BS 4449 Grade B500B.

Steel fabric reinforcement shall comply with the requirements of BS 4483 or similar approved International Standards and shall be delivered to Site in flat mats.

Manufacturer's certificates stating that the reinforcement complies with the above standards shall be forwarded to the Engineer prior to the dispatch of each consignment from the manufacturer's works. The Contractor, when required by

the Engineer to do so, shall arrange at his own expense for testing such samples of reinforcement steel, as the Engineer may from time to time require. The testing shall be carried out in an approved laboratory.

Should the tested samples of reinforcement steel from any consignment fail to comply in any respect with the required standards, then the Engineer may at his sole discretion order the removal from the Site of all steel from the consignment.

All bar and fabric reinforcement shall be stored on site on timber or concrete supports, suitably spaced to prevent excessive sagging and of sufficient height to keep off the ground. Each bundle shall be clearly marked stating the type of steel and the diameter. Different diameters shall be kept well separated

All reinforcement shall be free from oil, grease, loose rust, loose mill scale, pitting or other harmful matter immediately before placing the concrete. Cutting and bending of bars shall generally comply with recommendations of BS 8666 and shall be executed cold on an approved machine or table, to the shapes shown on the approved drawings and/or Bar Schedules.

Reinforcement shall be bent to the dimensions given in the Bar Schedules or as may be indicated on the approved drawings. Where Bar Schedules are used, they shall be in accordance with the BS 8666. Reinforcing bars shall be bent at temperatures in the range of 5°C to 100°C. Tolerances shall comply with the recommendation of BS 8666.

The internal radius of bends shall be in accordance with the BS 8666, shall not be less than twice the diameter of the bar in the case of mild steel and 3 times the diameter for high yield steel, except for stirrups which shall be bent to fit closely around the main bars. The length of straight bar beyond the end of the curve shall be at least 4 times the diameter of the bar, but minimum 50 mm. Re-bending of incorrectly bent bars shall not be permitted.

Should the Contractor decide to use pre-bent steel reinforcement from his supplier

as an alternative to site bent steel, he shall provide a hand-bender and a small site stock of each size and a type of unbent reinforcement.

Bars shall be placed to the required length, lap and spacing by the Contractor, as shown on the approved drawings or as directed. No welding of bars will be permitted. No splicing shall be made in the reinforcement.

The Contractor shall provide all necessary chairs, spacer blocks and ties to maintain the reinforcement firmly in place during the placing of concrete.

Concrete is not to be placed around any reinforcement until the shuttering and reinforcement have been inspected and approved by the Engineer.

Where delay occurs between the fixing of steel and depositing the concrete, the spacing of reinforcement shall again be carefully checked prior to concreting. If reinforcement has been exposed for a considerable time prior to concreting, bars shall be wire brushed to remove loose rust or other deposits. Any material brushed off which falls into the shuttering shall be cleaned when the formwork is cleaned out. The number, size and position of all bars shall be in exact accordance with the approved drawings. The intersection of all bars shall be bound with soft annealed wire as specified to prevent displacement before and during the pouring of concrete. Reinforcement shall be rigid in the planes in which it is laid and where boxed should form a rigid cage. In cases where bars project for future bending they shall be adequately protected and firmly supported against displacement and bending during concreting and in subsequent operations. No form of ties or tying methods, which are likely to cause spalling of concrete during form stripping, or dislocation of the concrete surface, shall be used. Connections external to the finished surfaces shall not be used.

During concreting the Contractor shall ensure that a competent steel fixer is in attendance on the work to adjust and correct reinforcement, if necessary, prior to and during the placing of concrete.

The cover to reinforcement shall follow the recommendations for protection against chloride attack (as contained in the soils reports) and shall be as shown on the approved drawings.

Reinforcement below ground level shall be protected against corrosion by epoxy coating or an approved concrete admixture.

Admixtures

The use of admixtures and additives to promote workability or any other purpose shall only be allowed with the prior approval in writing of the Engineer.

The admixtures used shall conform to the requirement of BS EN 480 & BS EN 934-2.

The admixtures shall be capable of maintaining essentially, the same composition and performance throughout the work, as, in original concrete proportions. The Contractor will ensure that the chloride content of the concrete mix constituents (water, fine and coarse aggregate) in their natural state, when used with admixtures, if required, shall not exceed the percentages specified in BS EN 1992.

The dosage rate of the admixtures shall be as recommended by the manufacturer. Manufacturer, when requested, shall provide a qualified concrete technician to assist in proportioning the concrete and advice on proper admixture formulations to meet job-site conditions.

Silica fume (microsilica)

Addition shall be considered to improve the durability of the concrete, subject to the approval of the Engineer. It shall comply with ASTM C-1240. Silica fume shall be in condensed form or slurry form with the following constituents:

SiO ₂	minimum 90%
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SO ₃	maximum 1.0%
C	maximum 6.0%

Special attention shall be paid, if silica fume is added to concrete. Dosing, mixing and especially curing need particular supervision. Super plasticiser may be required to avoid the additional need of water required for workability. In case of slurry form, water in slurry shall be added to the water content in the batching. A specialist of supplier shall be called for advice and supervision, whenever required by the Engineer.

Synthetic or metal fibres may be mixed in concrete to reduce shrinkage in some areas on approval by the Engineer only.

Corrosion inhibitors shall be considered for reinforced concrete structures in contact with capillary zone (Concrete specification class RC-S as per Table 10-1, Clause 10.4.1.ii).

Corrosion inhibitors shall be compatible with the required concrete mix and shall be appropriate to the environmental exposure. They shall be appropriate to the protection of steel reinforcement against corrosion for the 25 years design life of the structures. As all other additives, corrosion inhibitors having a general certificate of approval by acceptable building inspection and testing authority such as British Board of Agreement Certificate or a test mark shall be used and then only on the approval of the Engineer.

Curing Compounds

The use of curing compounds consisting of emulsified synthetic resin, solvent free wax or others shall be subject to approval by the Engineer. Before using, curing compounds are to be tested according to efficiency of protection against evaporation and compatibility to the binding of coating layers to be applied later.

The use of curing compound shall be limited to particular cases where wet curing is not practical or advisable.

Release Agents

The Contractor shall submit details of the release agent he proposes to use for the Engineer's approval.

When concrete surfaces are to receive an applied finish the Contractor shall ensure, that the release agent used will not affect the finish or bonding to the concrete.

Formwork

Formwork shall include all temporary or permanent moulds for forming the concrete, together with all temporary construction required for their support.

Forms complete with centring, cores and moulds shall be constructed to conform to shape, form, line and grade required and shall be maintained sufficiently rigid to prevent deformation under load.

Design

Formwork shall be designed as per provisions of BS 5975. It shall be designed for the worst combination of self-load, reinforcement weight, wet concrete load, concrete pressure, construction and wind loads together with all dynamic effects due to placing, vibrating and compacting concrete. For guidance, refer to appendix "C" of Concrete Society Technical Report No. 13 "Formwork", in the CIRIA Data sheet, "Concrete pressure on Formwork"

The Contractor shall be entirely responsible for the sufficiency of the formwork but shall, if required to do so, submit details thereof for approval. The drawings submitted shall show all general fixing and support details. The Engineer's approval does not absolve the Contractor of his responsibility.

Formwork shall be so designed that no damage to the concrete shall occur when

the formwork is removed. It shall be constructed, such that the formwork to the sides of members can be removed without disturbing the soffit formwork or its supports. Props and supports shall be designed to allow the formwork to be adjusted accurately to lines and levels, and due allowance shall be made for any settlement or deflection of the formwork that may arise during construction, so that the hardened concrete conforms to the specified line and level. Back-propping shall not be permitted.

Joints shall be leak proof and shall be arranged vertically or horizontally to conform to the pattern of the design.

Forms

Forms shall be of wood, metal or other material approved by the Engineer and shall conform to the following requirements:

Wood forms

All timber used for forms false work and centring shall be sound wood, well-seasoned and free from loose knots, shakes, large cracks, warping and other defects.

Form Lining

- a) Plywood - commercial, moisture resistant concrete form plywood. 5 ply, not less than 15 mm thick.
- b) Fibre board - A treated hard-pressed fibre board having a low degree of absorption, not less than 5 mm thick with one smooth side.

Form Oil and Form Sealer

Form oil and form sealer shall be of quality as approved by the Engineer.

Metal Forms

As approved by the Engineer and of the type that will produce surface finish equal to those specified for wood forms.

Form Ties

Form ties, shall be approved by the Engineer. This shall be adjustable type and free of attachments that will leave a hole or depression larger than Concrete cover or 22 mm whichever is smaller.

Coating

Forms for exposed surfaces shall be coated with oil before reinforcement is placed. Any oil on reinforcing steel shall be removed. Forms for unexposed surfaces may be thoroughly wetted with water in lieu of oiling, immediately before placing of concrete except during freezing weather. Excessive oiling of the forms shall not be permitted in order to prevent discoloration of the cement plaster. Where concrete surface is to be painted, the form-oil must not affect the bond between concrete and paint.

Ties

The Contractor shall submit to the Engineer for approval details of any ties or cast in fixings that he proposes to use in connection with his formwork. Any embedded metal ties shall not have any part of the tie closer to the finished concrete surface than the specified thickness of cover to the reinforcement. Holes left after removal of any ties shall be filled with mortar.

Wire ties will not be permitted where concrete surfaces will be exposed to weathering or at any point where discoloration will be objectionable.

Joints

All corners of facias, girders, beams and other exposed joints in more than one plane, unless otherwise indicated on the drawings or directed, shall have a 25 mm chamfer by mouldings placed in the forms.

In all temporary day work or other joints at the end of a period of work in horizontal and inclined work, stop end boards are to be securely fixed across the mould to form a watertight joint. The joints shall incorporate blocks of timber at least 75 mm thick, slightly tapered to ease withdrawal, and the area of the key so formed shall be about 30% of the area of the member. The blocks shall be kept back at least 50 mm from the exposed side of the member.

Where reinforcement or dowel bars pass through the stop end board, the board shall be drilled to allow the bars to pass through, or half round identifications made in such a way that the leakage of grout does not occur.

Removal of Forms

The Contractor, under no circumstances, shall strike the formwork until the concrete has attained adequate strength to resist damage, in particular to arises and features. The minimum time that must elapse between casting of the concrete and removal of formwork is given for the Contractor's guidance as follows:

Formwork to vertical surfaces, of foundations, walls, columns and beams	24 hours
Soffits of slabs (props)	10 days
Soffits of beams (props)	14 days

Formwork shall be removed without shock or vibration, which may damage the concrete.

Formwork which is to be re-used must have its surfaces scraped smooth and clean and be redressed.

Where concrete is to form a finished, the surface spacers used for positioning reinforcement are to be of the same mix as that used in the concrete, so as to present a uniform appearance.

Forms shall be removed in such a manner/sequence and at such time that, the complete safety of the structure is ensured. The Contractor should note that the loading from the false work and wet concrete, during construction of a floor, will not exceed the permissible loading on the floor immediately below. Consequently two of the floors immediately below the one being constructed will need to be used, to share the loading. While propping through two floors, the Contractor shall ensure, that the props beneath the floor last constructed are released over its full extent as soon as the concrete has achieved sufficient strength to support itself plus any superimposed loading, but not sooner than the periods given above. The props shall then be re-tightened so that these may be used to share the construction loading from the floor above.

Cast-in-Fixings and Sundry Items

The Contractor shall be responsible to accurately cast in the concrete work or fix to the formwork any fixings, ties, dowels, slots, holding down bolts, etc. required for securing blockwork, precast concrete work, steelwork or electrical and mechanical services for other trades and suppliers.

Provision shall be made for forming holes, chases, ducts, rebates, for building in of pipes, conduits and other fixings as shown on the drawings. Holding down bolts and washer plates shall be firmly set in the formwork in taper boxes, polystyrene blocks or other approved sleeves as shown on the drawings.

39.5 CONCRETE MIX DESIGN

Design Strength Specified Concrete. Conformity criteria for compressive strength
Concrete grades used in the Works shall be in accordance with BS EN 1992 and BS EN 206-1. The characteristic strength (grade designation), nominal maximum size of aggregate and minimum cement content shall be, as shown on the

approved drawings.

The Contractor shall be responsible for the design of concrete mixes and for the testing thereof, all, subject to the approval of the Engineer.

The maximum cement content shall not exceed 550 kg/m³ unless otherwise approved by the Engineer.

The maximum water/cement ratio shall not exceed 0.42 calculated with water content from admixture.

Unless otherwise approved, the slump of all concrete without admixtures shall be class S2 as per BS EN 206-1, but the slump with admixtures – super plasticiser shall be class S4 as per BS EN 206-1. Slump test shall be conducted in accordance with BS EN 12350.

The Contractor shall supply all necessary moulds for tests, shall cast all cubes, strip and store them in water for max 24 h at site. He shall also arrange for the transport of cubes to the place of testing and shall supply the Engineer with duplicate copies of all test certificates.

Conformity of concrete compressive strength is assessed on specimens tested at 7 and 28 days in accordance with BS EN 206-1. Conformity is confirmed if both the criteria (Criterion 1 and Criterion 2) given in Table “Conformity criteria for compressive strength” for either initial or continuous production are satisfied.

To confirm that each individual member belongs to the family a single family member shall be assessed against Criterion 3 as given in Table “Confirmation criterion for family members”.

Conformity criteria for compressive strength

Production	Number n of test results for compressive strength in the group	Criterion 1	Criterion 2
		Mean of n results (f_{cm}) N/mm ²	Any individual test result (f_{ci}) N/mm ²
Initial	3	$\geq f_{ck}+4.0$	$\geq f_{ck}-4.0$
Continuous	15	$\geq f_{ck}+1.148\sigma$	$\geq f_{ck}-4.0$

Confirmation criterion for family members

Number n of test results for compressive strength for a single concrete	Criterion 3
	Mean of n results (f_{cm}) for a single family member N/mm ²
2	$\geq f_{ck}-1.0$
3	$\geq f_{ck}+1.0$
4	$\geq f_{ck}+2.0$
5	$\geq f_{ck}+2.5$
6	$\geq f_{ck}+3.0$

Trial Mixes

The target mean compressive strength of the cubes tested in a laboratory at 28 days, shall exceed the specified characteristic strength by at least 10 N/mm^2 which is equivalent to a standard deviation of about 6MPa. Target mean values for each strength class are shown in Table.

	C12/15	C16/20	C20/25	C25/30	C30/37	C35/45	C40/50
Characteristic cube strength $f_{ck,cube}$	15	20	25	30	37	45	50
Target mean cube strength $f_{cm,cube}$	25	30	35	40	47	55	60

The strength quality of the concrete mixes proposed for use shall be established by tests made in advance of the beginning of operations, using the consistencies suitable for the work. The proportions of the concrete mixes shall be established by laboratory trial mixes in accordance with BS EN 1992, BS EN 206-1, BS EN 12350 and BS EN 12390. Trial design batches and testing shall be responsibility of the Contractor.

Trial mixes from three separate batches of material shall be made, for each grade of concrete, using the material proposed by the Contractor preferably under full scale production conditions.

No substitutions shall be made in the materials used in the work after the Engineer has approved the design mixes. New materials shall only be accepted after, pre-

qualification and tests have been approved by the Engineer.

The Contractor shall declare any change in the source of the material and any changes in the cement content consumption greater than 20.0 kg/m³ from that used in the trial mixes. The Contractor shall continue to adopt the approved trial mix for concrete production until such time as sufficient concrete batches have been tested, substantiate the use of the new materials or change in mix proportions subject to the Engineer's approval.

In the event that the Engineer is unable to accept the Contractors first mix proposals, the Contractor shall make further trial mixes, and carry out tests, at his own expense, until the Engineer is satisfied with the Contractor's proposals.

Concrete shall be proportioned by weight. Proportioning of aggregates shall be consistent with the required workability, and mix design.

Corrective additions to remedy deficiencies in aggregate gradations shall be used only with the Engineer's written permission. When such additions are permitted, the material shall be measured separately for each batch.

Control and Records

Before any designed mix is supplied, the Contractor shall supply the following information:

- a) The nature and source of each material;
- b) Full details and results of trial tests on the mix proposed;
- c) Proposed quantities of each ingredient per cubic metre of fully compacted concrete.

Notwithstanding approval of the Preliminary Sample test results, the Contractor shall be responsible for producing the specified concrete throughout the Contract. Should any variations in the mix become necessary or in the Contractor's opinion desirable, approval must be sought from the Engineer. Any extra cost in such variations shall be borne by the Contractor.

The Contractor shall keep a complete record of the concreting showing the date and time of placing and location of the concrete in the work.

39.6 TOLERANCES AND SETTING OUT

The Contractor shall be responsible for setting out the work accurately and for making all concrete sections and members accurately, in accordance with the dimensions shown on the drawings. The Contractor shall construct the Works in such a way that the fitting together of various components of the building such as steelwork, blockwork, doors, windows, finishes can be properly carried out.

Any work which is significantly out of level or alignment shall be liable for rejection and shall be rebuilt at the Contractor's expense. No cutting away or making up of hardened concrete work shall be permitted without the Engineer's approval.

All setting out dimensions	$\pm 5 \text{ mm}$
Sections of concrete members	$\pm 5 \text{ mm}$
Surfaces of foundations against ground (underside)	$\pm 5 \text{ mm} - 100 \text{ mm}$
Top surfaces of foundations, bases and piers	$\pm 5 \text{ mm} - 20 \text{ mm}$
Surface level of all ground slabs (3 m straight edge)	$\pm 3 \text{ mm}$
Surface level of all ground slabs to datum	$\pm 10 \text{ mm}$
Position of holding down bolts (mean of set)	$\pm 10 \text{ mm}$
Position of holding down bolts(to mean)	
(measured at surface of concrete)	$\pm 2 \text{ mm}$

Position of bolt pockets of equipment	
Foundation block of equipment supplier	$\pm 5 \text{ mm}$ / as per requirement

The Contractor shall adopt methods for setting out of the buildings which can be readily and repeatedly cross checked by the Engineer.

39.7 WORKMANSHIP

Supervision

The Contractor shall, for the duration of the concreting works employ on site a person, who is competent to supervise all stages of the production, testing and placing of concrete, to the standards required by this Specification. The Contractor shall supply the name, status and qualifications of such person to the Engineer for his approval.

Mixing of Concrete

All mixing carried out on Site shall be by power driven batch machines of approved size and type, manufactured in accordance with BS 1305, and tested in accordance with BS 3963. The batch machines shall have accurately calibrated device for the delivery of water.

The weighing and dispensing mechanisms shall be maintained in good order throughout the Contract. Their accuracy shall be within the tolerance described in BS 1305 and shall be checked against accurate weights and volumes. The mixer shall be properly maintained in accordance with the manufacturer's recommendations.

Cement supplied in bags shall be placed directly from the bag into the intake of the mixing plant and each batch must contain one or more complete bags of cement. No mixer having a rated capacity of less than a one-bag batch shall be used and the mixer shall not be charged in excess of its rated capacity.

All constituents shall be batched by weight. The weight of the fine and coarse aggregates shall be adjusted to allow for the free water content in them.

The materials shall be mixed to an even colour and consistency. The period of mixing shall be kept to a minimum, consistent with achieving satisfactory quality but shall not be less than 90 seconds. When densified microsilica is used the minimum wet mixing time shall be 60 seconds. Superplasticizer shall be used to achieve the required workability and the same shall be demonstrated during plant /laboratory trials as instructed by Engineer/Client. Prolonged mixing must be avoided. The mixer shall be operated at the manufacturer's recommended speed.

Mixing plant that has been out of action for more than 30 minutes, shall be thoroughly cleaned before any fresh concrete is mixed in it. The first batch of concrete through the mixer shall contain an excess of cement to allow coating of the inside of the mixing drum without reducing the required mortar content of the mix. When a change of mix is made to one use of a different type of cement, the mixing plant shall be thoroughly cleaned of all traces of the previously used cement, whatever be the time interval between successive mixes.

The time of Transportation of the concrete from the mixers to site must not exceed 45min for concretes not containing admixtures (for a concrete temp. 28-32°C). For concretes containing admixtures, the allowable transportation time will be determined based on the retarding effect of the admixture.

Ready Mixed Concrete

Ready mixed concrete batched off site, unless from a central mix plant and approved by the Engineer, shall not be used on the job.

1. Batching Plant

The concrete plant shall include, but not necessarily be limited to the following:

One (1) central mix concrete plant with an output capacity to match the job

demand. Mixing equipment shall include two (2) stationary mixing drums. Both mixer drums shall be automatically operated, controlled by single batching and control systems. The concrete plant shall also have a transit mix dry batch driveway.

2. Weighing and Batching Equipment

The batching controls shall be so interlocked that a new batching cycle cannot be started until all batches are completely empty. There shall be no loss of materials from the weighing and batching to delivery into transporting equipment.

Delivery of materials from the batching equipment shall be within the following limits of accuracy:

Material	Limit of Accuracy
Cement	$\pm 1\%$
Water	$\pm 1\%$
Aggregate	$\pm 1\%$
Admixture	$\pm 3\%$

3. Recording Equipment

The central mix plant shall be equipped with one recorder. The recorder shall be housed in a cabinet that is capable of being locked and shall be in a position convenient for observation by the plant operator. The recorder shall produce a printed or autographic record on a single visible chart or tape of all the data specified herein and, after the batch is discharged, shall return to zero. The chart or tape shall clearly indicate by stamped letters, numerals, colour ink, or other suitable means, the following data:

a) Number of batch;

- b) Batch size;
- c) Mix code;
- d) Time and data;
- e) Weight of each aggregate and identification;
- f) Weight of cement and identification;
- g) Weight or volume of water
- h) Weight of ice;
- i) Volume of each admixture and identification;
- j) Moisture content of fine aggregate.

4. Protection of Equipment

All weighing, indicating, recording, and control equipment shall be protected against exposure to dust and weather and shall be protected from plant vibration. All recording and control equipment shall be installed in a control room that is ventilated, properly lighted, and large enough to accommodate operating and inspection personnel.

5. Moisture Control

Natural moisture content in fine aggregate shall be uniform and stable as batched. When variations are indicated by use of moisture meters, compensation for batch weight shall be accomplished by adding or extracting water from the aggregate. In no case shall the free moisture content be higher than 6%.

Acceptance of Concrete Mixes

Concrete mixes shall be evaluated for strength and uniformity after tests have been conducted in accordance with the procedures specified in British Standards.

Concrete mixes will be considered satisfactory as long as the specimens tested equal or exceed the criteria specified in British Standards for strength and uniformity requirements.

Rejection of Concrete Mixes

Concrete mixes will be rejected if they fail to meet one or more requirements that cannot be brought into compliance or are visually unsatisfactory as related

to any of the following:

- a) Improper class of concrete;
- b) Unworkability;
- c) Overmixing;
- d) Air Content slump or temperature not within specified limits;
- e) Oversized aggregate;
- f) Maximum water-cement ratio is exceeded.

39.8 TRANSPORT AND PLACING

The methods of transporting and placing concrete shall be agreed with the Engineer before concreting commences and shall be such that segregation of the constituents is avoided and that concrete is placed in the Works as soon as possible after mixing. Plant and equipment used shall be kept free of material, which may cause contamination of the concrete.

Concrete shall be conveyed from mixer to forms as rapidly as practicable without segregation or loss of ingredients. Belt conveyors, chutes, or other similar equipment will be permitted provided their usage conforms strictly to the requirements specified in BS EN 206-1 & BS EN 1992.

Placing Preparation for Placing

Water shall be removed from excavations before concrete is deposited. Any flow of water shall be diverted through proper side drains and shall be removed without washing over freshly deposited concrete. All dewatering works shall be continued as long as required. Hardened concrete, debris, and foreign materials shall be removed from interior of forms and from inner surfaces of mixing and conveying equipment.

Concrete shall be placed in the dry and all water shall be removed from the forms before placement.

Wood forms, unless lined, shall be oiled or wetted with water in advance of placing concrete so that joints will tighten and prevent seepage of cement grout from the mix. Reinforcement shall be secured in position, inspected, and approved by the Engineer before placing the concrete. Runways or other means approved by the Engineer shall be provided for wheeled equipment to convey the concrete to the points of deposit. Equipment used to deposit concrete shall not be wheeled over reinforcement nor shall runways be supported on reinforcement.

No concrete shall be placed in the structure until the Engineer has approved the formwork and the reinforcement.

The Contractor shall give the Engineer 24 hours written notice before placing to allow time for his approval and presence during concrete placement.

If concreting is not carried out within 24 hours of approval being given, fresh approval shall be sought.

Placing

Concrete shall be handled from mixer or transport vehicle to the place of final deposit in a continuous manner and as rapidly as practicable until a given operation is completed. Concrete that has attained its initial set or has contained its water content for more than 1-1/2 hours or 300 drum revolutions, whichever comes first, shall not be deposited in the work. Forms or reinforcement shall not be splashed with concrete in advance of placing. Concrete shall be deposited in the form as nearly as practicable in final position to avoid re-handling. Immediately after depositing, concrete shall be compacted by thorough agitation, by vibration or in a manner approved by the Engineer. The mixture is to be worked into corners and around reinforcement and inserts, to prevent formation of voids. Tapping or other external vibration of forms shall not be permitted. Concrete shall not be placed on concrete sufficiently hard to cause formation of seams and planes of weakness within the section. Concrete shall not be allowed to drop freely more than 1.50 m in unexposed work, nor more than 0.9 m in exposed work. Where

greater drops are required, a tremie or other means approved by the Engineer shall be employed. The discharge of the tremies shall be controlled so that the concrete may be effectively compacted into horizontal layers not more than 0.3 m thick, and the spacing of the tremies shall be such that segregation does not occur.

Placing and compaction methods must be arranged not only to ensure complete compaction of each layer, but also to allow for successive layers to follow each other as closely as possible and in no circumstances after initial set has occurred in the preceding layer.

Cold Weather Placement

Cold weather concreting shall be in accordance with BS EN 1992, BS EN 206-1 or CIRIA Report 67.

Hot Weather Placement

The Contractor shall ensure that the Concrete is not adversely affected by the climate factors, namely, higher air temperature, low relative humidity and wind velocity. Calculations or experiments showing that the dry bulb temperature of the placed concrete, taking into consideration the heat of hydration of cement, does not exceed 38°C and that the rate of water evaporation does not exceed 980 g/m² per hour shall be submitted by the Contractor to the Engineer's approval.

Air and concrete thermometers shall be kept on the site. Concrete shall not be placed if the shade temperature exceeds 40°C or the concrete temperature exceeds 32°C.

Special precautions shall be taken if the shade temperature exceeds 28°C. Between May and August inclusive, placing of concrete, unless specifically directed otherwise by the Engineer, shall not be done after 09.00 hours and before 16.00 hours, and, if necessary, shall be carried out at night in which case, an adequate lighting arrangement shall be made.

When the air temperature is expected to reach 38°C or the rate of water evaporation is expected to reach 980g/m² per hour, precautions consisting of dampening the subgrade and the forms, erecting sunshades and windbreaks and reducing time between placement of concrete and start of curing shall be taken.

The Contractor shall take all precautions to prevent or minimise the undesirable hot weather effects by conforming to the requirements of BS EN 1992 & BS EN 206-1 except as modified herein. The Contractor shall lower the water temperature by mechanical refrigeration or by mixing water with crushed ice, or by pre-cooling the aggregates so that the temperature of the concrete as delivered shall not exceed 25°C for massive types of heavy construction and 32°C for other concrete structures. Ice, when used as part of and for cooling mixing water, shall be limited to a maximum of 90 % of the total water content. Ice shall be completely melted in mixing water prior to adding water to the mixer.

Evaporation shall be minimised, particularly during the first few hours subsequent to placing concrete, by suitable means such as applying moisture by fog spraying or any other means approved by the Engineer. A water-reducing, set-retarding chemical admixture conforming to the requirements of BS EN 480 & BS EN 934-2 may be used in varying proportions under different air temperature conditions. The admixture shall meet the requirements specified herein or elsewhere in the Specification. During the placing of all concrete exposed or subject to rapid evaporation from drying conditions, including hot weather, heated interior during cold weather, drying winds, and sunlight, work shall be protected with an concrete curing compound preventing excessive water evaporation.

Recommendations of the manufacturer shall be followed.

Chute Placement

When, upon the Engineer's approval, concrete is conveyed by chute, there shall be a continuous flow of concrete for each batch. The chute shall be of suitable material with sections set at approximately the same slope, namely, not less than

one (1) vertical to three (3) horizontal, nor more than one (1) vertical to two (2) horizontal. The discharge end of the chute shall be provided with baffle plate to prevent segregation. If the height of the discharge end of the chute is more than three (3) times the thickness of the layer being deposited, but not more than 1.50 above the surface of concrete in forms, a spout shall be used, and the lower end maintained as near the surface of deposit as practicable. When placing is intermittent, the chute shall discharge into a hopper. The chute shall be thoroughly cleaned before and after each run. Waste material and flushing water shall be discharged outside of the forms.

Vibrating

Concrete shall be thoroughly compacted during and immediately after depositing by vibrating the concrete internally by means of mechanical vibrating equipment. Vibrators shall not be used to move concrete.

Internal mechanical vibrators shall be of a type approved by the Engineer. They shall be of sturdy construction, adequately powered, capable of transmitting vibration to the concrete in frequencies of not less than 3500 impulses per minute and shall provide a vibration of sufficient intensity to cause flow or settlement of the concrete into place without separation of the ingredients.

The vibratory element shall be inserted into the concrete at the point of deposit and in the areas of freshly placed concrete. The time of vibration shall be of sufficient duration to accomplish thorough consolidation, complete embedment of the reinforcement, the production of smooth surfaces free from honeycombing and air bubbles, and the one which permits the concrete to be worked into all angles and corners of the forms. However, over-vibration shall be avoided and vibration shall continue only until the concrete has become uniformly plastic and shall not continue to the extent that pools of grout are formed. The length of time of vibration depends upon the frequency of the vibration (impulses per minute), size of vibrators and the slump of the concrete. The length of time must be determined in

the field.

The internal vibrators shall be applied at points uniformly spaced not farther apart than the radius over which the vibration is visibly effective and shall be applied close enough to the forms to effectively vibrate the surface concrete. The vibration shall not be dissipated in lateral motion but shall be concentrated in vertical settlement in consolidation of the concrete.

The vibrator shall not be used to push or distribute the concrete laterally. The vibration element shall be inserted in the concrete mass, at sufficient depth to vibrate the bottom of each layer effectively, in as nearly a vertical position as practicable. It shall be withdrawn completely from the concrete before being advanced to the next point of application.

To secure even and dense surfaces, free from aggregate pockets or honeycomb, vibration shall be supplemented by working or spading by hand in the corners and angles of forms and along form surfaces while the concrete is plastic under the vibratory action.

A sufficient number of vibrators shall be employed so that, at the required rate of placement a thorough consolidation is secured throughout the entire volume of each layer of concrete. Extra vibrators shall be on hand for emergency use and for use when other vibrators are being serviced.

The use of surface vibrators to supplement internal vibration will be permitted when satisfactory surfaces cannot be obtained by the internal vibration alone and when the Contractor has obtained the approval by the Engineer for such equipment to be used. Surface vibrators shall be applied only long enough to embed the coarse aggregate and to bring enough mortar to prepare surface for satisfactory finishing.

Grouting

Before depositing new concrete on or against concrete that has set, the existing surfaces shall be thoroughly roughened and cleaned of laitance, foreign matter

and loose particles. Forms shall be re-tightened and existing surfaces slushed with a grout coat of mortar consisting of cement and fine aggregate in the same proportion in the mix, but not leaner than one (1) part fine aggregate, after the existing surface has been moistened. New concrete shall be placed before the grout has attained initial set. Horizontal construction joints shall be given a brush coat of grout consisting of cement and fine aggregate in the same proportion as concrete to be placed, followed by approximately 75 mm of concrete of regular mix, except that the proportion of coarse aggregate shall be reduced to 50%.

High strength grout for precision support of machine base and soleplates, including equipment subject to thermal movement, tanks, column baseplates, bridge seats, anchor bolts and dowels, etc., shall be a non-shrink, ready-touse, fluid precision grout material, proportioned, premixed and packaged at the factory, delivered to the job site to be placed with only the addition of water. Forming, plating, and curing shall be as specified.

Compressive and flexural strengths of the non-shrink grouts shall be as follows:

Type of Grout	Consistency	Compressive strength *		Flexural strength **	
		N/mm ²			
		7 days	28 days	7 days	28 days
Cementitious	Flowable	45	65	8	10

Epox y	High flow	80		25	
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* compressive strength shall be in accordance with BS 1881, Part 116 / with BS 6319, Part 3 (epoxies)

**cubes size shall be 100 mm and the flexural strength shall be tested in accordance with BS 4551.

Embedded Items

All inserts, anchor bolts, sleeves and other embedded items shall be accurately located, using templates where appropriate, and held securely to prevent displacement during the placing of the concrete. Aluminium items shall be completely covered and protected when embedded in the concrete.

Except where shown on the drawings, no fixtures shall be attached to the concrete by shot fixing or drilling without approval of the Engineer. Notwithstanding any such authorisation, the Contractor shall be responsible for any and all damages so caused to the concrete and shall repair and make them good at his own cost.

Joints and Stoppages

Stops in concrete, at the end of a period of work, shall be made only at construction joint locations shown on the drawings and/or positions approved. Where the positions of construction joints are not indicated on the drawings, these may be assumed, for estimating purposes, to occur at 5 metre intervals in foundations and retaining walls and at one-third to one-quarter of span in slabs and beams subject to a maximum spacing of approximately 9 meters.

At construction joint location the surface of the completed concrete shall be prepared by spraying, wire brushing or chipping so that it is free from all laitance, scum and loose material and shows a slightly roughened texture and tips of the coarse aggregate exposed. Before continuing concreting the exposed concrete face shall be thoroughly wetted.

In the ground floor slab (where ground bearing), construction joints, crack inducer joints, contraction joints and expansion joints, as detailed on the drawings, shall be incorporated into the work as appropriate. The slab shall be cast in strips not more than 4.0 m wide, in alternating sequence, across the width of the building. A minimum of 3 days shall elapse between the casting of adjacent strips unless otherwise approved by the Engineer. Within each strip, crack induced joints shall be provided at not more than 5.0 m spacing, and contraction joints shall be provided at not more than 15.0 m spacing.

Construction joints shall be provided between adjacent strips with contraction joints at every 4th joint.

Proposals for the casting sequence and the layout of joints shall be submitted by the Contractor for the Engineer's approval.

Curing, Protection and Durability

Curing

The Contractor shall provide the Engineer with full details of the method of curing he proposes to adopt for all parts of the structure, including columns and walls.

Freshly placed concrete shall be protected from sun, wind, exposure and excessive drying out for a minimum period of 14 days and kept continuously wet for the initial 7 days, unless otherwise approved by the Engineer.

For moist curing, the concrete shall be completely covered with absorbent material which shall be maintained in a wet condition by applying water in the form of a fine spray.

Membrane curing sheets of impermeable material shall be fixed in close contact with the concrete as soon as it is practicable after casting. If any drying has occurred the hardened concrete shall be completely saturated with a fine spray before fixing the membrane. The edges and lapped joints shall be held down to prevent the circulation

of air.

Sprayed curing compounds will not normally be permitted on surfaces, which are to receive an applied finish. Where permitted they shall contain a dye to give visual indication of even and complete application.

Where water is used for curing concrete work buried in the ground, care should be taken to avoid excessive curing water from running below the foundation.

Protection

All concrete during setting and hardening shall be protected from shock, vibration or damage from any cause. Where damage does occur, all remedial works and consequential delays shall be at the Contractor's expense.

Concrete surfaces exposed at the completion of works shall be protected from shock, vibration or damage from any cause. Where damage does occur, all remedial works and consequential delays shall be at the Contractor's expense.

Concrete surfaces exposed at the completion of works shall be protected against discolouration or disfiguration from rust and damage by falling materials or any other cause. Before making good any damage, the Contractor shall obtain Engineer's approval of the methods and materials proposed.

Materials and plant shall not be stalled on any newly constructed floor without the permission of the Engineer.

Durability

General

Durability is, being another important property of the concrete beside strength, affected by the design, mix design of concrete and workmanship. It depends highly on an adequate mix design and on the effectiveness of quality control during mixing, compacting and curing.

Limitation of Cracks Width

Crack width of outdoor reinforced concrete components, and of structures and components subject to dry-wet cycles in ground water shall be limited to 0.15 mm.

Chemical Attack (Leaching, Carbonation, Chloride and Sulphate Attack)

Dissolved calcium hydroxide in hardened concrete components may be leached out where water moves through pores and cracks in and out, impairing the durability of concrete. Low permeable concrete along with the addition of microsilica, which is fixing free calcium hydroxide, would reduce the potential of leaching.

Carbonation is also can be slowed down by dense concrete and appropriate concrete cover to the reinforcement will extend the time for reaching the reinforcement. Especially for the reinforced components, which cannot be protected by coating properly like outdoor slabs and stairs subject to abrasion, top concrete cover shall be increased to 4 cm.

Chlorides may be introduced in to concrete through the constituent materials. Limits of total chloride content of concrete shall be less than 0.10% by the weight of cement for Type V - sulphate resisting cement and 0.30% for OPC and Type II- cement.

Limits of internal soluble sulphates shall be less than 4% by the weight of cement.

Alkali-Aggregate Reaction

In case of potentially reactive aggregates, alkalis content in the cement ($\text{Na}_2\text{O} + 0.658 \times \text{K}_2\text{O}$) shall be less than 0.6 percent.

Permeability and Absorption

Low permeability is an important factor for water retaining structures, where water-tightness of concrete is required. Accordingly besides other factors to achieve a dense concrete, reducing of shrinkage potential and choose of aggregates of low porosity are essential. Coarse grained cements shall be avoided, since they tend to produce

cement paste with relatively high porosity. Microsilica is reducing the permeability, however due to requirement of higher mix water, adequate dosing and handling would be required.

Shrinkage

Shrinkage,-plastic, autogenous and drying- is one of most critical factors in the durability of reinforced concrete. Besides the constructive measures to limit the restrains like provisions of expansion and shrinkage joints and proper curing as stated above, shrinkage can be reduced by the lower cement mortar content in the concrete.

Concrete in Contact with the Ground

All structural (reinforced) concrete in contact with the ground shall be designed and constructed to ensure protection from the aggressive nature of the sub-soil. This will be achieved by type of cement, special admixtures, painting etc. The Contractor shall carry out additional detailed investigations to quantify the corrosiveness of the strata. Such concrete protection shall follow the requirements shown in Standard Drawings for Concrete Protection.

Based on the results of the chloride and sulphate level stated in the soil investigation report, or as directed by the Engineer, the Contractor shall ensure that all concrete receives a suitable protection as specified below and in accordance with standard drawings for concrete protection:

Sub-soil Chemical Environment	Protective Coating Case	Type of Cement
Sulphate and chloride within allowable limits	1	OPC
Only sulphates exceed the allowable limit (>1.2%)	2	SRC

Only Chlorides exceed the allowable limit (>0.05%)	3	OPC*
Both sulphate and chloride exceed the allowable limits with presence of ground water	4A	OPC
Both sulphate and chloride exceed the allowable limits with presence of ground water	4B	OPC

*corrosion inhibitors to be used.

Type 1: two bitumen/rubber emulsion coats.

Type 2: two bitumen/rubber emulsion coats.

Type 3: two bitumen/rubber emulsion coats + protective coating resistant to chlorides applied on blinding concrete only

Type 4A: Approved Protection of epoxy based paint resistant to Sulphate and chloride + waterproofing membrane which mechanically bonds to poured concrete or approved bonding agent resistant to Sulphate and chloride on blinding concrete.

Type 4B: Waterproofing membrane + waterproofing membrane which mechanically bonds to poured concrete or approved bonding agent resistant to Sulphate and chloride on blinding concrete.

Concrete above Ground Level

All external reinforced concrete above ground level, which is to be left exposed or to receive a paint finish only shall be coated with a penetrating protective sealant. This shall comprise of a relevant primer to form a barrier for sulphate, chloride and carbon dioxide ingress. The finished surface shall provide a reduction in chloride ion of 95%.

Concrete in Contact with Oil or Oily Water

All concrete surfaces, which may come into contact with oil or oily water, will have to be adequately protected against attack (paint, etc.).

Surface Finishes Other than Slabs & Floors "Fair Faced" (F1 Formwork)

Where surface finishes are described on the drawings as "fair faced", the Contractor shall obtain an even finish to the concrete by the use of good quality plywood having a clean smooth impervious surface, free from all defects and with true clear arises.

The resulting concreting shall be free from honeycombing, stains, fins, lipping, nail and screw marks, raised grain marks or any other imperfections and shall be of a uniform surface texture and colour. Only very minor surface blemishes caused by entrapped air or water will be accepted provided that they do not exceed ½ % by area of each square metre considered separately and in addition they shall not be concentrated in a manner such that they are noticeable.

No attempt shall be made to rub down or fill blemishes without the prior approval of the Engineer.

Covered Concrete Surfaces - "As Struck" (F2 Formwork)

The formwork for all concrete which is to be covered by render, plaster, or otherwise hidden shall be constructed in wrought board or other suitable materials. The removal of minor fins or form marks shall not be required, but all holes, cavities, and irregularities shall be made good after inspection by the Engineer and to his approval.

Exposed Aggregate Finish

The Contractor shall be required to produce an exposed aggregate finish of uniform appearance, free of construction and formwork joints. In addition the

resulting finish shall be free from honeycombing, stains or other imperfections.

The exposed aggregate finish is to be produced by the use of concrete retarders and "brush and wash" techniques. The Contractor shall ensure that while placing the concrete is not discharged against the treated face of the formwork and that vibrators do not come into contact with the treated face. The Contractor must also ensure that close contact is maintained between the fresh concrete and the retarder.

The Contractor shall provide the Engineer with details of any proposed concrete retarding agent, together with his proposed methods of application, and shall obtain the Engineer's approval before the retarder is applied to the formwork.

Subject to the approval of the Engineer an exposed aggregate finish may be produced by tooling, bush hammering or sand blasting, but at no extra cost to the Contract.

The method of forming the exposed aggregate finish shall not be changed during the Contract without the prior approval of the Engineer.

At the start of the Contract the Contractor shall produce a sample panel, not less than 1.0 metre square, of the exposed aggregate finish he intends to provide throughout the Contract. He shall seek and obtain the Engineer's approval before any such finish is incorporated into the Works.

The Engineer may require from the Contractor to provide, at no extra cost to the Contract, additional samples of exposed aggregate finish before granting approval to the Contractor's methods.

The approved sample shall be retained on Site and shall form a reference sample. The Engineer reserves the right to instruct for the removal and reinstatement, at no extra charge to the Contract, of any areas of exposed aggregate finish in work which, in his opinion, fail to reach the standard and appearance of the reference sample.

Concrete Floor and Slab Finishes

Screeded Finish

Where the floor slab is to receive a screeded finish, the slab shall be laid to the slopes and levels shown on the drawings and the top surface shall be tamped whilst unset, to produce a suitable keyed surface for the receipt of the appropriate finishing materials

Floated Finish

Where a floated finish is required to the floor slabs the top surface shall be levelled and floated whilst unset to an uniform finish to the slopes and levels shown on the drawings. The floating shall be done in such a manner as not to bring an excess of mortar to the surface.

Dustproof Finish

Where concrete surfaces are required to provide a dustproof finish these shall be treated with two coats of approved material. Each coat shall be applied with a soft brush on a clean and dry surface in accordance with the manufacturer's printed instructions.

Non-Slip Finish

Concrete surfaces described on the drawings as having a non-slip finish shall be treated with carborundum dust, evenly sprinkled on whilst the concrete is still green, at a rate of 1 1/2 kg/m² lightly trowelled in before final finishing. Alternatively, the carborundum dust may be incorporated into the finish by means of a mechanical power float.

Hardened Finish

Where a hardened finish is required to the floor slabs these shall be treated with three coats of approved material. Each coat shall be applied with a soft

brush on a clean and dry surface in accordance with the manufacturer's printed instructions.

Finishing Unformed Surfaces

Finishing unformed surfaces shall be tamped, floated, trowelled or brushed as defined below and shown on the drawings.

Type T. Tamped surfaces shall be formed by levelling and tamping the concrete to produce a uniform plain or ridged surface, surplus concrete being struck off by a straight edge immediately after compaction. It is also the first stage of the following finish.

Type F. Floated surfaces shall be uniform surface which has been worked no more than is necessary to remove screed marks by hand with a wood float or by power float of a type approved by the Engineer. The surface shall not be floated until the concrete has hardened sufficiently.

Type ST. Steel trowelled shall be a hard, smooth finish, free from trowel marks and formed with a steel trowel under firm pressure. Trowelling shall not commence until the moisture film has disappeared and the concrete has hardened sufficiently to prevent excess laitance from being worked to the surface. If laitance is brought to the surface it shall be removed.

Type BR. Brushing shall be performed before the concrete has hardened by drawing a wire broom over the concrete surface at right angles to the traffic flow to give an average texture depth of 1 mm.

For ground slab concrete shall be treated with sodium silicate or a similar dust preventive coating. This must be applied in accordance with the manufacturer's instructions.

Over site Blinding Concrete

Over site blinding concrete shall be laid with its top surface free of projecting aggregate, irregularities or ridges and shall be satisfactorily smooth so that polythene sheeting or bituminous membrane or protection on epoxy base can be laid on the surface of the blinding, protected with 25mm additional mortar layer to avoid risk of puncturing or tearing.

Watertight Construction

Where watertight construction is specified on the drawings:

1. The Contractor shall be responsible for achieving water tightness of the work so specified.
2. Joints in concrete shall be located only at positions shown on the drawings.
3. Continuous PVC waterbars shall be incorporated in all joints, the locations of which are to be agreed with the Engineer.
4. The design of the mix must be such as to produce a dense waterproof and damp proof concrete with the lowest possible shrinkage characteristics.
5. After completion a thorough check shall be made on all joints to ensure that no imperfection exists.

39.9 TESTING OF CONCRETE

General

All testing specified shall be carried out at an independent testing laboratory approved by the Engineer. Immediately following the award of the Contract, the Contractor shall submit for approval the name of the laboratory he proposes to use. Certified copies of all test certificates and reports prepared by the approved laboratory shall be submitted directly to the Engineer.

Cost of Testing

The Contractor is to allow for the cost of all testing of reinforcement, cement, aggregates, water and concrete as described in this specification, including the

cost of sampling and transportation to the approved tester.

Sampling and Testing

Sampling

Generally, sampling and testing of concrete shall comply with BS EN 12350 and BS EN 12390 and have to be carried out in the presence of the Engineer at an approved independent testing laboratory.

A slump test shall be carried out on each sample from which cubes are made. The slump test shall be carried out immediately after taking the sample. The amount and type of slump shall be recorded and related to the cubes of which it is representative. The results of the slumps test shall accompany the relevant test cube results.

Testing workability shall involve at least one sample taken from each mix (OPC or SRC) or concrete each day and an additional sample for each 5 m³ of structural concrete.

For each mix of each grade, the equivalent slump measured by the cone test shall be determined by trial mixes. Control shall be maintained by measuring the slump at the point of placing.

Testing strength shall involve at least one sample and shall be taken from each mix (OPC or SRC) of concrete each day and an additional sample for each 20 m³ or 20 batches of structural concrete whichever is the more frequent testing rate. A more frequent testing rate may be required by the Engineer at the start of the work and where the quality is crucial or in doubt.

Compressive Strength Testing

Standard 150 mm cubes (a set of three) shall be made from each sample, stored and tested at 28 days in accordance with BS EN 12390 and BS EN 206-1.

One set of additional cubes for testing at 7 days shall be taken from each sample

until the concrete production has been shown to be to the Engineer's satisfaction.

Test reports for strength shall contain the information required by BS EN 12390 together with the information about the workability and the information listed below:

1. Name of Contractor,
2. Identification of mixer or ready mix supplier and dept,
3. Grade of concrete,
4. Type of cement,
5. Section of work represented by sample,
6. Density of cube (kg/m^3).

Seven Day Tests

The seven day test results shall indicate a crushing strength at least two-thirds of the twenty eight day strength where ordinary Portland cement is used, or at least 50% of the twenty eight day strength were sulphate resisting cement is used.

Acceptance of Concrete Works

The concrete works shall be considered in compliance with the strength requirements of the specification if the 28 days cube tests results comply with BS EN 206-1.

a) Slump Test

Consistency of the fresh concrete shall be constantly supervised by visual inspection during concreting. For each type of concrete, the consistency check measurement shall be performed at the time of first placing the concrete, every truck load supplied during concreting and as per Engineer's instructions and every time the specimens for preliminary tests and quality control tests are made. Consistency of the concrete shall be adjusted to the requirement of pumping, but slump class of concrete, after pouring shall be (as per BS EN 206-1):

- Structural Concrete made with microsilica and/or super plasticiser – Slump Class S4

- Non Structural Concrete – Slump Class S3

The Contractor shall carry out slump tests as required or as otherwise directed by the Engineer. Slump tests shall be performed in accordance with BS EN 12350 and the Contractor shall provide the necessary apparatus free of cost.

b) Compacting Factor Test

If so directed by the Engineer, the Contractor shall carry out compacting factor tests in accordance with BS EN 12350 and shall provide the necessary apparatus free of cost.

c) Durability Tests

Following laboratory tests shall be performed in accordance with the relevant standards:

- Drying shrinkage (Bre Digest 357)
- Absorption (BS 1881 Part 122) $\leq 2\%$
- Water penetration (DIN 1048) ≤ 8 mm (with microsilica)
 ≤ 50 mm (without microsilica)
- AASHTO T277 Rapid Chloride ≤ 800 coulombs

Rapid Chloride Permeability test (RCPT) shall be conducted on hardened concrete at 28 days age, initially during trial mixes and subsequently during works, as instructed by Engineer/Client.

Unsatisfactory Concrete Works

Should any of the test results be unsatisfactory, the Engineer may order the work to be stopped pending his further instructions. Executed work for which test results are unsatisfactory shall be liable to rejection and if so directed the work shall be rebuilt at the Contractor's expense.

In the case that the 7-day works cube tests prove unsatisfactory, the work may be stopped but shall not be liable to rejection pending the result of the 28-day test. If the test results fail to comply with the requirements the work represented shall be immediately liable to rejection. The Contractor may however be given the option of cutting three approved specimens from the completed work and preparing there from test cubes or cores which shall be tested as for Works test cubes. Should the average strength of these specimens attain the minimum 28 day strength, the work will be accepted but otherwise the work will remain liable to rejection as above.

The cost of all such cuttings, preparation of specimens, transportation and testing, and of making good the portions of the structure affected shall be borne by the Contractor.

Regardless of satisfactory test cube results, any concrete work which, in the Engineer's opinion, is excessively honeycombed or in any other way is defective, shall be liable to rejection. Minor defects apparent on stripping the formwork must be made good at the Contractor's expense. No such repair work shall be carried out until after inspection by the Engineer and his approval of the proposed treatment has been given. Work which has not been previously inspected but which shows signs of such treatment shall be liable to rejection as defective work.

The cost of all delays on site due to faulty concrete work shall be borne by the Contractor.

39.10 DAMP PROOF MEMBRANE

The damp proof membrane under all ground slabs shall be as described in specifications for Excavation and earthwork. The outer vertical face of all pits and ducts within the ground and any other areas indicated by the Engineer, where required, shall be finished with three coats of cold bitumen / rubber solution.

39.11 PRECAST CONCRETE

Casting

All units to be formed in precast concrete shall be cast in strongly proportioned moulds fitted with the requisites for the formation of chamfers radii, V-grooves, lifting holes etc., to produce units of the required quality.

The concrete shall be poured and vibrated so as to dispel all air and ensure that the moulds are perfectly filled with concrete. No plastering of any exposed face or surface shall be allowed.

Handling

Precast concrete units shall have obtained sufficient strength to prevent any damage or distortion or overstressing before removal from the casting beds.

Protection

During all subsequent handling, storage and transporting the precast units shall be protected against any damage or surface staining.

Jointing

Units shall be levelled on spacer blocks or shims, the top levels of the spacers or shims to be first below the surface level of the jointing material. Side cover to spacers or shims shall comply with approved cover dimensions to reinforcement in in-situ reinforced concrete works.

Tolerances

All tolerances shall be within limits laid down in the approved Standard(s).

Use of Precast Units

No precast unit shall be incorporated in the Permanent Works until at least one month after the casting date, unless otherwise approved by the Engineer.

Where items of precast work such as lintels, rainwater chutes, cover slabs, etc. are required, the general provision of this specification shall equally apply.

No precast items that are damaged, shipped or otherwise defective shall be set in the work.

39.12 MORTAR FOR REPAIR WORK

All the existing damaged and deteriorated chimney (concrete) foundations shall be remedied by an approved MORTAR for repair jobs.

The mortar shall met but not limited to the following requirements:

- high compressive and flexural strengths (more than 40 N/mm² after 7 days and more than 60 N/mm² after 28 days)
- shrinkage compensation
- high workability and cohesiveness
- high bond to old concrete
- high bond to steel
- resistance to chemical attack
- resistance to high temperature
- low water/cement ratio but slump not less than 150 mm.

Before applying the mortar for repair work, the Method Statement for the surface preparation and application shall be approved by the OETC/Engineer.

40 STRUCTURAL STEELWORK

40.1 GENERAL

The intent of this specification is to cover the requirements for the design, fabrication, delivery, erection and protection of all structural steelwork required for the construction of buildings and miscellaneous structures as required, for the total completion of works covered under the contract.

40.2 CODES AND STANDARDS

The latest editions and/or addenda thereto of the following standards and specifications form a part of this specification.

BS EN 1993	Eurocode 3: Design of steel structures.
BS EN 1994	Eurocode 4: Design of composite steel and concrete structures.
BS 499-1	Welding terms and symbols. Glossary for welding, brazing and thermal cutting
BS EN ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods
BS EN 10143	Specification for continuously hot dip zinc coated and iron-zinc alloy coated steel: wide strip sheet/plate and slit.
BS EN 10162	Cold rolled steel sections. Technical delivery conditions. Dimensional and cross-sectional tolerances
BS 3083	Specification for shot dip zinc coated and hot dip Aluminium/zinc coated corrugated steel sheets for general purposes.
BS 4190	Specification for ISO metric black hexagon bolts, screws and nuts.
BS 7079	General introduction to standards for preparation of steel substrates before application of paints and related products
BS 4320	Specification for metal washers for general engineering purposes. Metric series
BS EN 10025	Hot rolled products of structural steels. General technical delivery conditions
BS 4395	Specification for high strength friction grip bolts and associated nuts and washers for structural

engineering

BS EN 1090	Execution of steel structures and aluminium structures.
BS EN 10296	Welded circular steel tubes for mechanical and general engineering purposes.
BS EN 1011	Welding. Recommendations for welding of metallic materials.
BS EN ISO 2560	Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels. Classification
BS EN 287	Qualification test of welders. Fusion welding.
BS EN ISO 9606	Approval testing of welders. Fusion welding.
BS EN ISO 15614	Specification and qualification of welding procedures for metallic materials. Welding procedure test.
BS EN 571	Non-destructive testing. Penetrant testing.

40.3 DESIGN AND SHOP DRAWINGS

The design of structural steelwork shall be in accordance with BS EN 1993 and as per standards listed in this specification.

Before any fabrication has started, checked shop drawings along with supporting design calculations as applicable shall be submitted to and approved by the Engineer, at least four weeks in advance. Drawings shall indicate all connections, details and other pertinent data, erection plans, bills of materials and shall show location of holes and other connections necessary for attachment of work of other

trades.

Shop drawings shall be made in conformity with the best modern practices and with due regard to speed and economy in fabrication and erection.

Such Engineer approval, based on checking of general design and arrangement only, shall not relieve the Contractor of the responsibility for the correctness of all measurements, detailing, fabrication, alignment and erection of the works.

All members shall be marked on erection drawings so that all pieces can be identified in the field. Shop and field welding shall be clearly distinguished.

40.4 TESTING AND INSPECTION

The Contractor shall be required to perform tests and submit test certificates for the materials to be used in the work. The tests shall include but not be limited to the following in accordance with BS EN 10025.

(1) Chemical analysis

(2) Tensile tests

(3) Bend tests

(4) Flattening tests

The tests shall be carried out by an approved testing authority and notice shall be given for the intended execution of any such test.

If any sample fails a test, the consignment it represents may be rejected in part or in whole.

All materials and fabrication shall be liable for inspection and testing as per the requirements of the above specifications and standards. All parts of the fabricator's shop engaged in this work shall be accessible for this purpose at all times. The Contractor shall provide all necessary help in men, materials,

instruments, etc. for inspection and testing whenever required, at no extra cost to the Employer.

If the Engineer is not satisfied with the testing in the Contractor's shop, the Contractor will make arrangements for testing elsewhere as directed by the Engineer. The costs of such tests shall be borne by the Employer if the results are satisfactory, otherwise, it will be borne by the Contractor.

Materials once rejected shall never be used unless the defect is rectifiable in the opinion of the Engineer.

Release of materials shall not bind the Employer to accept the work should it be found not to comply with specifications before or after erection.

40.5 FABRICATION

The fabrication and workmanship shall be equal to the best modern practices and shall comply with the requirements of BS EN 1090.

If straightening is necessary, it shall be done by mechanical means. Heating should preferably be avoided. In the case that it becomes essential, heating shall be allowed to localized heat of limited amount.

Oxygen cutting shall preferably be done by machine. Oxygen cut edges which will be subjected to substantial stress or which are to have weld metal deposited on them shall be free from gouges.

Planning or finishing of sheared or gas cut edges of plates or shapes will not be required unless shown on drawing or included in edge preparation for welding.

All connections shall be concentric. One-sided or other types of eccentric connections will not be permitted unless approved by the Engineer.

All shop fabrication and connections shall be welded and important welded joints shall be subject to testing. Field connections shall be with high tensile bolts unless

otherwise permitted by the Engineer. For connections of purlins, girts and members 200 mm in depth or smaller, low carbon steel bolts may be used, if approved by the Engineer. If low carbon steel bolts are used, they shall be of different diameters than the high tensile bolts to avoid mix-up at site.

Any structural connection shall be either welded or bolted and no mixed connections shall be allowed.

All holes shall be drilled. Enlargement of holes shall not be permitted by burning.

Allowance shall be made for draw-in type detailing of all diagonal members.

All columns shall be milled at ends for complete bearing at splices and base plates.

Tolerances in fabrication shall be according to limits set out in the relevant BS standards.

All projecting diaphragms and brackets shall be shipped loose to eliminate damage in accordance with usual practice for export shipping.

40.6 WELDING

Metal-arc welding of steel to BS EN 10025 shall be in accordance with the requirements of BS EN 1011.

Run-on/run-off plates shall be used during butt welding.

Fillet welds shall be continuous to form a complete seal where two members join.

The Contractor shall obtain approval of the types of electrodes proposed for use. Welding electrodes shall give a weld deposit with mechanical properties not less than the minimum specified for the parent metal. These shall comply with BS EN ISO 2560. Hydrogen-controlled electrodes shall be used for butt-welding of steel over 25 mm thick.

Welders employed on the work shall be tested to BS EN 287 and BS EN ISO

9606. Welding shall be carried out under the supervision of a competent welding technologist and the test pieces shall be tested to BS EN ISO 15614. The Contractor shall make radiographic examination of butt welds in accordance with Section 8 of American Petroleum Industry (API) Standard 1104 and carry out dye-penetrant tests in accordance with BS EN 571.

In general, 10% of the length of each butt weld shall be radio graphically inspected and 10% shall be tested using penetrant, 5% of the length of each filler weld shall be tested using penetrant. The location of lengths to be tested shall be as directed.

40.7 BOLTED CONNECTIONS

The threaded portions of bolts shall be outside the parts bolted together and the ends shall protrude by at least one complete thread and by not more than three complete threads beyond the outer face of the tightened nut.

Holes shall not be distorted or enlarged by the use of drifts.

High strength friction grip bolts shall be fitted in accordance with BS EN 1993.

The use of load-indicating washers shall be in accordance with the manufacturer's recommendations.

40.8 SITE WELDING

The Contractor may, subject to prior approval, use site welding as an alternative to bolted connections.

Site welded joints shall be inspected by radiography in accordance with section 8 of API standard 1104. Initially 100% of each butt weld shall be inspected.

If approved, the number of inspections may be subsequently reduced.

Finished welds shall comply with section 6 of API Standard 1104. Defective welds shall be cutout, remade, and re-tested as approved.

40.9 GALVANIZING

Galvanizing of steelwork, if required, shall be carried out after fabrication is complete. Steelwork required to be galvanized shall be pickled in dilute hydrochloric acid then washed, fluxed and stoved, and coated with zinc by dipping in a bath of molten zinc. Components shall be immersed in the bath only for a period sufficient to attain the temperature of the bath and shall be withdrawn at a suitable speed so that a coating of min 900g/m² of surface is achieved. Components shall be covered evenly on all surfaces.

Lightweight gauge metal work shall be galvanized by the hot-dip process as specified in BS 3083 or BS EN ISO 1461.

Contact between galvanized steel members and aluminum surfaces shall be prevented by means of an approved insulating layer.

Galvanized steelwork shall receive specified paint treatment and shall be cleaned, degreased, abraded and etch primed beforehand.

40.10 SURFACE PREPARATION FOR PROTECTIVE COATING

Surface shall be cleaned to BS 7079 before any protective treatment is commenced. Steelwork shall be degreased and shot or grit blasted to Sa 2 1/2 quality standard with a surface amplitude of 50-75 microns to remove rust and millscale; dust and debris shall be removed by vacuum cleaner, compressed air or brush. Site welds and adjacent steelwork shall be blast cleaned and similarly prepared. Surface defects shall be removed in accordance with BS EN 10025.

Regular millscale detection tests shall be made using the Copper Sulphate method.

Blasting operations and painting processes shall be segregated.

40.11 PAINTING GENERALLY

Paint shall be applied by brushing or spraying in accordance with the

manufacturer's instructions. Thinners shall only be added to paint in strict accordance with the manufacturer's permitted percentages.

Viscosity tests shall be carried out on random samples of mixed paints as directed. Brushes stored in thinners shall be worked out to remove thinners before reuse.

Painting shall not be carried out when the steelwork temperature is below 4°C or above 38°C, or less than 3°C above the dew point, nor when the relative humidity is above 80%.

Stripe coats shall be applied to welds and steel edges before painting. Strong paint films shall be achieved on all cleats, arises, bolt holes, bolt heads and the like.

Protective treatment other than the site applied coatings shall be applied under factory conditions in an enclosed shop. Completed coats shall be checked for continuity by a low voltage wet-sponge holiday detector and for thickness by an Elcometer.

If a required film thickness is given it shall be the minimum dry film thickness (DFT) as measured by an Elcometer; the Elcometer shall be calibrated for each coating by the use of a shim of known thickness placed upon the shot-blasted blank or the underlying coat, and the shim shall correspond with the theoretical film thickness of the surface of coating to be measured. Otherwise a full coating shall be applied in accordance with the rate of coverage recommended by the manufacturer having regard to the surface profile of the steel and the conditions of application.

Sample plates shall be prepared for approval and shall thereafter be adopted as the standard to be achieved in the finished work.

The Contractor shall prevent dust and dirt coming into contact with freshly painted surfaces.

Before the site painting coats are applied, the surfaces shall be washed with clean

water to remove salt and other impurities.

Paint shall not be applied to the embedded portions of metal items except for the portions within 75 mm of the finished concrete surface.

40.12 APPLICATION OF PROTECTIVE LAYERS

Blast cleaned surfaces shall be kept dry and over coated within 4 hours of the start of cleaning (2 hours for outdoor blast-cleaning). They shall be treated in accordance with the protective treatment schedule, except faying surfaces for HSFG connections.

The painting scheme shall generally consist of surface preparation, prime coat, intermediate coat and finish coat. The work shall be carried out as specified in the specification for painting.

All fabricated structural steelwork shall be shop painted before dispatch and adequately protected against damage during transit and handling.

Surface preparation, prime coat and intermediate coats are to be applied in the shop as specified. The finish coat shall be applied after erection. Before application of the finish coat, any damage to the shop paint shall be touched up with the same paints and approved by the Engineer.

40.13 PROTECTION ON BOLTS AND CONNECTION

Bolts, including friction-grip bolts, nuts and washers shall be hot dip spungalvanized. The treads of nuts may be re-tapped as provided for in BS EN ISO 1461.

Faying surfaces of high-strength friction-grip connections shall be blast cleaned to Sa 2 1/2 quality standard, masked within two hours to exclude air and only exposed just before bolting-up. Paint or contaminants shall not be allowed on faying surfaces.

MATERIALS FOR STEELWORK PROTECTION

Materials for steelwork protection shall be to the approval of the Engineer.

SCHEDULE OF PROTECTIVE TREATMENT

Protective treatment to steelwork shall be in accordance with the painting specifications detailed elsewhere.

40.14 PAINTING OF GALVANIZED FASTENERS AFTER ERECTION

After erection of galvanized bolt heads, bolt ends, nuts and washers shall be degreased with degreasing agent which has an emulsifying action then rinsed with clean water and abraded and painted to the specification of adjacent steelwork.

40.15 DISPATCH, HANDLING AND STORAGE

All bolts, nuts, washers and loose plates shall be shipped to the site in sealed containers, properly marked with the type, size and quantity.

All material shall be properly protected to prevent damage in shipment. Bolts, nuts, washers and other small loose items shall be packed in boxes. Plates and sections edge prepared for field welding shall be protected.

When the steel is transported to the job site by ship, conformance to special crating and shipping requirements shall be the responsibility of the Contractor.

The Contractor shall unload and store all fabricated steel at the site. If any structural steel and accessories arrive at the site in bent or distorted condition, the Contractor shall properly straighten those sections, shapes and connections to the members at no extra cost to the Employer and with the approval and acceptance of the Engineer. Any structural member that has been damaged in the course of shipment to the extent of seriously affecting the properties of the members and cannot be repaired or aligned, in the opinion of the Engineer, shall be replaced by a new member at no additional cost to the Employer.

Proper care shall be taken in storing and handling of fabricated materials at site to avoid damage to painting. Stacking shall be done clear off ground and in order

of erection as far as possible to reduce multiple handling.

40.16 BUILDING LINES AND BENCH MARKS

The Contractor shall be responsible for the accurate establishment and maintenance of building lines, bench marks, and required elevations for the proper erection of steel at the site.

40.17 ANCHOR BOLTS

Deliver anchor bolts and other incidental items of structural steel required to be built into concrete with instructions for their installation, at proper time to avoid delay in the work. Provide templates for anchor bolts to ensure correct placement in concrete.

40.18 ERECTION

The method and sequence of erection shall have the prior approval of the Engineer. The sequence of erection is to be prepared in relation to the requirements of other works to follow, to achieve scheduled completion of the project.

All column bearing plates or billets shall be placed, wedged or skimmed to the proper elevation and locations. Grouting under base plates will be performed under specification for concrete.

The Contractor shall provide all necessary guys and braces to ensure the alignment and stability of the structural steel members until all are properly connected and bolted. Temporary guys and bracings shall support all dead load, wind load and erection loads, and shall remain in place until, in the opinion of the Engineer, they can be removed without danger to the stability of the structure.

As the work progresses, the erected members shall be brought to plumb and level. No grouting shall be made until as much of the structure as will be stiffened thereby has been properly aligned and the joints fully tightened. The entire

erection has to be done within the allowable limits of tolerances as per BS specifications.

All field connections shall be through high strength bolts. Temporary erection bolts shall be of the same diameter as final bolts and the number of erection bolts per joint shall be adequate for the safety of the joint. Drifting with pins may be used only to bring the members together for minor misfits, taking care not to damage the materials in the process.

Welding when required and approved by the Engineer, shall be performed by qualified operators, who have previously been tested as per approved standards for this type of work.

All techniques pertaining to welding shall conform to the requirements of British Codes.

Any error that may occur in shop work which prevents the proper assembling and fitting of parts by moderate use of drift pins shall immediately be called to the attention of the Engineer and approval of the method of procedure of correction obtained.

The use of cutting torches to enlarge or alter holes is prohibited.

40.19 CLADDING/ROOF SHEETING

GI Cladding for wall, roof and flashings shall be to ASTM A-446 or equivalent for base material to ASTM A525 or equivalent for galvanization.

The cladding shall be 26 gauge, galvanized steel ribbed panels, baked enamel polyester painted with film thickness 1.0 mil on external and 0.5 mil film thickness on the internal face.

Fasteners shall be self-tapping sheet metal screws with metal and neoprene washer. All screws shall be color coated to match cladding and shall be zinc plated steel.

Relocated cladding shall be checked for damages and damaged sheeting shall be replaced to the satisfaction of the Engineer.

Fabrication of Cladding

All cutting shall be by mechanical means either by a power driven saw or by a steel hacksaw and care shall be taken to ensure that exposed cut edges are clean and perfectly straight and that no distortion or damage is caused to the sheets.

All flashings shall be bent by mechanical means in the Contractor's Works. All cut edges shall be clean and perfectly straight.

Flashings shall have neat and accurate joints free from distortion and surface blemishes. The external surfaces of flashings shall match the surface of adjacent sheeting.

Erection of Cladding

The Contractor shall not fix cladding until all the steelwork to which the cladding will be fixed, is approved by the Engineer.

The cladding and flashings shall be carefully set into position and substantially secured to side walls and roof with all necessary fixings, washers, fillers, tapes etc., all as described in the Specification.

All sheets shall be properly fixed in relation to each other and to adjacent components. Side-wall sheeting shall be carefully plumbed and all sheeting shall be properly aligned. The finished areas of cladding shall be in true plane, regular in arrangements, free from damage and to the satisfaction of the Engineer.

The completed installation shall be secure and water tight when subjected to the specified wind loads. All joints in the cladding shall be dust tight.

Flashings shall be fixed at all changes of plane in the sheetings and at junctions between the sheeting and the other components as detailed on the approved

drawings.

The sheeting shall be arranged to lap over the upstand of the flashings, which itself shall project to cover the corrugations of the sheeting above or below it, generally as detailed on the approved drawings.

All the top of the cladding, the flashings shall lap up over the sheeting and shall be properly secured. Corner flashings shall terminate on the large flat rib and shall be secured to the rib.

All flashings shall be carefully fixed, true to level and in straight alignment, particularly those which project to the face of side wall cladding. At intermediate joints in these projecting flashings, concealed jointing plates 150 mm long and to fit the inside profile of the flashing, shall be secured both to maintain alignment and to provide weathering at these positions. Where a minimum gap is left between the ends of the flashings, sufficient to permit thermal movement without buckling, an approved mastic bed shall be provided at the interface between jointing plates and under the surface of flashings.

Before erection of the cladding, the Contractor shall ensure that two coats of bitumastic paint are applied to all concrete, mortar or plaster faces where these are to be in contact with the cladding.

Special shaped flashings shall be provided to suit pipes or special protrusions through cladding with a close fit to the components. Filler blocks as specified shall be provided to seal open joints where necessary.

Pipes passing through the cladding shall be fitted with a sheet splayed weathering cloak, secured to the pipe with a bolted pipe clip bedded in PVC adhesive insulating tape.

Special consideration shall be given to the surrounding sheeting or flashings to pipe or other protrusion where higher temperature may exist.

Trough fillers shall be employed to form a continuous seal at any location where open ends of sheeting are not closed by sealed ends. These fillers shall be formed from expanded polyethylene accurately cut to match the inside or outside of the profile.

All interfaces of different metals shall be completely separated by insertion of PVC adhesive insulating tape to the approval of the Engineer.

The tape shall be of adequate dimensions so that it extends 6 mm beyond each edge of the interfaces.

All main and secondary fixings shall be obtained from one manufacturer only.

All fixings shall be completely weather-tight when installed and all possible measures shall be taken to avoid corrosion of any kind either in the fixings themselves or in the adjacent sheeting.

Care shall be taken in securing all fixings to ensure that they do not impair the efficiency of the sheeting and load spreading and sealing washers.

Insulation

The roof insulation shall be in accordance with the design requirements for control of temperature within the building.

The insulation shall be non-combustible, shall be self-supporting between purlins and shall conform to appropriate British Standards. The minimum thickness shall be 50 mm.

40.20 GROUTING OF STRUCTURAL STEELWORK AND/OR PLANT

The erection of structures and plant upon foundations at site shall include grouting beneath base plates and around anchor bolts in order to:

- a. even dimensional tolerances between steelwork and concrete surface
- b. transmit loads from the structure to the foundation.

The Contractor shall supply all holding down bolts, base plates, nuts washers, templates and packing required for the proper installation of the plant being supplied.

All items requiring to be embedded or built into concrete work such as foundation bolt assemblies together with templates shall be delivered to site in good time. The Contractor is to level and adjust all the base plates on the foundations. Not until each item is set up to the approval of the Engineer and the plant contractor shall grouting/concreting commence.

The Contractor is responsible for ensuring that levels and adjustments made by him as aforesaid are not disturbed by grouting or concreting operations and that such work is to be to the satisfaction of the Engineer. Base plates shall be drilled to provide the necessary vent holes for grouting or concreting operations.

Grouting shall be non-shrink ready to use mix. Grouting is to be carried out in strict accordance with the manufacturer's instructions and to be supervised by an experienced person. No grouting will commence unless the Engineer's approval is obtained for the grouting material and procedure.

The surface area of the concrete which is to be covered by grout is to be thoroughly cleaned and all laitance removed from the surface by means of hammer and chisel (a power hammer shall not be used).

All work in connection with grouting under steelwork shall be carried out under the supervision of an experienced person employed by the Contractor.

Mixing shall be carried out strictly in accordance with the manufacturer's recommendations and to the approval of the Engineer.

Seven days after the grouting of bolt holes the Contractor shall tighten the bolts and carry out a final alignment check.

On receiving confirmation from the Engineer that the final alignment has been

approved, the Contractor shall complete the grouting under the base plate, ensuring that the grout completely fills the space and that it is thoroughly compacted and free from air pockets.

Any grouting that in the opinion of the Engineer is defective shall be cut out and replaced at the Contractor's expense.

41 MASONRY

41.1 GENERAL

The intent of this specification is to define the minimum requirement for the design and construction of all masonry work in accordance with the drawings and as specified herein. All works pertaining to masonry units, lintels, embedment and miscellaneous items as applicable, are covered under the scope.

41.2 CODES AND STANDARDS

Latest editions of codes, specifications and standards of the issues listed below shall be followed. In the event of conflicts between this spec & referenced codes and standards, the more stringent applicable requirements shall govern.

BS EN 1996	Eurocode 6. Design of masonry structures
BS EN 197	Specification for Portland cements.
BS 743	Specification for materials for damp proof courses.
BS 1200	Specification for building sand from natural sources.
BS EN 13139	Aggregates for mortar
BS EN 845-1	Specification for ancillary components for

	masonry. Ties, tension straps, hangers and brackets
BS 4027	Specification for sulphate resisting Portland cement.
BS 4551	Mortar. Methods of test for mortar. Chemical analysis and physical testing
BS EN 1015	Methods of test for mortar for masonry
BS 6073-2	Precast concrete masonry units. Guide for specifying precast concrete masonry units

Deviations

It is the intent of this specification to establish acceptable standards of quality and performance. Minor deviations in details due to manufacturer's standard shop process will be considered for acceptance provided that, in the opinion of the Engineer, the proposed substitutions are equal in quality and performance to the specified material. All deviations shall be presented in writing in the form of proposal and shall be specifically indicated on the shop drawings. Thinner gauges, inferior hardware, electro-deposited zinc coating in lieu of hot-dip galvanizing when specified, etc., will not be considered as minor deviations.

41.3 MATERIALS

Delivery, Storage and Handling

The Engineer's approval shall be obtained for all proposed manufacturers and suppliers of all blocks, damp-proof courses and other materials.

Manufacturers or suppliers may not be subsequently changed without the approval of the Engineer.

All materials shall be so delivered, stored, and handled as to prevent the inclusion of foreign materials and the damage of materials by water or breakage. Packaged materials shall be delivered and stored in the original packages until ready for use. Packages or materials showing evidence of water or other damage shall be rejected. All materials shall be of the respective qualities specified herein. Masonry units shall not be dumped, but shall be carefully unloaded and stacked.

Precast Concrete Blocks and Calcium Silicate Bricks

The precast concrete blocks are to comply with the requirements of BS 6073 and with the following requirements:

- (a) Where on the drawings, blockwork is described as solid, then it shall be constructed using solid blocks and not hollow blocks and not hollow blocks filled with concrete.
- (b) All non-load-bearing blockwork shall be of hollow blocks.
- (c) Blocks made with sulphate resisting cement shall be marked in a permanent and distinguishing manner and shall be stored on Site separately from blocks made with OPC.
- (d) Testing of Blocks shall be in accordance with BS 6073 and the Contractor shall submit the results of testing to the Engineer at regular, but not exceeding fortnightly intervals.

Prior to manufacture/delivery, the Contractor shall arrange to supply two samples of each block for the Engineer's approval. The approved samples shall be clearly marked and retained until completion of the Contract.

All concrete blocks shall comply with BS 6073. The average compressive strength of the blocks and the lowest compressive strength of any individual block tested in accordance with BS 6073 shall not be less than the values given below:

Average of 10 blocks : 7.0 N/mm²

Lowest individual block : 5.6 N/mm²

The water absorption of the blocks shall not exceed 14 percent of the dry weight.

The blocks shall be made from a mix of 250 kg of cement to 1500 kg of fine aggregates. The fine aggregates shall comply with BS EN 12620. Cement and water shall be as specified in Clause 5.7.4 (Concrete Works, see Materials) of this Specification.

Precast concrete blocks shall be manufactured using an approved machine or vibrating table. Blocks shall be true in shape, even in size, square with sharp arises and free from flaws and holes. After removal from the machine the blocks shall be laid out on their pallets under cover in separate rows one block high for a minimum of 24 hours and kept wet by watering with a fine spray.

The blocks may then be removed from their pallets and shall remain under cover and be kept wet by watering for a further period of six days after which they may be stacked nor more than five high until required for use. Blocks shall not be built into the Works until they are at least 21 days old.

Blocks shall generally be nominally 390 mm long and 190 mm high and 100 mm, 150, 190 or 200 thick (nominal). Blocks for the inner leaf of cavity wall may be hollow but blocks for other walls shall normally be solid. Where blocks are to be used in work to be plastered or rendered the faces shall be scored which the blocks are still 'green' to provide a key.

Manufacturer's tests certificates shall be produced in respect of each type of concrete block employed, and the manufacturer must give a written warranty that all blocks are properly cured and dried before delivery to site. Each batch of blocks shall be marked in a distinguishing manner.

Bricks shall generally be solid of compressive strength not less than 15N/mm² and with the density of not less than 1800 kg/m³. Color of brick to be to the approval of the Engineer.

Mortars

- (a) Cement for mortar shall comply with BS EN 197 for the works above ground and BS 4027 the works below ground. Mortar for blockwork shall be cement mortar, with the proportions 1:3 to 1:4 for OPC to sand. All mortar shall be mixed in a power driven mixer, and all materials shall be screened before mixing. Mortar - with or without plasticizer - shall only be mixed in quantity for the work immediately in hand. Mortar shall be used within 2 hours of mixing, and any mortar not used by then shall be discarded and not reworked.

Alternative mortar mixes may be used subject to the Engineer's approval in writing. For reinforced blockwork the voids shall be filled with concrete mix Ref. 20/10 (or 20S/10 as appropriate) as specified under the Concrete Works. The voids shall be filled and properly tamped in each course before the next course is laid.

- (b) Fine aggregate shall comply with BS 1200 and water for mortar shall be as specified under the Specification for Concrete Works.
- (i) Mortar for load-bearing walls shall be a mix measured by volume of 1 part cement, 1 part lime to 6 parts fine aggregate.
- (ii) Mortar for non-load bearing walls shall be a mix measured by volume of 1 part cement, 3 parts lime and 12 parts fine aggregate. Plasticisers shall not be used without the approval of the Engineer.
- (iii) Mortar for reinforced blockwork shall be 1 part cement 1 part lime and 6 parts fine aggregate.
- (iv) Alternative mortar mixes may be used subject to the Engineer's approval in writing. For reinforced blockwork the voids shall be filled with concrete mix Ref. 20/10 (or 20S/10 as appropriate) as specified under the Concrete Works. The voids shall be filled and properly

tamped in each course before the next course is laid.

- (c) The materials for the mortar shall be measured accurately to conform to the specified mix proportions. The mortar shall be properly mixed by machine. No mortar which has been allowed to set prior to use shall be revised or used in the work.

Grout for use with unit masonry work shall be fine or coarse grout as applicable. It shall be used for filling cores of masonry units at control expansion joints where indicated or as required, at control expansion joints where indicated or as required, at door frames, and at other locations where a grouting application is indicated on drawings or as required.

Concrete Masonry Lintels

Masonry lintels, where required, shall be reinforced precast lintels made of the same aggregate used for the concrete masonry units as indicated on the design drawings. Where indicated to be of masonry, exposed surface of lintel shall match concrete masonry in texture and finish as closely as possible. Lintels shall have not less than 200 mm bearing at each end.

Anchors and Ties

- (a) Unless otherwise specifically indicated on the drawings anchor and ties shall be of the type and application most suitable and shall be of galvanised mild steel. These shall conform to BS EN 845-1.
- (b) Wire ties for anchoring masonry partitions to exterior masonry walls shall be of joint reinforcement segments with longitudinal wires bent as necessary to provide bond equivalent to a cross wire at each end.
- (c) Corrugated or crimped metal ties shall be not less than 22 mm wide and of sheet steel not lighter than 0.9 mm in nominal thickness.
- (d) Dovetail-type adjustable anchors for use with embedded slots or inserts,

where indicated, shall be of sheets steel not lighter than 1.5 mm in thickness by 25 mm wide flat anchors for concrete masonry units.

Additives

The use of additives is subject to the Engineer's approval and shall be considered only if a detailed description of the product proposed for use is submitted with a complete description of the quantities and proportions proposed for use. Calcium chloride shall not be used where mortar will contact galvanized reinforcing or ties.

Reinforcement

Wall ties of fabric reinforcement for bonding walls where shown on the drawings or requested by the Engineer shall be provided.

Rod reinforcement for concrete infill and lintels shall be as reinforcement described in the specifications for Concrete Work.

Damp Proof Course

Felt for damp proof courses shall be bituminous three ply felt to BS 743 Type A.

Cement Plaster

Materials for cement plaster i.e. cement, lime, fine or coarse sand shall conform to the requirement as described under mortar and concrete work.

Thickness and finishes of plaster shall be as specified in the drawings.

41.4 LAYING OF BLOCKS

All blockwork shall be laid in stretcher bond solidly bedded, jointed and flushed up in mortar. Where wall faces are to be plastered or rendered the joints shall be raked out to form key. No cut half blocks are to be used to form bond.

Any defective blocks or bricks found in the work after completion are to be cut out and replaced and defective workmanship shall similarly be remedied all at the

Contractor's expenses.

The nominal thickness of all bed and prepped joints is to be 10 mm.

All blocks are to be thoroughly wetted before laying. All walls are to be carried up evenly course by course. During block laying, an open joint not less than 13 mm wide shall be left between the ends of all concrete lintels whether precast or cast in-situ, and the block adjacent to those ends. These open joints shall be left as long as possible during construction and not filled in until plastering or other work renders such filling necessary. All such joints shall be properly filled in before completion of the work. A piece of bituminous felt shall be laid on the blockwork under the concrete lintel bearing.

Where slabs or beams are to be cast over hollow blockwork walls, all voids in the blocks for the top course are to be filled with 1:3 mortar a minimum of 24 hours before slabs or beams are cast.

All wall faces to receive in-situ finishings or cement and sand backings shall be hacked and the joints raked out as necessary to produce an adequate key.

All external and internal wall faces where specified as fair face shall be built with blocks having unblemished surfaces, with good clean finishes to all exposed edges and shall be pointed with a bucket handle joint as the work proceeds.

Where hollow blocks about a window, door or other opening, or to fix butterfly or other ties, the voids in the blocks adjacent to the opening or containing the ties shall be filled with 1:4 mortar.

Lintels

Concrete for lintels is to comply with the Clauses of the Section for concrete. Lintels are to be set flush with the wall face, have a rough surface to provide the key when the wall is to be plastered or rendered. The dimensions will be as shown on the drawings.

Blockwork Walls

Unless noted otherwise, all blockwork walls shall be constructed of 190 mm thick hollow blocks, constructed in accordance with BS EN 1996 with a minimum compressive strength of 10.5 N/mm² for bearing walls. Where a bed or perpend joint is not solidly filled or where it is found that the Contractor has used blocks other than the blocks specified, the whole panel of wall will be considered suspect and will have to be removed and rebuilt at the Contractor's expense.

Unless noted otherwise all non bearing walls described on the drawings shall be constructed of 190 mm hollow blocks having an average compressive strength of 7 N/mm².

Below ground slab level all blocks, mortar and concrete fill to voids to be manufactured using sulphate resisting cement.

Edge Connection Details

Unless described on the drawings to the contrary, the detail at joints shall be as follows:

Vertical joints between blockwork and concrete column or wall

For all blockwork walls, galvanized mild steel butterfly pattern wall ties to BS EN 845-1 are to be cast in concrete at 400 mm vertical spacing and then built into the mortar bed joints of the wall. In addition, for 100 mm blockwork walls built directly on a ground bearing slab, two layers of building paper or similar shall be provided in the joint to separate the wall from the concrete element.

Vertical connection between blockwork and blockwork at changes of direction

All walls must be properly bonded at intersections except where a wall which is built off a ground bearing slab joints a wall built off a ground beam or footing in which case a vertical joint shall be provided with two layers of building paper or

similar between. The walls shall be together with galvanized butterfly ties as described above at 400 mm vertical spacing.

Horizontal joint at the top of the wall between the wall and concrete beam or slab over

- (a) Load bearing walls required to support a concrete floor or roof shall have a separating joint consisting of two layers of a preformed plastic sheet 2 mm thick used to provide a positive separation between horizontal concrete & brick work surfaces at the top of the wall to provide a slip surface.

The corners and intersections of loadbearing walls shall be constructed with hollow blocks and shall have the voids filled with concrete reinforced with one 12 mm high yield steel bar for the full height of each void. Bars shall be lapped with started bars from footings. At L-shaped corners three voids shall be filled and at T-shaped intersections four voids shall be filled. To allow the removal of excess mortar prior to concreting, cleanout openings shall be formed at the base of reinforced sections of wall by the use 190 x 190 x 90 mm solid block supports laid with second course perpend.

The top course of walls shall be constructed of solid blocks.

- (b) Non load bearing 200 or 150 mm wall - the top course of blockwork shall be constructed after the structure over has been constructed, props removed and a period of 14 days minimum has elapsed after the construction of the remainder of the wall. All voids in the blocks for the top course are to be filled with 1:3 mortar a minimum of 24 hours prior to erection. The joint between the top course of blocks and the structure over shall then be packed tight with semi-dry mortar well rammed in.
- (c) All 100 mm walls shall be constructed as (b) above except the joint between the top course of blocks and the slab or beam over which shall be pointed with a weak mix mortar.

Cavity Walls

Where both skins of cavity walls are built in blockwork, the skins shall be tied together with galvanised mild steel butterfly pattern wall ties to BS EN 845-1 spaced at the rate of one every 800 mm horizontally and 400 mm vertically, staggered at every 400 mm vertically at ends, jambs and quoins.

Where cavities of cavity walls are formed between blockwork and concrete, the blockwork skin shall be tied at every course to the concrete by means of galvanized mild steel butterfly pattern wall ties to BS EN 845-1 spaced every 800 mm horizontally.

The cavities of hollow blocks and cavities of cavity walls shall be kept clear of mortar and other droppings.

Protection

The Contractor shall ensure that the finished walls are not damaged by subsequent operations.

The Contractor is to protect newly or partially built walls against it being dried too rapidly by the sun heat or from any other adverse climatic effects and is to follow the Engineer's instructions in this matter.

The Contractor shall in all cases cover all newly erected walling with hessian or other material approved by the Engineer and shall keep the same wet for at least three days.

The Contractor shall prop and stabilize all walls prior to erection of floors and/or roofs and shall not remove any props without the prior agreement of the Engineer.

The Contractor shall submit to the Engineer for his approval a method for protecting the cavities of hollow blocks and cavities of cavity walls against concrete falling into these cavities while casting floor and roof slab.

41.5 JOINTS

After the mortar has taken its initial set, joints in walls and partitions shall be tooled slightly concave with a mortar thoroughly compacted and pressed against the edges of the units. The following categories of joints on the weather side of exterior masonry walls shall be raked out to a depth of 20 mm and left ready for chalking and sealing:

- (a) Control Joints
- (b) Joints between metal frames and masonry
- (c) Other joints where so indicated on drawings

Sealing of Joints

All vertical and horizontal joints in blockwork shall be sealed by an approved material.

Compressible joint fillers shall be cut to exact widths and shall have all edges neatly trimmed and recessed 10 mm from all external faces.

Fixing of filler shall be strictly in accordance with the manufacturer's printed instructions.

Where services are required to pass through blockwork walls the Contractor shall be required to provide either lintels or sleeves to prevent damages to the services pipe and the rate for this work will be deemed to have been included in the Contractor's billed rates.

Where vertical chases are required to be cut into hollow block walls, the voids of the blocks so affected shall be exposed and all the voids completely filled with concrete having minimum 28 day strength of 20 N/mm². Horizontal or diagonal chases in blockwork walls will not be permitted.

Movement Joints

Movement joints between top of blockwork and underside of concrete shall be located as shown on the drawings and shall be made with two layers of 1.5 mm thick preformed plastic strips.

External Painting of Joinery Bedded Against Blockwork

Joinery bedded against blockwork (or concrete) shall be painted in standard grade cream color.

42 CAULKING AND SEALING

42.1 GENERAL

The intent of this specification is to define the minimum requirement for the supply, installation and completion of caulking and sealing work in accordance with the drawings and as specified herein.

42.2 STANDARDS AND CODES

Latest editions of Codes and Standards, of the issues listed below, form a part of this specification. In the event of discrepancies between this specification and the referenced codes, specifications or standards, the more stringent applicable requirement shall govern.

BS EN ISO 11600	Building construction. Jointing products. Classification and requirements for sealants
BS 6093	Design of joints and jointing in building construction. Guide
BS 6956-1	Jointing materials and compounds. Specification for corrugated metal joint rings

Deviations

It is the intent of this specification to establish acceptable standard of quality and performance. Minor deviations in details due to manufacturer's standard shop process will be considered for acceptance provided that, in the opinion of the Engineer, the proposed substitutions are equal in quality and performance to the specified material. All deviations shall be called out in writing in the proposal and shall be supported by manufacturer's technical literature and test data.

42.3 GENERAL REQUIREMENTS

Locations to be Caulked and Sealed

It is the intent of this specification that the following locations be caulked or sealed as applicable to provide a weatherproof and dustproof joint between materials of construction in accordance with the drawings and as generally specified herein.

The following categories of joints shall be caulked and sealed as applicable.

- (a) Joints at exterior of all doors in exterior walls
- (b) Joints at other frames in exterior walls
- (c) Control joints
- (d) Duct, pipe and electrical penetrations in exterior walls and as otherwise indicated.

Caulking

Caulking shall be defined as the application of an oil-based compound designed for joints having very limited movement capability conforming to specifications and shall be limited to interior usage.

Sealing

Sealing shall be defined as the application of elastomeric or rubber-based compounds designed for joints having moderate movement capability and for use where exposure to weather is indicated. Generally, sealants shall be used for all exterior work, for specific interior applications where so indicated as sealant, and at the option of the Contractor, for locations where caulking is indicated or specified.

42.4 MATERIALS

General

Materials shall conform to the respective specifications and other requirements herein specified. Caulking compounds and sealants shall be delivered to the job site in sealed containers labeled to show the designated name, formula or specification number, lot number, color, date of manufacture, shelf life, curing time when applicable, and the manufacturer's name and directions for application.

Backup material

Backup material shall be one of the following types:

- (a) Closed cell resilient urethane or polyvinyl chloride foam.
- (b) Closed cell polyethylene foam.
- (c) Closed cell sponge or vinyl or rubber round joint filler.
- (d) Polychloroprene tubes or beads.

(e) Polyisobutylene extrusions.

(f) Oilless dry jute.

Bond Preventative Material

Bond preventative material shall be one of the following, as best suited for the application:

- (a) Polyethylene tape with pressure-sensitive adhesive. The adhesive shall only be required to hold the tape to the construction materials indicated
- (b) Aluminum foil conforming to BS.
- (c) Wax paper shall conform to BS.

Masking Tape

Masking tape shall conform to BS.

Caulking compound

Caulking compound shall be limited to interior usage and shall conform to BS and shall be non-staining, and shall be delivered to the building site in the manufacturer's original sealed package.

Sealing Compounds

Sealing compounds for exterior usage and where otherwise specified or indicated shall be one of the following at the Contractor's option:

- (a) A two-component rubber-based compound conforming to BS shall be used for joints in horizontal surfaces, and type II compound shall be used for joints in vertical surfaces.
- (b) A single component, curing type, rubber-based, chemically curing compound conforming to BS Type I compound shall be used for joints in horizontal surfaces, and shall be used for joints in vertical surfaces.

-
- (c) A single-component, solvent-release, acrylic type conforming to BS.

Primers

Primers shall not stain the surfaces to be sealed and shall be as recommended by the sealant manufacturer.

Rope Yarn

Rope yarn shall be raveled strands or rope fiber free from tar, oil, and other staining elements, and shall conform to BS.

42.5 SURFACE PREPARATION

Surface Preparation for Oil Based Caulking Compound

The surfaces of joints to be sealed with caulking compound shall be cleaned of particles of mortar, dust, and other foreign matter and shall be brushed out just prior to caulking. Where necessary to provide a suitable backstop, the joint shall be packed tightly with rope yarn to achieve depth of the joint as required.

Surface Preparation for Rubber-Based Sealants

Concrete, tile and masonry surfaces in contact with sealant shall be dry, sound and well brushed and wiped dust free. Oil or grease shall be removed with solvents, and surfaces shall be wiped with clean rags. Laitance and mortar shall be removed from the joint cavity. Where a backstop is required, backup material shall be inserted in the joint cavity to the required depth.

Steel surfaces in contact with sealant shall be scraped and wire-brushed to remove loose mill scale. Dirt, oil or grease shall be removed by solvent cleaning, and surface shall be wiped with clean rags.

Aluminum surfaces in contact with rubber-based sealants shall be cleaned of temporary protective coatings, dirt, oil, and grease. When masking tape is used as a protective cover, the tape shall be removed just prior to applying the sealant.

Solvents used to remove protective coatings shall be as recommended by the manufacturer of the aluminum work and shall be non-staining.

Bond-preventive materials for rubber-based sealants shall be installed on the bottom or back of the joint cavity to prevent the sealant from adhering. The material shall be carefully applied so as to avoid contamination of adjoining surfaces or breaking bond with surfaces other than those required.

42.6 APPLICATION

Application of Oil Based Caulking Compound

The ambient temperature shall be between 5°C and 38°C when the compound is applied. Compound shall be gun-applied with a nozzle of proper size to fit the width of joint indicated, and shall be forced into grooves with sufficient pressure to expel air and fill the groove solidly. Caulking shall be uniformly smooth and free of wrinkles, and shall be left sufficient convex to result in a flush joint when dry.

Application of Rubber-Based Sealants

The ambient temperature shall be between 5°C and 38°C when the sealant is applied.

Primer shall be used on concrete masonry units, or other porous surfaces in accordance with instructions furnished with the sealant.

Paper masking tape shall be placed on the finish surface on one or both sides of a joint cavity to protect adjacent finish surface from sealant smears. Masking tape shall be removed within 10 minutes after joint has been filled and tooled.

Joint shall be tooled slightly concave after sealant has been installed. When tooling white or light color sealant, a dry or water-wet tool shall be used.

42.7 Cleaning

The surfaces adjoining the caulked and sealed joints shall be cleaned of smears or

other soiling resulting from the caulking and sealing application.

43 CARPENTRY, JOINERY AND IRONMONGERY

43.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing of all inputs necessary and incidental to the fabrication and installation of treated woodwork in accordance with the drawings and as specified herein.

43.2 CODES AND STANDARDS

Latest edition of the Codes and Standards of the issues listed below form a part of this specification. In the event of discrepancies between this specification and the referenced codes, specification or standards, the more stringent applicable requirements shall govern.

BS 373	Methods of testing small clear specimens of timber
BS 1186	Timber for & workmanship in joinery
BS EN 1116	Kitchen furniture. Co-ordinating sizes for kitchen furniture and kitchen appliances
BS EN 301	Adhesives, phenolic and aminoplastic, for loading bearing timber structures. Classification and performance requirements
BS EN 302	Adhesives for load bearing timber structures
BS 1210	Specification for wood screws
BS EN 13310	Kitchen sinks. Functional requirements and test methods
BS EN 438	High-pressure decorative laminates (HPL). Sheets based on thermosetting resins (usually called

		laminates). Introduction and general information
BS	EN	Building hardware. Lever handles and knob
1906		furniture. Requirements and test methods
BS	EN	Eurocode 6. Design of masonry structures
1996		
BS	EN	Building hardware. Locks and latches.
12209		Mechanically operated locks, latches and locking
		plates. Requirements and test methods
BS EN 636		Plywood. Specifications
BS EN 314-		Plywood. Bonding quality. Test methods
1		
BS	EN	Building hardware. Single-axis hinges.
1935		Requirements and test methods
BS EN 942		Timber in joinery. General requirements

Delivery, Storage and Handling

The woodwork shall not be placed until the building is enclosed and wet operations are completed and dry. The work shall be protected against dampness during and after delivery.

Store out of the way of work in progress, in well ventilated room and where not exposed to extreme changes in temperature and humidity.

Handle materials in such a manner as to prevent damage to products or finishes.

43.3 SUBMITTALS

Both the vendor and the sample finish shall be submitted to the Engineer for approval prior to commencement of work. No work shall commence until the samples have been approved.

43.4 MATERIALS

Timber

The following timbers shall be used for carpentry and joinery work:

a) Timber for Concealed Work

Softwood used in the permanent works shall be approved whitewood and shall be treated before fixing with two coats of clear wood preservative of the approved manufacturer.

Concealed surfaces of softwood joinery shall be primed.

b) Timber for Exposed Joinery

Timber for exposed joinery, and where referred to as hardwood, shall be approved selected Red Meranti or other approved species, unless specifically described otherwise, and shall conform to the relevant requirements of BS 373 & BS EN 1995.

Timber 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 wrought die square and true on all four sides, or circular, to the scantlings and shapes on the Drawings.

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 and the knot nowhere occupies more than one sixth of the width of the surface.

Samples of each of the approved hardwoods shall be kept on Site, stores in such a manner that the color shall not be affected by sunlight. All hardwood subsequently used in the Works shall be of the same quality and color as the approved samples.

Joinery shall be of sufficient size and strength for its specific function. All work whether hardwood or softwood shall comply with the requirements of BS 1186 & BS EN 942 and no imperfection in the timber shall exceed that permitted under Appendix C, Class 15 of that standard for work to receive a clear finish and Class 1 for work to be painted with an opaque finish.

c) Moisture Content of Timber

Moisture content of timber shall comply with the requirements of BS 1186 & BS EN 942.

Softwood shall have a maximum moisture content of 15%.

Hardwood shall have a maximum moisture content of 12% and shall be kiln dried or properly seasoned by other approved means.

The Contractor shall supply a copy of timber supplier's certificate specifying the moisture content of the timber on delivery.

Timber for joinery work shall be properly stacked and protected from the

weather and ground moisture and stored in such a way that the moisture content is not affected.

Plywood and Melamine

Plywood for external applications or in contact with external surfaces shall comply with BS EN 636 and be equal in quality to Grade 2, Type WRP.

Plywood for internal applications shall comply with BS EN 636 and be equal in quality to Grade 2, Type MR.

Face veneer shall be hard and durable and capable of being finished to a smooth surface and be equal to an approved sample.

Melamine shall be not less than 1.5 mm thick and of a quality similar to that marketed as Formica complying with BS EN 438, Class 1, and of an approved color and pattern.

Joinery finished with a decorative laminated sheet shall have a suitable balancing laminated sheet on the reverse side. The laminates shall be beveled off with a plane along all arises.

Where laminate is fixed to doors or shelves, etc., without a laminate to the outer edge, a raised hardwood lipping shall be provided and the laminate finished flush against the lipping.

Adhesives

Adhesives for woodwork shall have proportions at least equal to type MR as specified in BS EN 301 and BS EN 302.

Adhesives for fixing laminated plastic sheets to wood surfaces shall be petroleum based contact adhesives of approved type. PVA types of adhesives will not be accepted.

43.5 DOORS AND WINDOWS

Flush Door

Flush doors shall comply generally with the requirements of CP 151, Part 1. Samples shall be submitted for approval.

The core of solid core flush doors shall be constructed of longitudinal laminations of precision planed timber, butt-jointed and glued with resin based adhesive under hydraulic pressure, the whole forming a rigid fire-resistant raft. Both sides shall be covered with external grade plywood not less than 6 mm thick.

Flush doors shall have 10 mm hardwood lipping tongued in to all edges. In the case of hardwood faced veneer, hardwood face veneers shall be Group 1 Burma Teak, stripped Sapele or other approved and shall be sliced out and matched as directed. For doors to receive a painted finish, rotary cut veneers may be used.

Metal air-transfer grilles shall be of approved aluminum design.

The Contractor shall store flush doors in a weatherproof shed and they shall be stacked in a flat position so that their true shape is preserved until required for use.

Where flush doors are external to a building they shall be provided with door seals.

Louvered Doors and Windows

Louvered doors and windows shall be of red meranti constructed and framed up to the sizes shown on the drawings. Doors and windows shall be rigid in construction and free from sag and bowing.

Framed and Panelled Doors

Framed and paneled doors shall be of red meranti to the sizes and sections as indicated on the drawings and shall be to the requirements of CP 151, Part 1.

The doors shall be made in such a way as to avoid sag, bowing and generally in

rigid construction.

43.6 WORKMANSHIP

The Contractor shall provide temporary doors where necessary during the progress of the work.

Structural timbers shall extend in one piece between their supports or fixings or be jointed in an approved manner.

Where structural timbers are notched over supports, the depth of the notch shall not be more than two-fifths of the depth of the timber.

Where structural timbers are to be cut for the passage of pipes and the like, cuts shall be made as near to the neutral axis as possible and shall not exceed one third of the depth of the timber. Alternatively, they shall be made in the top edge of the timber as far from the centre of the span as possible.

Carpentry work which does not form an essential part of the structural fabric shall not be executed nor brought onto Site until required, unless the Contractor can show that such materials will be adequately stored and protected.

Timber for joinery work shall be cut to size and shape, properly jointed and put together, including framing, gluing, dowelling, screwing and mortising, etc.

Joinery shall be prepared and framed up and put together at least four weeks before being installed, but shall not be glued or wedged up until immediately before installation. Should any shrinkage or other defects appear in the work, the defective parts or units shall be replaced.

Joints and quality of workmanship shall be in accordance with BS 1186 & BS EN 942.

Timber required to be wrought shall have the faces brought to a smooth finish (not machine planed only) with all arises pencil-rounded.

Dimensions of joinery items to be fitted into structural openings shall be obtained in situ and not from the Drawings.

Faces of timber in contact with the structure or other non-wood surfaces shall be treated with preservative and primed before fixing.

Cover beads, architraves, etc. abutting any irregular surface shall be accurately scribed to fit.

43.7 BUILT-IN JOINERY

Where joinery works are to be built-in before the surrounding building carcass is completed, the Contractor shall ensure that the joinery works are set plumb and true and shall not be damaged or displaced by subsequent building operations.

43.8 FIXED-IN JOINERY

Where joinery works are to be fixed-in after the surrounding building carcass is completed, the Contractor shall ensure that the necessary fixings are incorporated in the carcass. The work shall be fixed in plumb and true and in accordance with the Drawings with all necessary wedges and shims as detailed or as may be directed. Overhead clearances and levels shall be maintained where applicable.

Cupboard Fittings and Cabinets

Kitchen and Tea Room units shall conform to BS 6222 & BS EN 1116.

Wall and floor finishes within Cupboards shall match finishes in adjacent areas. Kitchen cabinets and work tops shall be proprietary from a range approved by the Engineer.

Stainless steel sinks and drainers shall have a standard satin finish and shall comply with BS EN 13310.

The Contractor shall store, assemble and fix the kitchen fittings in accordance with the manufacturer's printed instructions and shall leave them clean and in perfect

working order at completion.

Joints between sinks, worktops and walls shall be sealed with approved silicone sealant.

The Carcasses of Units and Shelves shall be made from high density (750 kg/m³) chip board panels of minimum 18 mm thickness and shall be covered with melamine resins and shall have easy to clean and abrasion proof surfaces.

The base units shall have side holes allowing easy assembly, and with inner holes for adjustment of the shelves at various heights. The base units shall have adjustable plinth feet, allowing a perfect leveling of the Units, even on irregular floors.

Draught Excluders, Weather-Proof Stripping and Threshold Seals

These shall be of a proprietary manufacture approved by the Engineer.

Seals shall be formed from high tensile heat treated aluminum alloy with elastomeric inserts. The finish shall be anodized natural aluminum. Screws shall be bright zinc plated double passivated to ZN3.

Laboratory Units

Laboratory units shall be by an approved proprietary manufacturer generally to the dimensions as shown on the drawings and to be complete with all accessories and ironmongery, e.g. handles, hinges, catches, etc. Finish to be plastic laminate with balancing layer on reverse side colors to be selected by the Engineer. Worktops shall be finished in a heavy-duty post-formed laminate with built-in service ducts as shown on the drawings.

Frames and Linings

Frames and linings shall be secured at jambs by screwing to sawn hardwood grounds, blockings or packing pieces. The latter shall be secured to the structure

at jambs by screws and plugs at maximum 600 mm centers.

Architraves, Door Stops, Skirting, Etc.

Architraves, door stops, cover beads, etc., shall be mitered at external angles and scribed at internal angles.

Access panels shall be easily removable, held in position with domed cups and screws, and be formed with 25 mm blackboard, painted and with edges lipped with 15 mm hardwood.

43.9 FIXINGS AND JOINTINGS

Hardwood grounds in carpentry work shall be put together with steel nails except where described as framed when it shall be properly jointed and held together with glue and steel screws. Fixings shall be steel screws.

Fixing of hardwood joinery shall be by means of brass wood screws to BS 1210.

Screw heads in work to be painted shall be properly countersunk and stopped.

Screw Fixing of Aluminum

Where aluminum components are fixed to joinery work, aluminum or cadmium plated screws and washers shall be used. Brass screws shall not be used in conjunction with aluminum.

Protection of Joinery from Damage

Joinery shall be protected from damage during the course of the Works. The Contractor shall ensure that doors, drawers, etc., work easily and shall make all necessary adjustments before handing over and during the maintenance period.

43.10 IRONMONGERY

Ironmongery, including locks, latches, knobs, handles, closers, kick plates, indicator bolts, barrel bolts and cupboard door pulls and latches, etc., shall be of

good quality in accordance with:

BS EN 1935	Building hardware. Single-axis hinges. Requirements and test methods
BS EN 1906	Building hardware. Lever handles and knob furniture. Requirements and test methods
BS EN 12209	Building hardware. Locks and latches. Mechanically operated locks, latches and locking plates. Requirements and test methods

The fitting and fixing of ironmongery shall be in accordance with the manufacturer's instructions. Ironmongery shall be trially fitted prior to any finishing then, removed or finished and fixed on completion of all applied surfacing. Hinges shall be aluminum butt hinges countersunk-screwed to door and frame; generally three 150 mm hinges for framed doors (including paneled units of this type) and solid core doors and two 150 mm hinges for flush plywood hollow core doors.

Doors shall be properly and accurately hung to fit neatly into mortises in frames.

Locks shall be provided with two sets of keys and door closers shall be provided with adjusters. All ironmongery shall be fixed with matching screws.

Ironmongery shall be kept carefully wrapped and protected until required and when fixed shall be carefully protected against defacement by mortar and plaster droppings, paint splashes, smudges, etc

43.11 DOORMATS AND PINBOARD

Doormats shall be close tread of the size to fit the matwells shown on the drawings.

Pin board

Pin board shall be overall size 1600 x 1000 mm including external 60 x 30 mm hardwood edging framework, to hold 10 mm thick soft board with a backing of 12 mm thick plywood. All the above are screwed to external 50 x 20 mm hardwood cleft fillet, which in turn is fixed to the wall.

44 ROOF WATERPROOFING AND INSULATION

44.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing of all materials and services necessary for an insulation or incidental to the construction and completion of waterproofing system complete in accordance with the drawings and as specified herein.

Water proof roofing system shall be installed to the manufacturers instructions and detailed specifications and solely by their licensed installers or applicators. The installation shall be guaranteed jointly and severally by manufacturers and the licensed applicator for a minimum period of ten years.

44.2 GENERAL REQUIREMENTS

The roof insulation and waterproofing system shall be a multilayer system comprising screed, waterproofing membrane, thermal insulation, protection layer, concrete paviors and flashing etc. or rigid polyurethane foam spray system to DIN 53420/ASTMD 1622 with screed, protection layer and roof pavior etc. for accessible roofs and just the rigid polyurethane foam spray for inaccessible roofs.

The details of waterproofing system shall generally include the following as applicable:

Lightweight Screed

The lightweight screed shall be laid on the roof at 5‰ slope. The screed density shall be 800 - 1000 kg/m³. The minimum thickness of the screed shall be 50 mm. The lightweight screed shall be to the approval of the Engineer and shall be laid as per manufacturer's specifications.

The lightweight concrete shall be chemically inert, stable, impermeable, inorganic.

Twenty eight day crushing strength shall be at least 2.0 N/m².

The screed shall be cured in accordance with the concrete specification for a period of not less than seven days during this time the screen shall not be subjected to traffic of any kind.

The surface shall be finished flat and true.

The screeds and toppings shall be allowed to dry out thoroughly before subsequent roofing operations are carried out.

Screed and toppings shall not be laid during rain.

Water Proofing Membrane

The waterproofing membrane shall be min. 4 mm thick elastomeric self adhesive or equal and shall be laid on the roof as per the manufacturer's instructions.

Thermal Insulation

Thermal insulation board shall strictly conform to BS 3837, expanded polystyrene boards. It shall be either, type A, grade VHD (molded boards with skins), or type A grade SHD (extruded boards with skins) with standard dimension 1250 x 600 x

50 mm. It shall be laid over the waterproofing membrane as per manufacturer's instructions.

Separation Layer and Protection Layer

A synthetic fiber mesh of polyester base shall be installed with a 300 mm overlap on top of the roof insulation.

Precast Concrete Paviers

Precast concrete paviers shall comply generally to BS EN 1339 & BS EN 1340 and shall be laid to cover the whole area of the roof plans. Dimensions shall be as shown on detail drawings. Paviers shall be hydraulically pressed.

Flashings Generally

Flashings shall be in aluminum, half hard super purity grade 0.91 mm to BS EN 485. Flashings shall be neatly tucked into grooves dressed down and formed with a welged drip, as indicated on the drawings.

All aluminum surfaces in contact with concrete cement or lime mortar shall be painted with one coat of bituminous paint.

Certified Statement on Installation

A certified statement to the effect that all roofing, insulation and flashing have been installed in strict accordance with the manufacturer's printed instructions for a 10 year bonded roof and the performance is guaranteed for a period of 10 years shall be furnished by the Contractor to the Engineer.

44.3 PIPES THROUGH ROOF SLAB

All waste stacks, ducts and pipes penetrating the roof slab, to be weatherproofed in accordance with the Engineer's details consisting blockwork upstand and concrete slab, with pipe turned through 90°C.

45 MISCELLANEOUS METALWORK

45.1 GENERAL

The intent of this specification is to define the minimum requirement for furnishing and installation of all miscellaneous metalwork in accordance with this specification.

The work includes, but is not necessarily limited only to the miscellaneous metalworks listed below:

- a) Balustrading & Handrails
- b) Steel Access Ladders
- c) Beam and Girder Plates for Mechanical and Electrical Supports
- d) Loose Channels and Toe Angles
- e) Chequered Plates
- f) Gratings
- g) Angle or Channel Frames for Floor Openings, Gratings
- h) Gratings
- i) Platforms
- j) Steel Frames and Lintels for Rolling Doors
- k) Frames, Covers and Gratings

45.2 CODES AND STANDARDS

BS EN 1993 Standard Specification for Structural steel and all relevant BS Standards as included for structural steelwork shall apply or any other equivalent codes, subject to approval of the Engineer.

45.3 SHOP DRAWINGS

Before fabrication of any miscellaneous metal has started, the Contractor shall submit shop drawings for approval to the Engineer. The Contractor shall furnish complete setting out and fabrication drawings for all miscellaneous metal. These drawings shall include all details of miscellaneous metal required to complete this section of work. Material fabricated or delivered to the site before approval of shop drawing shall be subject to rejection by the Engineer.

45.4 MATERIALS

All materials shall be the best of their respective kinds, free from all imperfections that will impair their strength, durability and appearance. All materials shall meet the current applicable specifications of BS. All material shall be well finished bars, plates, strips, angles, rolled sections, extruded sections, pipes, etc. as required and specified, clean and free from mill scale, flake, rust pitting. Cast iron shall be soft, rough gray iron. Accessories for connection of cast iron shall be of steel unless otherwise specified. Materials required or indicated to be galvanized, shall be so treated after fabrication.

45.5 WORKMANSHIP

Ferrous and non-ferrous materials shall be well formed to shape and size, with sharp lines and angles. Shearing and punching shall leave clean, true lines and surfaces. Shop connections shall be bolted or welded. Field connections shall be bolted or welded in accordance with the best practice. Fastening shall be countersunk into exposed work and finished works, except as otherwise required. Screws shall not be used where avoidable. All mitered corners shall be ground after shop welding. Joints and intersections shall be accurately made, in true planes, with adequate fastenings. Bolted work shall be screwed up tight and threads nicked to prevent loosening, except those miscellaneous metal items to be removable or portable, and shall have lock or split washers. Joints exposed to weather shall be watertight.

Casting shall be free from warp or defects that impair their strength or appearance. Exposed surfaces shall have smooth finish and well defined, sharp lines and arises. Joints shall be milled to a close fit. The Contractor shall perform all shop requirements of cutting, drilling, tapping and fitting to accommodate other work coming in contact with or passing through these materials. He shall also ascertain and take particular care that all holes, cutouts, etc., have been provided as no claim for extra payment on this account will be considered or allowed.

All structural fabrication work shall conform to provisions of the relevant British Standards as listed in specification for "Structural Steelwork".

45.6 MISCELLANEOUS METALS AND FIXTURES

The Contractor shall furnish complete GI pipes and sockets toe channels, angles and plates etc. as required. Channels and angles shall be fabricated of structural shapes. Intersecting corners of toe channels and angles shall be mitered.

Balustrade and Handrails

Balustrade and handrails shall comply with BS 6180.

Steel Access Ladders

Steel access ladders shall comply with BS 4211.

Chequered Plate

Chequered Plate shall be hot dipped galvanized after all cutting for lifting eyes, penetrations and fitting have been completed. After suitable priming, the place shall receive a further 2-coat epoxy paint system in a color approved by the Engineer. Where chequered plate spans more than 750 mm it shall be suitably stiffened with angle backing.

Chequered plate shall be supported on 50 x 50 mm angle anchored into the concrete with lugs at 1.0 m centers. On top of the angle is to be welded an 8mm deep by 10mm wide bar to retain the chequered plate. This is to be flush with the finished floor level (FFL).

Two-way pattern chequered plate, to match stair tread chequered plate, for floors and platforms shall be of thickness and locations as required for load. Chequered plates that are to be removable shall be provided with two lifting holes, and size of plates shall be such as to afford easy handling. Other plate shall be provided with fasteners as required. All plates shall rest flat on their supports without

rocking. All edges of plates shall be ground or cut smooth and straight with 3 mm clearance between plates. Unsupported chequered plate will be stiffened with angles where required for loading. Cut-outs and openings required for chequered plate shall be shop formed and reinforced to dimensions and locations as required by the Engineer. Furnish banding strip or angle for openings required to be cut out in the field. Furnish all other necessary accessories for chequered plate required for field installation.

Where chequered plate is required to be furnished with grating, it shall be securely shop welded. Interior chequered plates shall be shop painted and exterior ones shall be hot dipped galvanized after fabrication.

Gratings

Steel gratings shall be welded type rectangular pattern of sizes as required. Bearing bars shall be 30 mm on centers, unless otherwise directed, and twisted or spiraled cross bars not more than 100 mm on centers. Interior gratings shall be shop painted and exterior gratings shall be hot dipped galvanized after fabrication. Galvanizing shall be minimum 65 microns. All gratings are to be bolted or clipped to their supports to allow for removability. Cut neat circular or square opening for the passage of pipes, ducts, etc., through grating. Such openings shall have 50 mm clearance for bare and insulated pipes and ducts at all points. Bank all openings with 150 x 6 mm steel plate curbs welded to each intersecting member of the grating. Do all necessary cutting and fitting in the field. Provide toe plates at all unprotected open sides at end of grating. Sizes and locations of openings shall cater to the Structural, Mechanical, Electrical and Special process requirements.

Steel Frames and Lintels for Rolling Doors

Steel lintels shall be provided for all opening dimensions for rolling steel doors. Provide a minimum of three adjustable anchors per frame jambs as required when built into masonry. Anchors shall be fabricated from 6 mmx100 mm steel flats extending 300 mm into mortar joints to floor by steel angle clips. All frames shall

be neatly mitered at corners, securely full welded and ground flush. Provide all necessary field bolts, clips, etc., for frames and lintels.

Frames, Covers and Gratings

Frames, Covers and Gratings for manholes and catch basins shall be of heavy duty casting. Iron casting shall conform to ASTM a 48, Class 20. All casting shall be true to pattern in form and dimension, free from faults, sponginess, cracks, blowholes, and other defects affecting their strength. Bearing surfaces between cast frames, covers and grates shall be machined, fitted together and match marked to prevent rocking.

45.7 CLEANING

After erection and installation, all miscellaneous metalwork shall be thoroughly cleaned. Work under this section that has become damaged during the course or erection or installation shall be replaced by the Contractor at his expense as directed by the Engineer.

46 ALUMINIUM METALWORKS

46.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing and installation of all works necessary for or incidental to the construction and completion of works as indicated on the drawings and as specified herein.

The work includes, but is not necessarily limited only to the aluminum metalwork listed below:

- a) Doors, Windows and Frames
- b) Louvers and flyscreens
- c) Flashings and Trims
- d) Architraves, Door Stops etc.
- e) External Traffic Signs
- f) Directional and Information Signs

46.2 CODES AND STANDARDS

Latest editions of codes, specifications and Standards of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto. In the event of conflicts or discrepancies between this specification and the referenced codes, specifications or standards, the more stringent applicable requirement shall govern.

BS EN 1999	Eurocode 9. Design of aluminium structures
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BS 1161	Specification for aluminium alloy sections for
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structural purposes

BS 1473	Specification for wrought aluminium and aluminium alloys for general engineering purposes. Rivet bolt and screw stock.
BS 1494-1	Specification for fixing accessories for building purposes. Fixings for sheet, roof and wall coverings
BS 3987	Specification for anodic oxide coatings on wrought aluminum for external architectural applications.
BS 4873	Specification for aluminum alloy windows.
BS 4842	Specification for liquid organic coatings for application to aluminium alloy extrusions, sheet and preformed sections for external architectural purposes, and for the finish on aluminium alloy extrusions, sheet and preformed sections coated
CP 143-15	Code of practice for sheet roof and wall coverings. Code of practice for sheet roof and wall coverings. Aluminium. Metric units
BS 1245	Pedestrian doorsets and door frames made from steel sheet. Specification
BS 405	Specification for uncoated expanded metal carbon steel sheets for general purposes.

Deviations

It is the intent of this specification to establish acceptable standards of quality.

Minor deviations in details due to manufacturer's standard shop process will be considered for acceptance provided that, in the opinion of Engineer, the proposed substitutions are equal in quality to those specified. Thinner gages and inferior weather stripping will not be considered as minor deviations. All deviations shall be called out in writing in the form of proposal, and shall be specifically indicated on the shop drawings.

Related Work Specified Elsewhere

The following categories of work are covered under other specifications and not specified herein:

- a) Glass and glazing
- b) Caulking and sealing

46.3 SUBMITTALS

Shop drawings, catalog cuts containing sufficient technical information and samples indicating finish and construction shall be submitted and approval obtained before beginning fabrication.

Material shall not be delivered to the jobsite before certified drawings have been issued by the Contractor. Shop drawings shall indicate the following information:

- a) Location and elevation of each type of item of work
- b) Details of construction and dimensions
- c) Hardware details
- d) Location and details of joints to accommodate movement due to expansion and contraction
- e) Gauges of metal
- f) Type of finish
- g) Installation details

Design Data

- a) Design data shall be submitted to the Engineer.

- b) Submit evidence that each aluminum door will reasonably withstand racking and maintain square corners without sagging.
- c) Submit design calculations confirming that aluminum entranceway designs submitted for approval can safely withstand the maximum wind load velocity for the geographical locality of the project.

46.4 DELIVERY, STORAGE AND HANDLING

All materials shall be delivered, stored, and handled in a manner to prevent damage of any type. All packaged materials shall be delivered to the project in the manufacturer's original unopened containers. All materials shall be stored under cover in watertight enclosure, but affording proper air circulation.

Store door and windows upright on wood stripping to keep bottom of doors at least 25 mm or more off the floor or ground, with at least 6 mm between individual pieces.

Exposed finish surfaces of pre-finished items shall be fully protected with non-staining masking tape or other suitable covering.

Special storage and handling requirements of the manufacturer shall be followed.

Any unit, part or accessory damaged in any manner shall not be used in the work but shall be replaced by a new undamaged unit, part or accessory of same quality and design.

46.5 MATERIALS AND GENERAL REQUIREMENTS

Materials

Extruded aluminum shall be of BS alloy HE 30; sheet aluminum shall be BS alloy NS 3 or 4, and all other forms of aluminum shall be of alloys which possess such properties that they will be durable in the climate that exists on Site.

Aluminum for angles and channels shall be BS alloy HE 30 and together with bolts, screws etc., shall comply with the relevant requirements of BS 1161, BS 1473 &

BS 1494 Part 1.

Materials for windows, screens and doors, form of construction finishes and performance shall generally be in accordance with BS 4873.

Aluminum sheet or strip shall not be less than 0.9 mm in thickness with a degree of hardness corresponding to the recommendations in BS CP 143, Part 15, appropriate to its thickness and composition. Fixing shall be with aluminum clips secured with aluminum alloy screws.

Aluminum louvers and flyscreens shall be of approved manufacturer. All aluminum parts shall be finished in stoved polyester powder paint to BS 4842.

General Requirements

Doors and Door Frames

Aluminum entrance doors and vestibule doors, where shown, shall be "Medium Style". Each exterior door left shall be 1.0 m wide by 2.150 m high unless indicated otherwise in drawings. Aluminum frames and transom frames shall be 45 mm face dimension by 115 mm depth and be designed to receive 19 mm thick tempered insulating plate glass. All members shall be designed for recessed glazing with vinyl glazing inserts, and without the use of applied stops. No exposed fastenings shall be used.

All door and frame sections shall be extruded aluminum. Aluminum alloys shall be standard with the manufacturer used. Doors and frames shall be given anodised finish of approved color. The sections shall be etched and anodized to a guaranteed penetration of 0.0010 one hour, 25 micron to BS 3987.

Doors shall have maximum security hookbolt lock and 457.200 mm lever type flush ikbolts for pairs of doors. Operating hardware shall be offset pivots as supplied by the door manufacturer. Provide panic bars and closers as per door schedule.

Fluted aluminum thresholds shall be supplied for all exterior doors unless indicated otherwise in drawings. Finish shall match finish of door frames.

Doors and frames shall be factory prepared before shipment in conformance with British Standard as applicable.

Mortising, reinforcing, drilling and tapping for mortised hardware shall be done at door manufacturer's plant.

Concealed reinforcement of aluminum doors and frames for all hardware shall be installed at the factory, including reinforcement for surface applied hardware, weather-stripping, and other attachments.

Reinforcements and supports for lock and latch case shall be in accord with British Standard as applicable.

All necessary rod reinforcing shall be provided in the top and bottom door rails to meet structural requirements as specified herein.

Provide plaster guards on door frames for hinge and strike guards for strike reinforcement.

Rubber or neoprene silencers shall be provided for each aluminum door frame.

Drilling and tapping for surface applied hardware shall be done in the field.

Each exterior aluminum door shall be weather-stripped by metal backed wool pile cloth weather-stripping at jambs, head, sill and meeting stiles. Groove retaining the weather-stripping shall be an integral part of the basic extrusion and not an applied member.

Each door leaf shall be provided with an adjusting mechanism located in the top rail near the lock stile to provide for minor clearance adjustments after installation.

Windows

General

Windows shall be of the types indicated. Each window shall consist of a unit including frame, mullions where indicated or required, and anchors.

All frame sections shall be tubular extruded aluminum shapes and of alloy as per BS as applicable. Frame sections shall be not less than 50 mm deep from front to back and 60 mm high from top to bottom. The four corners of all window frames shall be miter-cut and electronic fusion welded throughout the entire section profile. Welds shall be dressed smooth on exposed and contact surfaces. Miter-cut mechanical joints may also be used provided they are Engineer approved prior to fabrication.

Windows shall be arranged for inside glazing with aluminum snap-in glazing beads designed to accommodate insulating glass as specified. Snap-in glazing beads shall securely interlocked into the extruded window sections. Glazing rebate legs shall not be less than 19 mm in height.

Mullions, Sills and Trims

Mullions, sills, trim and other window sub-assemblies, indicated on the drawings or as necessary to properly complete each aluminum window installation, shall be of size and design to suit the window assembly, be compatible with the windows, and conform to the requirements for these sub-assemblies as specified in relevant British Standards.

Anchors and Clips etc.

Anchors, clips, bolts and screws necessary to secure windows and mullions shall be provided and shall be, at manufacturer's option, with aluminum, non-magnetic stainless steel, or zinc coated steel.

Hinges shall be of anodized extruded aluminum and of the quality as the windows. Pivoting on stainless steel pins spaced by other stainless steel or nylon washers.

All windows shall be fitted with handles and limiting stays of a material compatible

with the window material and shall be of a simple but highly functional design approved by the Engineer.

Side hung casements shall be friction stays as approved by the Engineer.

Finish

All windows furnished under this specification shall have aluminum surfaces provided with a satin finish, followed by an anodic oxide coating. The coating shall be similar to that specified for doors.

Weather stripping shall be of neoprene or woven pile as applicable and shall continue around whole perimeter of casement form and outer frame, wherever groove is provided in extruded sections.

All windows shall be glazed using a water and dust protective gasket on rebates and PVC pressure gasket snapped into extruded profiles of sections.

Aluminum Louvers and Flyscreens

Louvers

Louvers shall be continuous horizontal static single banks comprising cold roll formed louvers mounted at 50 mm or 100 mm pitch on concealed mullions and incorporating head, jamb and sill sections with mullion shoes. Fixing shall be by means of stainless steel bolts through mullion shoes with isolating grommets and washers. Gaps between louver frames and structural openings shall be sealed both sides with the manufacturer's recommended mastic sealant.

The Contractor shall store, assemble and fix aluminum louvers and flyscreens in accordance with the manufacturer's printed instructions and shall leave them clean and in perfect working order on completion.

Flyscreens

Frames shall be of anodized extruded aluminum sections and be of the same

quality as the windows. Mesh shall be PVC coated glass fiber approved by the Engineer and shall be held secure by PVC rods inserted in a groove provided in the frame section.

Aluminium Flashings and Trims

Aluminium sheet turned up against walls and upstands shall be welded to an aluminium flashing or apron strip. Flashings and apron strips shall be folded and tucked into blockwork joints to a minimum depth of 25 mm, secured by folded aluminium sheet wedges, with pointed with sealant. Vertical joints in aprons and flashings shall be welded.

Care shall be taken to avoid contact of aluminium with dissimilar metals, and materials containing alkalis, etc.

Architrave, Door Stops, etc.

Architraves, door stops, etc., shall be properly mitred at intersections.

External Traffic Signs

External traffic signs shall be manufactured to BS EN 12899 from 3 mm aluminum faced with reflective sheeting. Signs shall be Class 2 reflective faced with gray backs. The signs shall generally be 900 mm diameter in size and shall conform in layout to the most recent edition or the "Highways Designs and Standards for the Sultanate of Oman". Signs shall be lettered in Arabic and English (where required); and shall be supplied complete with fixing holes; rounded corners; and stainless steel clips (2 per sign) and stainless steel bolts and nuts for fixing to posts. Posts shall be manufacturer in 75 mm diameter galvanized iron tube set in 0.5x0.5x0.7 m concrete foundations (concrete grade 20/20). Posts shall be painted with 300 mm vertical alternate bands of black and white paint.

Directional and Information Signs

External directional and information signs for post mounting shall be manufactured

to BS EN 12899 from 3 mm aluminum class 2 reflective faced. The background borders, logo and lettering of the signs shall be screen printed in accordance with the requirements of the Employer's corporate identity brochure and to the sizes given on the Contract Drawings.

The signs shall be lettered in Arabic and English and shall be supplied complete with rounded corners; fixing holes; stainless steel clips and stainless steel bolts and nuts for fixing to posts.

Posts shall be manufactured in 75 mm diameter galvanized iron tube set in 0.5x0.5x0.7 m concrete foundations (concrete grade 20/20). Posts shall be painted white.

External signs for wall mounting shall be manufactured in 22 SWG aluminum Class 2 reflective faced, complete with rounded corners, fixing holes and stainless steel slips for wall fixing.

Internal Warning/Prohibition/Information Signs

Internal warning, prohibition and/or information signs shall be manufactured in 1 mm thick rigid plastic complete with fixing holes and rounded corners. Signs shall be 300x250 mm in size and lettered in Arabic and English.

Protective Coating

Protective coating shall be applied by the manufacturer to exposed surface of all aluminum components subject to staining from alkaline, mortar, plaster, abrasion and other construction abuses, except surfaces which will receive caulking or sealant.

Before application of the protective lacquer, manufacturer shall remove any moisture, dirt and other foreign material from the finish surfaces to insure adhesion of the protective lacquer. Surface which will receive caulking shall be kept free of the protective lacquer by covering same with tape before the lacquer is sprayed.

Insofar as is practical remove lacquer in field after construction is completed and immediately prior to field cleaning.

Protection from Dissimilar Materials

Where aluminum is to be in contact with steel or other ferrous metal, concrete, mortar, plaster or other dissimilar construction materials, the facing surfaces of the aluminum shall be protected with non-absorbing tape or be painted before erection with a heavy coat of coal-tar emulsion or alkali-resistant bituminous paint.

Protective tape, emulsion or paint shall not be applied to aluminum surfaces visible in the finished work.

46.6 INSTALLATION

Preliminary Inspection

Examine conditions at each location where aluminum entranceways are to be installed. Check field measurements to insure that work is ready to receive the entranceway assemblies. Co-ordinate all dimensions, fittings, anchors and other items directly connected with the aluminum entranceway assemblies.

Aluminum entranceway assemblies shall be erected accurately, plumb, level, square, true to line and in alignment with the work of other trades. Vertical and horizontal frame members shall be fastened securely together with neat hairline joints.

Install all hardware not installed in the factory, including cylinder locks specified in Finish Hardware. Each aluminum door shall be installed complete with weather-stripping and hardware, and adjusted for perfect operation.

Joints between all aluminum members, entranceway frames and surrounding construction shall be sealed by another trade as specified in Caulking and Sealing.

Doors and Windows shall be installed without forcing or distortion so that sills and

heads are level and jambs are plumb. Window frames shall be securely anchored into the supporting construction. Joints between metal windows and metal members including mullions shall be set in mastic of the type recommended by the window manufacturer. Excess mastic shall be removed before hardening. Metal surfaces shall be cleaned and any staining or discoloring of the finish shall be restored or the unit replaced.

46.7 CLEANING AND PROTECTION

After completing the erection of the entranceway assemblies and the adjustment of doors therein, each assembly shall be cleaned.

Remove protective materials and clean exposed aluminum surfaces with clear water, or water with soap or household detergent rinsed with clear water. Glass shall be washed with a stiff fiber brush, soap or household detergent and thoroughly rinsed with clear water.

Stained or discolored members shall be thoroughly cleaned or have the finish restored in accordance with Architectural Aluminum Manufacturer's Association Recommendations.

After installation, the exposed portions of each entranceway assembly shall be adequately and properly protected from any type of damage. Any damage must be immediately and properly corrected.

47 HOLLOW METAL DOORS AND FRAMES

47.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing and erection of hollow metal doors and pressed steel frames as specified in the integrated security systems (section 24) and as indicated on the drawings and as specified herein.

47.2 CODES AND STANDARDS

Latest editions of British codes, Specifications and standards form a part of this specification to the extent indicated by the references thereto. In the event of conflicts or discrepancies between this specification and the referenced codes, specifications or standards, the more stringent applicable requirement shall govern.

NFPA 80 : (Fire Doors and Fire Windows - 1992 Edition)

NFPA 251: (Standard Method of Fire Tests of Building Construction and Material)

NFPA 252 : (Fire Tests of Doors Assemblies)

BS 746 : (Fire Tests on Building Materials and Structures)

Pt. 20 :Method of determination of the fire resistance of elements of construction (general principles)

Pt. 22 : Methods for determination of the fire resistance of non-load bearing elements of construction

Deviations

It is the intent of this specification to establish acceptable standards of quality and performance. Minor deviations in details due to manufacturer's standard shop process will be considered for acceptance provided that, in the opinion of the Engineer, the proposed substitutions are equal in quality and performance to the specified material. All deviations shall be called out in writing in the proposal and shall be specifically indicated on the shop drawings.

Related Work Specified Elsewhere

The following items or categories of work are covered under other specifications and not specified herein:

-
- a) Structural Channel Frames
 - b) Caulking
 - c) Field Painting

47.3 MATERIAL AND GENERAL REQUIREMENTS

Steel

Doors and frames shall be factory fabricated from steel sheets conforming to British Standards as applicable.

Shop Finish

After fabrication, doors and frames shall be thoroughly cleaned, pretreated with a bonderizing or phosphating treatment to provide a strong bond between metal and paint, and shop primed with a rust inhibiting metal primer paint. Unless otherwise indicated, the primer shall be in accordance with the job painting specification.

Workmanship

The finished items shall be rigid, neat in appearance, and free from defects, warps or buckle. Molded members shall be sharp in details, straight and true. Corner joints shall be coped and mitered, well formed, and in true alignment. Exposed welded joints shall be dressed smooth.

Preparation for Hardware

Doors and frames shall be prepared for hardware in conformance with the templates provided under the Hardware Specification or as otherwise required by the hardware indicated on the drawings, and to the requirements of the British standards as applicable. Cutting, reinforcing, drilling, and tapping of doors and frames shall be done at the factory, except that drilling and tapping for surface applied hardware will be done in the field when the hardware is applied. Door frames shall be prepared for silencers, and rubber or vinyl silencers shall be provided with the frames.

Provision for Glazing

Doors and frames with openings indicated to be glazed shall be prepared to receive the glass. Glazing stops on the outside of exterior openings and on the outside of interior openings for secure areas shall be non-removable. Glazing beads on the inside of openings shall be removable screw-on or snap-on type. Muntins, when indicated or required, shall interlock at intersections and be securely fastened to the perimeter of the opening. Glass requirements are specified under the Glass and glazing Specification.

Louvers

Where indicated on drawings, doors shall be provided with louvers. Louvers shall be sightproof type, inserted into the doors, and formed of not less than No. 20 gauge (1.0 mm) steel. Blades of inserted louvers shall be welded or tenoned to frame, and the entire assembly shall be fastened to the door to present a neat appearance and to be non-removable from the outside of the door.

47.4 CONSTRUCTION OF FRAMES

General

Pressed steel frames for doors shall be of the combination buck, frame and trim type of the sizes and details indicated. Gauges of metal shall not be lighter than 1.6 mm.

Frame shall be the knockdown type or welded unit type.

Welded unit type frames shall have headers of jambs secured at the corners either by internal welding of faces or by welded splice plates and shall be further secured at the rabbet either by welding or by mechanical interlock. As an alternate, the headers and jambs shall be secured at the corners by external welding of faces and grinding smooth. Faces of frames at junction of head and jamb shall present neat line joints.

Knockdown type frame shall have joints that interlock rigidly so as to maintain alignment of parts and provide functionally satisfactory performance of completed frames when field assembled.

Jambs shall be notched at bottom to provide neat fit over thresholds at openings where thresholds are indicated.

Anchors

Frames shall be provided with a minimum of three wall anchors per jamb as required for the adjoining wall construction and anchors for attachment of frame to the floor. Anchors shall be of not less than 1.6 mm steel.

47.5 CONSTRUCTION OF DOORS

General

Doors shall be 45 mm thick, and of type, size and design indicated. Door clearances shall not exceed 3 mm at head and jambs, 6 mm at meeting stiles of pair of doors, and 20 mm at bottom measured from the finished floor line. Exterior doors shall have the top and bottom edges closed flush and sealed against water penetration. On an outward opening single leaf door, any clearance between the locking stile and the door frame shall be covered by an external mild steel plate 150 x 230 x 10 mm, positioned to cover the lock bolt in the thrown position. On double leaf unrelated doors, external and internal covering strips extending the full length of the meeting stiles shall be fitted.

Full Flush Doors

Fabricate doors of 2 outer sheets of minimum 1.6 mm steel for all doors, with edges welded and finished flush. Seams and joints are not acceptable on door faces or edges. Reinforce outer face sheets with minimum 0.9 mm interlocking vertical channels or Z-shaped members spaced not over 150 mm apart and spot welded to outer face sheets. Provide continuous reinforcing channels welded to

face sheets at top and bottom of door. Place fullthick cork, fiberboard or mineral wool board in spaces between reinforcing channels. Optional allowable framing for core: A continuous truss formed inner core of sheet metal, not lighter than 0.38 mm may be substituted for reinforcing specified, provided it is spot welded to face sheets every 65 mm horizontally and vertically over entire surface of both sides. Mouldings, if required, shall be not lighter than 1.6 mm.

Full flush construction shall have face sheet of not less than 1.6 mm steel, shall have no seams or joints on door faces, and shall have top and bottom closed with a recessed channel or a flush end closure treatment.

47.6 DELIVERY AND STORAGE

To provide protection during shipment, welded unit type frames shall be strapped together in pairs with heads at opposite ends or provided with temporary steel spreaders at the bottom of each frame; and knockdown type frames shall be securely strapped in bundles. Materials shall be delivered to the site in undamaged condition, stored out of contact with the ground and under a weathertight covering, permitting good air circulation. Whenever they become evident, abraded, scarred or rusty areas shall be cleaned and touched up with the paint used for the shop painting.

47.7 INSTALLATION

Frames shall be plumbed, leveled and rigidly secured in place. Temporary spreaders shall be installed until the wall at the frame is completed and the frame is securely anchored in its final position. Wall anchors on door frames shall be welded to frame and installed approximately at the hinge and strike levels. The hinges shall be continuously welded to the door. Doors shall be installed in conjunction with the application of the hardware.

Weather-stripping and thresholds shall be installed at exterior door openings to provide a weathertight installation.

47.8 Shop Drawings

Shop drawings including door schedule shall be submitted for approval and approval received before delivery of the doors and frames. Shop drawings shall indicate the following information:

- a) Location of each door and frame
- b) Elevation of each type of door and frame
- c) Details of construction
- d) Method of assembling sections
- e) Gauges of metal
- f) Location and extent of hardware reinforcement
- g) Location of hardware
- h) Type and location of struts and anchors for frames
- i) Identification of surface preparation pretreatment and shop primer

Approval of shop drawings will be for arrangement only and shall not relieve the fabricator of the responsibility for errors, omissions, or the accuracy of his own dimensions.

48 STEEL/ALUMINUM ROLLING DOORS

48.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing and installation of steel/aluminum rolling doors in accordance with the integrated security systems (section 24) as well as with the drawings and as specified herein.

Steel/aluminum rolling doors shall be of types specified below and manufactured by a manufacturer actively engaged in the production of such steel/aluminum rolling doors. Manufacturer's catalog cuts containing sufficient technical information must be submitted for approval prior to submission of shop drawings.

48.2 MATERIALS

Curtains shall be constructed of interlocking roll-formed galvanized with

transparent protective paint steel slats or bright-rolled with transparent protective paint aluminum slats to provide a curtain stiffness to withstand wind pressure of 125 kg per square meter. Galvanized steel slats shall be tight-coat galvanized with a coating of 0.40 kg/m² of flat metal, free from flaking or peeling.

Curtains shall be equipped with a rolled steel/aluminum bottom bar consisting of two angles of equal weight, one on each side, securely fastened to the bottom of curtain for reinforcement and to provide contact against the sill when closed. The ends of the alternate interlocking slats shall be fitted with malleable iron end locks which shall act as a wearing surface in the guides and prevent lateral movement of individual curtain slats. Curtain shall also be equipped with wind locks.

Guides shall be formed of standard rolled steel angles not less than 5 mm thick and of sufficient depth to retain curtains in place under design wind pressure. They shall be attached to jambs, plumb and true, by bolts and not less than 10 mm diameter, spaced not more than 65 mm on centers. Guides shall be fitted at top into slots cast in the mouth of the roller shaft brackets.

Roller shaft shall be steel pipe of sufficient diameter to reduce deflection not to exceed 2.5 mm per meter of span.

Ends of roller shaft shall be completely closed by cast-iron plugs machined to fit I.D. of pipe and secured by cap screws. Roller shaft shall house all counterbalancing mechanism including an oil-tempered helical steel spring capable of producing sufficient torque to assure easy operation of the door curtain from any position. Spring tension shall be adjustable by means of adjusting wheel on the outside of the end bracket.

Brackets shall be of heavy cast iron or steel, designed to form an end closure support for the hood. Ends of roller shaft shall be journalled into bracket hubs of sufficient thickness to provide ample bearing surface for load of roller shaft and curtain.

Operator bracket hub and plug in spring end of shaft shall be fitted with self-lubricating bronze bearings or permanently lubricated sealed ball bearings.

Hoods shall be of not less than 24 gage bonderised-hot-galvanized steel formed to fit contour of end brackets in the neat manner and reinforced with stiffening rolls at top and bottom edges.

Thermal bridges and fine-pored PU rigid foam infill shall be provided to ensure thermal insulation in all double skinned door profiles according to BS EN 12428.

48.3 OPERATION

Motorized doors shall be electrically operated. 415 V, 3 phase, 50 Hz electric motor and worm reducing gears shall be separate unit coupled together and so designed and constructed that in case of failure in the electrical system the door can be operated by means of an auxiliary chain-gear operating mechanism. A control lever shall be located within easy reach from the floor which will instantly engage the auxiliary chain-gear operating mechanism. Power unit shall be self-locking and capable of holding the door in any position in case of failure of the counterbalancing spring.

Motor unit shall be so designed that the motor can be completely removed without interfering with the operation of the door by the auxiliary chain-gear operator.

Electric motor shall be fitted with ball bearings and be of sufficient capacity to move the door curtain in either direction from any position at a speed of 200 mm/s.

Electric control shall include the following: Moulded case circuit breaker, reversing across-the-line type automatic starter with overload relays, solenoid brake interlock switch, limit switch, and three button "Open", "Close" and "Stop" push-button control switch.

Manually operated doors shall be operated mechanically by means of a chain-gear operator. Hand chain is to be galvanized.

Gears shall be of high-grade gray iron cast from machine cast patterns. Gear reduction shall be calculated to reduce pull on hand chain to not over 15.75 kg.

48.4 PAINT

Galvanized steel for curtain slats shall have 0.40 kg of zinc per square meter and shall be chemically cleaned and bonderized for paint bond, and shall be given on dip coat of rust-inhibiting synthetic enamel which shall be baked on at 175 °C prior to roll forming.

All other surfaces of door parts shall be given one shop coat of rust-inhibiting paint.

48.5 SPECIAL FEATURES

A compressible rubber seal shall be attached to the standard double-angle bottom bar to provide additional weathering at the sill.

A rubber weathering seal at the hood shall be provided to prevent air flow around coil.

Weathering at the jambs shall be furnished along with a continuous flat end lock which will operate between two closely fitting metal slide bars attached to the inside of the guide channels for curved slats.

Combination end locks and wind locks with locking bars shall be furnished.

Transformer shall be furnished to reduce voltage at push-button switch to 120 V.

Automatic bottom bar shall be provided on the door curtain which shall be capable of stopping the downward movement of the curtain instantly upon contact with any obstruction in the door opening, and designed so that door may not be energized in downward direction until obstruction has been removed.

48.6 SHOP DRAWINGS

Shop drawings shall be submitted for approval prior to fabrication and delivery of

doors. Shop drawings shall indicate the following minimum information:

- a) Type, location and elevation of each door
- b) Details of Construction
- c) Gages of Materials
- d) Identification of surface preparation

Approval of shop drawings will be for arrangement only and shall not relieve the manufacturer of the responsibility for errors, omissions or the accuracy of his own dimensions.

49 FINISH HARDWARE

49.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing of all labor, supervision, materials, tools, equipment and services necessary for or incidental to the fabrication and installation of the finish hardware in accordance with the drawings and as specified herein.

Work under this section shall be performed in conjunction with the hollow metal doors and frames and aluminum doors and frames.

49.2 MATERIALS

Door Butts

Exterior door butts shall be 114 x 114 mm stainless steel.

Interior door butts shall be 114 x 101 mm prime coat finish.

Each door leaf shall be fitted with a minimum of three butts. Doors over 1 meter in width and/or 2.1 m in height shall have the number of butts recommended by the manufacturer. The construction of the butt hinges shall be such as to prevent removal of the hinge pins.

Closures

Door closures shall be rack and pinion type controlled by two independent valves. Closure shall require only one location on door for all openings up to 180 °. Key valves and through bolts shall be provided. Case shall be polished chrome.

Size of closure shall be determined by the manufacturer for the size, weight and usage of doors per their standard requirements.

Locks and Latches

Locks and latches shall be heavy duty mortise type with stainless steel armored fronts.

All locksets shall be master keyed in one set. Furnish two keys for each lock and 4 master keys for each building.

Knobs and escutcheon plates shall be of stainless steel.

Thresholds

Thresholds shall be aluminum, 127 mm wide, for exterior doors and 100 mm wide for interior doors where required or as indicated in drawings.

Thresholds shall be securely fastened to the floor with countersunk screws per manufacturer's requirements.

Silencers

Provide a minimum of three silencers per door on strike side.

Door Stops

Door Stops shall be aluminum (80 mm projection) with rubber bumper.

Push and Pull Plate

Push and Pull Plate shall be 75 x 300 mm.

Panic Device with Pull

Provide stainless steel Panic Device with pull as shown in the schedule. Size and weight shall be determined by the manufacturer per standard requirements.

Templates

Furnish and deliver to door manufacturers all templates required to permit fitting and reinforcing doors and frames that receive hardware.

49.3 HARDWARE SETS

Hardware Set No. 1

- 1) 1 1/2 pair butts
- 2) 1 Lockset - Mortise type
- 3) 1 Door Closure with holder

Hardware Set No. 2

Cylinder only. Other hardware shall be supplied by the door manufacturer.

Hardware Set No. 3

- 1) 1 1/2 pair butts
- 2) Panic Device with pull on outside face
- 3) Door Closure
- 4) Threshold

Hardware Set No. 4

- 1) 1 1/2 pair butts
- 2) 1 Lockset - Mortise type
- 3) Door Stop

Hardware Set No. 5

- 1) 1 1/2 pair butts
- 2) Push and Pull Plates
- 3) Door Closure

Hardware Set No. 6

- 1) 3 pair butts
- 2) Panic Device with pull outside
- 3) Top and bottom bolts (inactive leaf)
- 4) Two closers with holders
- 5) Threshold

49.4 HARDWARE SCHEDULE

A complete hardware schedule, indicating all specified hardware for each door, manufacturer's name, finishes and handles of doors, shall be submitted to the Engineer for approval prior to delivery.

Approval of the hardware schedules will be for types and usage only. Omissions as to number of sets will be the responsibility of the Contractor. All doors shall be provided with hardware and it is the responsibility of the Contractor to check every door for conformance.

49.5 SAMPLES

When requested by the Engineer samples of hardware shall be furnished and approved prior to fabrication or delivery.

50 GLASS AND GLAZING

50.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing and installation of all glass and glazing work in accordance with the drawings and as specified herein.

50.2 CODES AND STANDARDS

Latest editions of Codes, Specifications and Standards of the issues listed below,

but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto. In the event of conflicts and discrepancies between this specification and the referenced codes, specifications or standards, the more stringent applicable requirement shall govern.

BS 952-1	Glass for glazing - Classification
BS 952-2	Glass for glazing - Terminology for work on glass
BS 6262	Glazing for buildings

Deviations

It is the intent of this specification to establish acceptable standards of quality and performance. Minor deviations in details due to manufacturer's standard shop process will be considered for acceptance provided that, in the opinion of the Engineer, the proposed substitutions are equal in quality and performance to the specified material. All deviations shall be called out in writing in the form of proposal and shall be specifically indicated on the shop drawings.

Handling and Storage

The Contractor shall exercise great care to ensure that the glass is not damaged in handling.

Glass shall be stored under cover in a vertical position in storage racks.

50.3 MATERIALS

General

All materials shall be new and of a type and quality to meet the requirements specified herein. All materials shall be delivered to the jobsite in original packages

bearing the manufacturer's labels intact. Glass shall be of the type, quality and substance complying with BS 952, Part I, Table 1.

Wire Glass

Where wire glass is indicated, it shall be either polished or cast georgian wired glass 6 mm thick as indicated on the drawings.

Insulating Glass

Insulating glass shall be composed of two sheets of glass with an air space between, and sealed edges. Glass minimum thickness shall be 3 mm. Air space shall be 13 mm. Total minimum thickness of unit shall be 19 mm. Glass for use on the exterior of the buildings shall be of thickness required to withstand the designed wind pressure when set in the sizes shown on the drawings.

Tempered Insulating Plate Glass

Tempered plate glass, for use in aluminum exterior entrance ways and transoms shall be 19 mm thick "solar bronze" glass.

Clear Plate Glass

Clear plate glass for use in interior shall be 4 mm, 6 or 10 mm nominal thickness glazing quality, polished on both sides (glazing grade GG).

Obscured Glass

Obscured glass shall be rough cast glass to an approved pattern and shall be 4 mm or 6 mm thick as indicated on the drawings.

Glazing

Glazing shall be in accordance with BS 6262. Glazing to timber doors and frames shall have all rebates in timber cleaned and primed prior to glazing. Edges of glass shall be bedded in imitation wash leather strips of approved color and manufacture.

Mirrors

Mirror shall be silvered 6 mm clear float glass complying with BS 952.

Silvering shall be one side only and shall be protected with an electro copper backing, Shellac varnish and paint.

Mirrors shall be delivered to site cut to size and drilled for fixing. All exposed glass edges shall be ground smooth and beveled to the approval of the Engineer.

Mirror shall be countersunk drilled for and fixed with a minimum of four cover head screws with 15 mm diameter detachable screw covers.

Glazing Compounds and Preformed Glazing Sealants

Compounds shall be of suitable type approved for the application and, except as otherwise specified in British Standards, the use of non-skimming compounds, non-

resilient type preformed impregnated type gaskets will not be permitted. Metal sash putty will not be permitted. Materials used with aluminum frames shall be aluminum colored, non-staining, and not requiring painting. Other materials which will be exposed to view and unpainted shall be gray or neutral color.

Channel glazing compound shall be equal in performance to, but not limited to the following:

- a) Non-drying, knife grade polybutene sealant;
- b) One-part acrylic terpolymer sealant conforming to British Standards as applicable.

Glazing Accessories

Provide glazing accessories as required to supplement the major glazing materials to provide a complete installation, including glazing points, clips, shims, angles, beads, setting blocks and spacer strips.

Ferrous metal accessories which will be exposed in the finished work shall have a finish that will not corrode or stain while in service.

Glass setting tape, when used, shall be an approved non-oxidizing, non-migrating, non-corrosive extruded polybutene adhesive type.

Setting blocks and spacers shall be of neoprene. Shore durometer hardness of setting blocks shall be 60 to 70, and of spacers shall be 40 to 50.

Wedges or shims shall be cork or neoprene, or other approved material.

Glazing angles for setting wire glass in metal sash, when applicable, shall be continuous underwriters approved type. Other glazing angles shall be of metal electrolytically compatible with the metal of the glazing rebates.

50.4 SAMPLES AND EXTRA GLASS

Three samples of each type of glass and glazing compound proposed for use shall be submitted for approval. Materials used shall be identical to approved samples.

Provide extra amount of glass, at a minimum rate of 10 percent of each type of glass specified, due to breakage during shipping, handling and erection.

50.5 INSTALLATION

The sizes to provide the required edge clearance shall be determined by measuring the actual opening to receive the glass. Sheet glass shall be cut and installed with the visible lines or waves running with the horizontal dimensions. Labels shall be left in place until the installation is approved.

Glass Setting

Items to be glazed shall be field glazed, using glass of the type, quality and thickness indicated and specified. Preparation of surrounds and glazing, unless otherwise specified, shall be in accordance with the details and general conditions governing glazing in the FGMA glazing manual.

Aluminum windows may be glazed in conformance with one of the glazing methods described in the standards under which they are produced. Beads or

stops which are furnished with the items to be glazed shall be used to secure the glass in place.

Sills and finished surfaces shall be protected against stains resulting from dropping of glazing compounds.

50.6 REPAIR AND CLEANING

Broken panels shall be replaced and defective workmanship shall be corrected before acceptance of work.

After acceptance by the Engineer, all labels and loose or stray glazing compounds shall be removed from both sides of all panels of glass. Compound droppings shall be removed from sash, frames, doors, sills and floors.

Both sides of all panels shall be washed and cleaned thoroughly after compound has set.

All rubbish and debris resulting from the performance of the work shall be removed.

51 SUSPENDED ACOUSTIC CEILINGS

51.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing of all labor, supervision, materials, tools, equipment and services necessary for or incidental to the construction and completion of the suspended acoustic ceilings in accordance with the drawings and as specified herein.

Suspended acoustic ceilings shall consist of modular ceiling board panels, lay-in type, in an exposed tee suspension system. The furnishing and installation of electrical fixtures, wiring, air handling grilles or louvers, etc., is not covered by this specification.

51.2 CODES AND STANDARDS

Latest edition of British Codes, Specifications and Standards form a part of this specification to the extent indicated by the references thereto. In the event of conflicts or discrepancies between this specification and the referenced codes, specifications or standards, the more stringent applicable requirements shall govern.

Deviations

It is the intent of this specification to establish acceptable standards of quality and performance. Minor deviations in details due to manufacturer's standard shop process will be considered for acceptance provided that, in the opinion of the Engineer, the proposed substitutions are equal in quality and performance to the specified material. All deviations shall be called out in writing in the form of proposal and shall be specifically indicated on the shop drawings. Thinner gauges, primers other than those specified, inferior hardware, electro-deposited zinc coating in lieu of hot-dip galvanizing when specified, etc., will not be considered as minor deviations.

51.3 MATERIALS

Suspension System

Suspension system shall be the exposed grid type with main runners spaced 1.2 meters on centers, installed in the patterns indicated on the shop drawings, and shall have exposed members of aluminum or finished in aluminum for moisture resistant areas, and of white baked enameled finish in other areas, on all grid and angle trim surfaces. The suspension system shall be heavy duty rated. All steel roll-formed parts shall be electro-galvanized and bonderized. The suspension system shall be of sufficient strength and rigidity to carry acoustical units and the indicated lighting fixtures with a maximum deflection of 1/360 of its span.

Acoustic Panels

Non-moisture resistant acoustic panels shall be the lay-in ceiling board type, white painted finish, 600 mm by 600 mm nominal size unless otherwise required by the ceiling layout, not less than 15 mm thick, butt edge, conforming to BS and as approved by the Engineer.

Moisture-resistant acoustic panels where indicated to be the lay-in type, ceramic scrubbable vinyl finish 600 mm by 600 mm nominal size unless otherwise required by the ceiling layout, not less than 15 mm thick, conforming to BS and as approved by the Engineer.

Hanger Wire

Hanger wire shall be galvanized steel wire conforming to British standards, annealed, and not less than 2.65 mm.

Steel Strap Hangers

Steel strap hangers, where used, shall be 25 mm wide and 4 mm thick. Steel shall conform to British Standards.

51.4 ERECTION

Hangers

Hanger wires or, where required, strap hangers, shall in all cases be vertical. In reinforced concrete construction, wire-attaching plugs or anchoring devices shall be set in the formwork. Power-driven fasteners may be used where approved.

Layout of Suspension System

Cross tees shall be spaced 600 mm on center maximum and main runners shall be spaced 1.2 m on center. A metal edge molding shall be furnished where ceiling panels abut walls or vertical surfaces. Installation shall be in accordance with British Standard.

The system shall be symmetrical about the center line of the spaces unless

otherwise shown in reflected ceiling plan. Joints at ceiling penetrations of other work shall be neatly made and shall be as tight as practicable. Edge members shall be set tightly against the wall, joints shall be smooth, and external corners shall have one-piece units.

Openings

Support members shall be provided at ceiling openings such as those required for recessed light fixtures or for air supply or exhaust. Support members shall be of the size required to support the load of light or other fixtures, wiring, conduit and acoustical units without permitting deflection of the ceiling in excess of the requirements specified herein. Intermediate supports and suspension wires or straps shall be provided if required.

Inspection and Correction

At completion of job, repair or replace all ceiling board and runners that are out of level, broken, showing fractures, blemishes, or not properly coordinated with light fixtures and other ceiling fittings.

51.5 CLEANING

After completion of erection and other work liable to soil the acoustic ceiling board, it shall be cleaned of all dirt and stains. Touch-up with paint where required. All ceiling board units, supporting members, and edge moldings that are badly marred or damaged shall be removed and replaced with perfect materials.

51.6 SAMPLES

Samples of acoustic panels and metal suspension system components shall be submitted for the Engineer's approval as follows:

Acoustic panels: 1 sample,

51.7 SHOP DRAWINGS

Shop drawings shall be submitted for approval as required and approval obtained prior to delivery of acoustic ceiling components. Shop drawings shall be coordinated with all related work and shall show the following information:

- a) A reflected ceiling plan of areas indicated to receive acoustic ceiling, showing electrical and mechanical features.
- b) Typical intermediate framing and supports where required.
- c) Hanger fastening details.
- d) Acoustical-unit support at ceiling fittings.
- e) Details of splicing methods for main and cross runners.
- f) Areas to receive moisture-resistant ceilings.
- g) A table indicating load-carrying capacity of main and cross runners.

A note stating that the suspension-system members furnished will not deflect more than 1/360 of the span under the indicated loadings.

52 BUILDING FINISHES

52.1 GENERAL

The intent of this specification is to define the minimum requirement for the furnishing, installation and completion of all finishes for the buildings in accordance with the drawings and as specified herein.

52.2 CODES AND STANDARDS

Latest edition of Codes and Standards of the issues listed below, but referred to thereafter by basic designation only, form a part of this specification to the extent indicated by the references thereto. In the event of conflicts or discrepancies between this specification and the referenced codes, specifications or standards, the more stringent applicable requirement shall govern.

BS 5385	Wall and Floor tiling
BS EN 14411	Ceramic tiles. Definitions, classification, characteristics and marking
BS EN 1339	Concrete paving flags. Requirements and test methods
BS EN 1340	Concrete kerb units. Requirements and test methods
OS 3	Omani Standard - Precast Terrazzo Tiles
BS 8000	Workmanship on Building Sites
BS EN 649	Resilient floor coverings. Homogeneous and heterogeneous polyvinyl chloride floor coverings. Specification
BS EN ISO 10140	Acoustics. Laboratory measurement of sound insulation of building elements

Deviations

It is the intent of this specification to establish acceptable standards of quality and performance. Minor deviations in details due to manufacturer's standard shop process will be considered for acceptance provided that, in the opinion of the Engineer, the proposed substitutions are equal in quality and performance to the specified material. All deviations shall be spelled out in writing in the form of proposal and shall be specifically indicated on the shop drawings.

Submittals

Samples

Submit three samples each for approval.

Underlayment and Adhesives

Submit brand names and manufacturer's names for approval.

Literature

Submit manufacturer's literature and specifications.

Delivery, Storage and Handling

Packaged materials in manufacturer's original, undamaged containers bearing manufacturer's name and brand shall be delivered.

52.3 FLOOR SCREED

Floor screed shall be of Grade C35 mixed with the minimum practicable amount of water. The water/cement ratio shall not exceed 0.42.

Laying of Floor Screed

Screed shall be laid in bays of area not exceeding 16 m² and length not exceeding 5m.

Concrete floor slabs shall be sweep-blasted to remove laitance and shall have all loose material removed by brushing. Where electrical conduits and the like are to be buried in screeds they shall be rigidly fixed to the concrete floor and the screed continuously reinforced along the length of the conduit with a 150 mm wide strip of galvanized expanded metal mesh. The mesh shall be positioned midway between the crown of the conduit and finished screed level and shall be fixed to the concrete floor at 300 mm centers on both sides of the conduit by shot-fired masonry nails or other approved means. Floor slabs shall be soaked for 12 h with fresh water.

Standing water shall then be removed by brushing or compressed air, neat cement

grout scrubbed into the damp concrete surface and screed material laid immediately. Screed material shall be compacted and finished by wooden floats to the required levels and, where applicable, falls. The maximum permissible surface deviation shall be a 3 mm gap under a 3 m straight edge.

A minimum of 24 h shall elapse between placing of adjacent bays.

Finished bays shall be continuously wet cured for 7 days.

Epoxy Resin Based Floor Topping Screed

Epoxy resin based floor topping screed shall be a 3 component solvent free combination of epoxy resin and hardener filled with high crushing strength chemically inert aggregates possessing the following physical characteristics:

- (a) Density shall not be less than 2,000 kg/m³
- (b) The compressive strength shall not be less than 70 N/mm² in accordance with BS 6319 Part 2.
- (c) The flexural strength shall not be less than 25 N/mm² in accordance with BS 6319 Part 3.
- (d) The tensile strength shall not be less than 12 N/mm²- in accordance with BS 6319 Part 7.
- (e) The absorption shall not be greater than 0.12 % in accordance with ASTM, C413-83.
- (f) The slip resistance in dry/wet shall be not less than 63/55 respectively based upon test using TRRL Pendulum Tester.
- (g) The abrasion resistance shall have a maximum loss of 0.3 g in accordance with ASTM C944.
- (h) The minimum bond strength to the parent concrete floor shall exceed the minimum tensile strength of the parent concrete.
- (i) The minimum thickness shall be laid as 5mm and the maximum thickness shall be 12 mm.

The material shall be applied by experienced applicators duly certified by the material manufacturer.

All aspects of preparation, mixing, applying and subsequent finishing, shall be in full accordance with the manufacturer's instructions and recommendations.

Following completion of the application of the epoxy screed topping and approval of the same by the Engineer, the Contractor shall apply an epoxy based sealing paint over the entire area of the floor topping, which shall be fully compatible with the base screed.

52.4 UNGLAZED CERAMIC FLOOR TILES

Ceramic floor tiles thickness shall be minimum 8.0 mm, or in accordance with drawings and as specified herein, fully vitrified tiles to BS EN 14411, of a color selected by the Engineer from an approved manufacturer's standard range. The tiles shall be laid in accordance with BS 5385, Parts 3 & 5 using an approved Ceramic tile adhesive on a cement and sand floor screed. All joints shall be kept narrow and of regular width.

The tiles shall be laid so that the cutting is kept to a minimum and cut tiles are next to the skirting or walls. Cut edges of tiles shall be rubbed smooth.

All tiling shall be grouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat white cement. Any surplus grout shall be cleaned off the face of the tiling and surrounding surface immediately and all tiling shall be carefully cleaned off on completion.

ACID/ALKALI RESISTANT CERAMIC TILES AND SKIRTINGS - The tiles shall conform to BS EN 14411 and be able to withstand the acid/alkali resistance tests as prescribed under BS EN 14411. The tiles shall be minimum 8 mm thick suitable for industrial use, unless otherwise required by the Engineer.

52.5 UNGLAZED CERAMIC SKIRTING TILES

Unglazed ceramic skirting tiles shall be 8 mm thick. Metric cove tiles with round tops shall be fixed where the wall finish is other than tiling and square top cove tiles shall be fixed to meet wall tiling. Internal and external corners of skirting shall have proprietary corner tiles.

Grouting of Floor and Skirting Tiles

Floor and skirting tiles shall be fixed and grouted with a cement based adhesive with epoxy based grout in wet areas. Grout shall be colored as directed using proprietary color mix.

Laying and grouting of tiles shall be carried out strictly in accordance with the manufacturer's and fixing product manufacturer's instructions.

Where tiles abut sanitary fittings, gullies, pipes, etc., joints shall be sealed with an approved silicone sealant.

Finished tiling shall be true to level or shall fall smoothly to gullies without any discernible irregularity and joint lines shall be true to line without discernible deviations.

52.6 EXPANSION JOINTS IN FLOOR FINISHES

Expansion joints in floor finishes, etc. shall be a compressible filler sheet of selected fibers impregnated with bituminous emulsion, which will not extrude when compressed and finished with one part polyurethane sealant.

52.7 DIVIDING STRIPS

Dividing strips between different floor finishes shall be of approved aluminum section.

52.8 CONCRETE SURFACE HARDENER

Where detailed, concrete floors shall be treated with an approved concrete surface hardener applied strictly in accordance with the manufacturer's instructions.

Protection of Finished Flooring

Floor finishes shall be covered up and protected during the course of the works and cleaned off and left sound, true and level upon completion.

52.9 RENDER

Render shall be a mix measured by volume of one part of cement, one part of lime and four parts of sand.

Render shall be mixed dry in a clean container or on a clean board and then with the minimum practicable quantity of water added. The water/cement ratio shall not exceed 0.45.

Application of Render

1. Blockwork walls shall be left for at least 14 days before the application of render.
2. As far as is practicable, rendering shall not be commenced until all mechanical and electrical services, conduits, pipes, and fixtures have been installed.
3. Irregularities in surfaces to be rendered shall be filled with mortar, without lime, 24 hours before rendering has commenced. Joints in blockwork shall be raked out before rendering to form a good key. Concrete surfaces to be rendered shall be sweep-blasted or scabbled as approved by the Engineer to expose aggregate and provide an adequate mechanical key for the render.
4. Over all joints of concrete to block work, except where expansion or movement joints are incorporated, single layer of galvanized expanded metal mesh 400 mm wide shall be stapled at 500 mm centers.
5. Overall chases a single layer of expanded metal lath shall be secured as above to extend 150 mm minimum each side of chase.
6. Surfaces to be rendered shall be clean and free from dust, loose mortar and all traces of salts. Angle and stop beads shall be provided as required. They shall be obtained from the manufacturer, approved by Engineer and fixed as per manufacturer's instructions.
7. Surfaces shall be thoroughly sprayed with fresh water and surface water allowed to disappear before render is applied.
8. After preparation of surfaces a coat of cement slurry shall be applied to the damp surface to be rendered by means of rough cast machine, and wet cured for 24 hours.
9. The render coat shall then be applied to the damp slurry coat by means of trowels, between screeds laid, ruled and plumbed as necessary. This coat which shall be to the required thickness shall be allowed to set hard and then

wet cured.

Surfaces shall be finished with a sponge or with a wood or steel float to smooth flat surfaces free from all marks.

10. Wet curing of finished render shall be for 24 h when followed immediately by rough cast finish or otherwise for a minimum of 4 days, but as long as is necessary to prevent cracking.
11. The Contractor shall ensure that the work is protected from direct sunlight during execution and curing and that the surrounding building work and paving is protected from cement or rough cast splashes.

Edges of Render

Beveled or struck edges shall be worked where the render finishes against joinery work, fair faced concrete, etc. as indicated on the Drawings.

52.10 GLAZED CERAMIC WALL TILES

Glazed ceramic wall tiles thickness shall be minimum 6.0 mm thick and shall comply generally with BS EN 14411.

Edges and external angles shall have appropriate round edges tiles.

Fixing and grouting of wall tiles shall be executed in accordance with BS 5385, Part 1 or Part 2, as applicable.

Tiles shall be fixed with an approved tile adhesive and pointed in cement tinted to approval.

Particular care shall be taken to keep all courses perfectly horizontal, all perpend truly vertical and joint widths consistent.

Where tiling abuts wood or metal frames or other tiling at angles and around pipes, etc., it shall be carefully cut and fitted to form a close net joint. Tiling shall be continuous behind sanitary fittings.

52.11 PRECAST TERRAZZO TILES

The precast terrazzo tiles and skirting shall be made from cement and colored stone chipping as approved by the Engineer and manufactured in the Sultanate of Oman to comply with Omani Standard OS 3. The tiles shall be polished hard, durable and non-absorbent, of exact shape and even thickness and shall have sharp true edges and be the best of their respective types.

The tiles and skirting shall be bedded and jointed in cement mortar (1:4) on cement and sand (1:3) screed and the joints shall be kept narrow and surplus mortar wiped off immediately after laying.

The tiles shall be laid so that cutting is kept to a minimum and cut tiles are next to the skirting or walls; cut edges of tiles shall be rubbed smooth.

The tiling skirting shall be grouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match the tiling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surface immediately and all tiling shall be carefully cleaned off.

52.12 PRECAST CONCRETE EXPOSED AGGREGATE PAVIORS

Where precast concrete paviors are shown on the drawings, these shall be 300 x 300 x 50 mm thick, unless otherwise required by the Engineer, complying generally with the requirements of BS EN 1339 and BS EN 1340, manufactured from sulphate resisting grade 25 concrete.

Paviors shall have an exposed aggregate surface and shall be laid to an approved pattern with concave recessed pointing set in 25 mm cement/sand screed (1:4) laid on 50 mm blinding concrete.

52.13 GRANOLITHIC PAVING

Granolithic paving shall be composed of five parts of approved hard stone chipping, 10 mm and graded down, to 2 parts of cement by column mixed with

water to form a homogenous mass.

52.14 PVC FLOORING

General

The scope comprises supply and fixing of PVC tile and sheet flooring and skirting, including anti-static flooring and safety flooring.

Codes and Standards

The floors shall be laid in accordance with BS 5385, Parts 3 & 5.

The Flooring material shall be in accordance with BS EN 649, unbaked flexible PVC flooring and shall be classified as type A.

Anti-static flooring shall have an electrical resistance when installed between $5 \times 10^5 \Omega$ minimum and $2 \times 10^{10} \Omega$ maximum or shall be within the limits of such other recognized specification as may be agreed by the Engineer.

Safety flooring shall have an impervious surface and a high degree of slip resistance.

All flooring shall have a high degree of resistance to acids, alkalis and solvents.

The flooring shall have a rating for surface spread of flame of not less than Class 2 when tested in accordance with BS 476, Part 7.

Acoustic flooring shall conform to BS EN 651 and agreement rating G3Ws (U3P2E3C2).

Submittals

Samples

The Contractor shall provide the Engineer with samples covering the full color range of the flooring from the selected manufacturer, for color selection purposes,

and three full size tiles or a 600 mm x 600 mm long sample of skirting.

Samples of welded joint, including a joint between sheet and skirting, shall be submitted for approval.

The Contractor shall supply the manufacturer's full written description of the methods and materials needed to maintain the PVC floor areas in good condition.

Anti-Static Testing

Test results for the electrical resistance of anti-static floors shall be submitted to the Engineer.

Storage and Handling

The materials shall be delivered in the manufacturer's identification, thickness, size of tile, batch number, and BS mark.

The flooring material shall be stored in clean, dry, well-ventilated conditions.

The Contractor shall adequately protect the flooring from all damage, howsoever likely to be caused, before and after laying, between the two stages of finishing and until the time of handing over. Any damage which does occur shall be made good by the Contractor at his own expense, and the whole of the work shall be left in a state satisfactory to the Engineer.

Materials

Tiles and Sheet

The PVC flooring shall be minimum 3 mm thick to BS EN 649 type A, in selected standard light colors and to match the material used in the existing facilities.

Performance Characteristics

To meet all the

UK

BS EN 649

Performance requirements of the listed standards	West Germany	Type A
	Agreement	DIN 16951
		G5Ws (2.0 mm)
		(U4P3E3C2)
		G32s (1.5 mm)
Flame spread and smoke emission	BS 476, Part 7	Class 2
	DIN 4102	BI
	AS 1530.3	Flame spread 0 Smoke developed 6
Light Fastness	BS 2782, Part 5	= or > 7
	DIN 53389	= or > 7
Abrasion Resistance	DIN 51963	< or = 0.2 mm
	Taber Abrasion	> 58000 cycles
	Typical result	(2 mm)

Chemical Resistance

Good resistance to dilute acids and alkali.

Chemical resistance charts by shade are available on request.

Tiles dimensions shall be 300 x 300 mm or as requested by the Engineer.

Anti-Static Floor

Performance Characteristics

Dimension stability

All conform to BS EN 649, Type A.

Flexibility

All conform to BS EN 649, Type A.

Residual Indentation

All conform to BS EN 649, Type A.

Flame spread

Tested to BS 476, Part 7, and obtain a class rating.

Color Fastness

All colors pass at least Standard 7 on the Blue Scale.

Antistatic

Typical Results

Min. $1 \times 10^7 \Omega$, Max. $1 \times 10^9 \Omega$.

Static Conductive

Min. $5 \times 10^4 \Omega$, Max. $2 \times 10^6 \Omega$ conforms to BS 2050.

Conductive (R.O.F.)

Min. Nil Ω , Max. $5 \times 10^4 \Omega$ conforms to BS 2050.

Safety Floor

Performance Characteristics

General

It should be a heavy duty vinyl sheet safety flooring incorporating silicon carbide particles for enhanced slip resistance and traction underfoot. It should be produced in two surface designs - standard and embossed. Standard surface finish is designed for use in areas which are generally dry, with only occasional wetness or spillage, and where safety underfoot, hygiene and ease of cleaning are important factors. The embossed surface finish has been specially developed for areas which demand even greater traction underfoot,

e.g., wet areas, stairs ramps and emergency exists.

BS EN 649, Type A

Dimensional stability, flexibility and residual indentation conform to BS EN 649, Type A.

Flame Spread

Should be tested as per BS 476, Part 7, Class 1 rating.

Color Fastness

All colors should pass at least Standard 7 on the Blue Scale.

Hygiene

To contain bioguard - a safe and highly effective bacteriostat which inhibits the growth of gram-positive and gram-negative micro organisms, for extra hygiene protection.

Acoustic Floor

Performance characteristics

General

To a specially developed reinforced

closed cell PVC form backing.

Sound Insulation	To exceed the Grade 1 standard of the UK Building Regulations, 1976. When tested in accordance with BS EN ISO 10140. Measured against a bare concrete slab. To offer an average sound pressure reduction of 19 dB.
Dimensional Stability	Conform to BS EN 651
Residual Indentation	Conform to BS EN 651
Color Fastness	All color should pass at least Standard 7 on the blue scale.
Appearance Retention	Should contain Vinyl Kan Anti-soiling agent which helps to maintain a good look of the flooring.
Fire Rating	When tested to ASTM E648, should have a result of > 1.07 W/Cm ² . When tested to BS 476, Part 7 achieve Class 2.

Skirting

The skirting shall be 100 mm high, coved, of selected color from the manufacturer of the flooring. It shall have a maximum radius 12.5 mm cove at the bottom and rounded or tapered to edges. For tile floors the skirting shall be "set-on" type, and for sheet floors it shall be "set-in" type.

Adhesive

The adhesives shall be those specifically recommended by the flooring manufacturer to suit the particular flooring and skirting being used.

In particular the adhesive for anti-static flooring shall be an conductive adhesive recommended for the anti-static flooring by the manufacturer.

Welding Rod

The welding material shall match the color of the floor and skirting and shall be of a type acceptable to the manufacturer of the flooring.

Dividing Strip

Edges of the vinyl flooring in doorways or adjoining other finishes, etc., shall be protected by an approved plastic dividing strip 5 mm x full depth of screed and vinyl, of an approved color.

Workmanship

Surface Preparation

The Contractor shall ensure that the surface on which the flooring is to be laid is true with a tolerance of ± 3 mm under a 3 m straightedge in any direction, cleaned of all dirt, girt or other foreign matter, and dry; no water shall be used in cleaning the surface in preparation for laying the PVC flooring. Floors and wall surface shall be primed if so recommended by the manufacturer of tile and skirting or adhesive.

Preparation for Anti-Static Floors

For anti-static floors an isolating barrier of acrylic latex smoothing underpayment shall be applied to the whole surface of the sub floor to a minimum thickness of 3 mm prior to the installation of the anti-static floor.

Laying

Laying shall not commence until the building is well dried out and conditions of temperature and humidity are appropriate. The adhesive shall be spread evenly in the manner prescribed by the manufacturer.

The flooring shall be stuck down and rolled in two directions with a 70 kg roller.

Tiles shall be laid to a straight joint with any marbling or streaks running parallel, with no areas of concentrated marbling, and to layout satisfactory to the Engineer.

Narrow widths of tile, less than 50 mm, or widths of sheet less than 300 mm will not be allowed unless it can be shown that there is no alternative, in which case they shall be laid next to the skirting.

No water will be allowed on the PVC surface until 7 days after completion of laying.

Any adhesive which is accidentally spread on the exposed face of the PVC tile shall be removed without delay.

Welding

All sheet material junctions shall be welded. All welding shall be seamless. Joints on skirting, including internal and external angles, and junctions between skirting and flooring shall be welded.

Welding shall not be carried out until at least 48 hours after the adhesive has set.

The layout shall be to the approval of the Engineer, and all welding shall be in accordance with the manufacturer's instructions and to the satisfaction of the Engineer.

Testing and Marking of Anti-Static Floors

Prior to testing the floor shall be cleaned at least 24 hours before the test and then conditioned to the relative humidity and temperature specified by the manufacturer for the test. Testing shall be carried out with an insulation tester operating at 500 V, DC in accordance with procedures specified by the manufacturer.

An engraved plate shall be set in the floor stating the nature of the floor, by whom it was laid and the date of laying.

Skirting

Fix the skirting with approved adhesive to a true level line so that the whole of the back of the skirting is fully adhered to the wall surface.

Internal and external corners are to be accurately mitred

Finishing

Finishing shall take place in two identical stages, the first not less than 7 days after the completion of laying, the second after all other trades have left the areas concerned and immediately before handing over.

Finishing shall consist of cleaning either with warm water and a mild detergent or with a cleaning agent specifically recommended by the flooring manufacturer.

The floor shall then be sealed as recommended by the flooring manufacturer.

Under no circumstances shall a polish be applied to an anti-static floor.

Protection of Finished Flooring

Floor finishes shall be covered up and protected during the course of the works and cleaned off and left sound, true and level upon completion.

52.15 Raised Access Flooring

The raised access floor system shall be with removable lead bearing panels 600 x 600 mm nominally supported on adjustable pedestals and bolted stringers. Pedestals and stringers shall be of galvanized steel and shall permit snap-on connection and lateral locking of the ends of stringers.

All panels shall be total interchangeable and relockable, except cut panels. The system shall be capable of providing a close fit to all perimeters with perimeter joints with walls sealed.

Panels shall be constructed of 34 mm thick high density inert calcium sulphate core, strengthened with high mechanical resistant fibers with self extinguishing hard plastic edging, covered and sealed with 0.05 mm. thick aluminum foils on bottom side and finished on top with antistatic vinyl. The density of the inert materials shall be $1450 \text{ kg/m}^3 \pm 25 \text{ kg/m}^2$. The complete floor system shall comply with the following static loading:

Concentrated load	:	not less than 4.5 kN over 25 mm ²
Live load	:	not less than 10 kN N/m ²

The system shall not deflect by more than 1/250 of the shortest span or 2.5 mm which ever is less. The system shall not excessively bounce or move when subjected to pedestrian and light wheeled traffic.

53 PAINTING

53.1 GENERAL

The intent of this specification is to define the minimum requirement for the surface preparation, materials and application of materials necessary for painting of buildings.

Unless otherwise specified or directed by the Engineer all painting work shall be

done in accordance with the specification stated hereunder and British Standards as applicable.

Painting system and samples for the different coats and colors shall be provided for the Engineer's approval.

For the purpose of control, the various coats shall differ in colors. Colors of the finishing coats will be decided by the Engineer.

The Contractor shall make all necessary precautions to prevent chalking of the applied paint under any working and weather condition and if required to apply, an additional finishing coat.

If the Contractor desires to apply painting works to other standards than those specified hereunder he may do so only if approved by the Engineer. With regard to materials, the Contractor shall submit for the Engineer's approval full details of the materials he proposes to use, including the source of the basic raw materials, content, nature and percentage of thinner, solvent, number of components, type of coat, required surface preparation, method of application, coverage, drying time, time interval between coats, number of coats, toxic properties, physical properties, shelf life, pot life and flash point, etc. He shall describe in detail of handling the materials in order to give adequate protection during transport, site storage and subsequent erection.

The following standards and Code of Practice in their latest editions shall apply to works covered by this Clause:

BS EN	Driers for paints and varnishes
ISO 4619	
BS 381C	Specification for colors for identification, coding and special purposes
BS 1070	Specification for black paint (tar-based)

BS 1336	Specification for knotting
BS 3900- C5	Paints and varnishes. Determination of film thickness
BS 4800	Schedule of paint colors for building purposes
BS 7956	Specification for primers for woodwork
BS 6150	Painting of buildings. Code of practice
BS EN ISO 150	Raw, refined and boiled linseed oil for paints and varnishes. Specifications and methods of test

53.2 MATERIALS

Paint materials shall be of the type specified herein. If it is desired to use any material other than that specified, such substitution must have approval. A request for any substitution of material shall be made in writing, giving the name of the manufacturer, the specific name of each product and technical literature of each product as a substitute and the amount to be added or subtracted for such substitution.

The Contractor shall obtain from the manufacturer and shall submit to the Engineer a "paint manufacturer's guarantee" for the quality of each painting material and that each coat of paint is compatible with the previous and subsequent coats.

All pigmented paints and primers shall be delivered to site in tightly closable convenient sealed original containers packaged by the manufacturer if nothing to the contrary is stipulated in the specifications. The Containers shall be marked in a durable manner with the following particulars:

- I. Manufacturer
- II. Paint and relevant thinner
- III. Gross and net weights

IV. Date of supply by the maker's factory.

The containers shall be kept tightly closed until the contents are to be used. Immediately prior to use of the contents and before pouring into smaller containers for working purposes, any skin shall be removed and the contents stirred thoroughly, if necessary with a stirring appliance.

Isolation of non-compatible metals shall be provided in all installation by giving the metal a coat of asphalt and an isolation barrier (i.e. asphalt impregnated felt) to prevent contact with dissimilar metals, masonry, concrete or plaster.

The material noted herein shall not be applied on surfaces that will exceed 82°C at any time, except as noted otherwise.

Block Fillers/Stopping

Block filler for Masonry, cement plaster and concrete surfaces; 250 to 500 microns dry film thickness per coat, or as required to fill voids. It shall be carried out by using the following materials:

- I. For render it shall be cement-based filler.
- II. For concrete or blockwork it shall be of similar materials to the background and shall be finished with a similar texture.
- III. For internal woodwork, hardboard, fibreboard and plywood to be painted it shall be putty complying with BS 544 and shall be tinted to match the color of the undercoat.
- IV. For clear finished woodwork it shall be a putty complying with BS 544 and shall be tinted to match the surrounding woodwork. This shall only be applied to small holes and blemishes. Large holes shall be repaired with graving pieces or grain pins as per specification for joinery.

Catalysts, Solvents and Thinners

All catalysts, solvents and thinners shall be the type specified by the paint manufacturer.

53.3 SURFACE PREPARATION

The surface preparation to be used for each item shall be as specified in Clause 53.5.

Steel surfaces to be painted shall be cleaned to Sa 2 1/2 quality standard (equivalent to 2nd quality of BS 7079).

Blast Cleaning

The steel surfaces which are to be blast cleaned shall be chemically cleaned from deposits of oil or grease according to this specification.

During blast cleaning, the abrasive removes all mill scale, rust, corrosion, oxides, old paint and foreign matter. The steel surface is near white metal according to SA 2 1/2 or white metal according to SA 3, slightly roughened to form a suitable anchor pattern for the following coatings. The height of profile of the anchor pattern produced on the surface shall be approx. 50 microns.

Blasting shall be performed with compressed air. The compressed air used for nozzle blasting shall be free of detrimental amounts of oil and water (from condensation). Adequate separators and traps shall be provided. Nozzle pressure shall be at least 8 bar. Blasting abrasive shall consist of the following composition:

Steel grit (G 400 size) and steel shot (S 230 size) are only used in the workshop. At site, when using copper slag, the grit size shall be 0.5-1.5 mm. The use of other similar abrasives shall be subject to approval by the Engineer.

In case blasting abrasives are to be reused, they shall be cleaned of contamination before re-use. Sand shall not be used for blasting.

After the blast cleaning operation, the surfaces shall be cleaned with clean brushes or compressed air free of detrimental oil and water. The blasted surfaces, pockets and corners shall be absolutely free of blasting abrasives before the priming coat is applied.

Blast cleaning operations shall not be conducted on surfaces that will be wet after blasting, or when the relative humidity of the air is greater than 80 %.

Blast cleaning operation shall be done in such a manner, that no damage is done to partially or entirely completed portion of the painting work. The blasted areas shall be primed, as specified in the specification immediately after blasting and cleaning, at the latest within four (4) hours, but on the same day, before any visible or detrimental rusting occurs.

Surfaces completed but not meeting the standards set forth in this specification shall be re-worked at the Contractor's cost.

End parts of structural components and other surfaces on which welding is to be carried out shall preferably be covered by tape to avoid priming and to facilitate welding. Steel plates less than 4 mm thickness may not be blasted with steel grit or steel shot.

If steel structure material is delivered without corrosion protection or with temporary protection for shipping, the whole material must be blast cleaned at site for the final corrosion protection. In such cases, blasting and painting shall be performed in special temporary buildings or tents. The work shall be performed without hindering other activities at site or the operation of existing plant.

Mechanical Hand Cleaning According to Svensk Standard SIS 05 5900 St. 2 and St. 3

If necessary, unpainted surfaces shall be chemically cleaned according to this specification before the mechanical hand cleaning.

The basic requirements for mechanical hand cleaning is that all loose mill scale, loose paint, rust, weld spatter, and foreign matter shall be removed by scraping, hammering, brushing, grinding, etc., using hand tools or portable electric or pneumatic machines, light enough to be used as hand tools. Before painting work starts, the whole surface must be completely cleaned.

Steel surfaces shall be prepared according to Svensk standards SIS 05 5900 St 2 or St 3. The surface can be checked as to the needed quality by comparing it with the colored pictures given in the standard.

Galvanized metal to be painted shall be thoroughly cleaned with solvent to remove all oil.

Masonry, cement plaster and concrete surfaces to be painted shall be thoroughly cleaned by scraping and wire brushing to remove excess mortar, loose particles and scale. Efflorescence shall be removed by first wetting the surfaces with water and then scrubbing with a 20 percent solution of muriatic acid, followed by a thorough rinsing with water.

Wood surfaces to be painted shall be sanded to provide a smooth surface. Nail holes and other surface imperfections shall be filled with putty or wood filler. Knots and sap streaks shall be coated with shellac.

All surfaces to be painted shall be thoroughly cleaned of oil, grease and other foreign matter. Surfaces shall be free of moisture and contamination from chemicals and solvents.

Any additional surface preparation specified by the paint manufacturer shall be considered a part of this specification.

Hardware accessories, plates, lighting fixtures and similar items shall be removed or adequately protected before painting. Upon completion, the removed items shall be replaced. Doors shall be removed if necessary to paint bottom edges. Only skilled mechanics shall be used for removing and replacing the above items.

Any surface that cannot be put in proper condition for painting as specified herein shall be identified in writing or full responsibility shall be taken for rectifying any unsatisfactory finish which results there from.

53.4 APPLICATION

General

The paint manufacturer's instructions covering thinning, mixing, method of application, handling and drying time shall be strictly followed and considered a part of this specification.

Paint shall not be applied to damp surfaces or in rainy weather or when the temperature is below 13°C or above 32°C, except when specifically permitted to do so by the manufacturer's instructions.

Spray painting at the job site shall be permitted only at times and locations approved by the Employer/Engineer.

The prime coat shall be applied by brushing, rolling or spraying and on the same day as the surface is prepared.

Intermediate and finish coats shall be applied by brush, roller or spray method with the specified amount of time allowed between coats. At locations where spray method cannot be used, and the dry film thickness required in one coat cannot be obtained, additional coats shall be applied to obtain the required dry film thickness.

The color of each coat shall contrast with the previous coat's color to avoid skips and holidays. Finish colors will be specified in the Painting Schedule or amendments to this specification.

The quality workmanship shall be the best available. Finished work shall be uniform, smooth and free from runs, sags, defective brushing and clogging. Edges of painting adjoining other materials or colors shall be sharp and clear without overlapping.

At completion, finish shall be touched up, restored, and left in good condition, where damaged.

Finish coats of paint shall be compatible with the prime or finish coats applied by

fabricators or manufacturers. To determine if there is any reaction, a small area in an inconspicuous location shall be painted. If any reaction occurs, a suitable sealer shall be applied.

The film thickness shall be as specified in Clause 53.5. In addition, the film thickness of each and all coats of paint shall be as required by the manufacturer. The actual thickness obtained shall be checked with an approved thickness gauge. If it is found that the finished surfaces are not the specified thickness or specified color, another coat will be required.

Non-galvanized steel grating shall be painted before erection by either dipping or spraying.

Steel surfaces that will be concealed by building walls shall be primed and finish painted before the wall is erected.

Steel surfaces that will be concealed by building floors shall be primed and finished painted before the floor is erected.

Tops of structural steel members that will be covered by grating shall be primed and finished painted before the grating is permanently secured.

Adequate covers and dropcloths to protect the work of other trades and adjacent finishes from paint splatter shall be furnished and maintained in place while painting. Any paint spots or spillage, which may occur, shall be promptly removed.

Newly painted surfaces shall be protected with "Wet Paint" signs.

Proper ventilation and circulation of air shall be provided during application. Masks are recommended when spraying.

Sample Panels and Test Areas

Before painting with a particular system commences, the Contractor shall paint test areas or sample panels to demonstrate that the specified thickness and finish to the paint film is being obtained.

The paints, equipment and method of application used for test areas or sample panels shall be representative of those to be used for the work.

Approved test areas or sample panels shall be retained and shall form the standard for all subsequent work.

53.5 PAINTING REQUIREMENTS

Steelwork

Steel Surfaces Inside of Closed Buildings and Not Being Exposed to Industrial Atmosphere

At workshop

Blasting to SA 21/2 and application of a transport and storage coat with a one-component material of PVC/acryl -or alkyd resin combination with zinc chromate as active pigment, minimum 12 zinc/chromate of pigment part.

Dry film thickness 80 microns.

Pre-treatment at Site

If before erection damages of the transport and storage coat of paint are observed (maximum 20% of the steel surface damaged and under rust), blasting to SA 21/1 and application of the basis coat shall be performed again. If only touch-up is necessary, the surfaces shall be cleaned by washing with fresh water, they are then de-rusted and touch-up is performed using the same material as at works.

Painting at Site

Application of a second priming coat with a one component zinc chromate prime alkyde resin based, 18 % zinc chromate of pigment parts.

Dry Film Thickness 40 Microns

Application of two final coats of paint with a one component material alkyde resin

based, first final coat with micaceous iron oxide (m.i.o), second final coat with m.i.o or tint pigments, if decorative colors are required.

Dry Film Thickness together 80 micron.

Total dry film thickness 200 microns.

Steel Surface Outside of Buildings or Exposed to Industrial Atmosphere

At Workshop Same as above for inside of buildings.

Pre-treatment at Site Same as above.

Painting at Site

Application of a second priming coat of paint with the same material tuned as second primer.

Dry Film Thickness 60 Microns

Application of two final coats of paint with a one component material PVC/alkyde or alkyde resin combination, first final coat with m.i.o.

Dry Film Thickness together 100 micron.

Total dry film thickness 240 microns.

Steel Surface of Parts being Permanently in Contact with Sea Water or Industrial Water

At workshop

Blasting to SA 2^{1/2} and application of a transport and storage coat of paint, with a one-component material of PVC/Acryl -or alkyde with zinc chromate as active pigment, minimum 13 % zinc/chromate of pigment part.

Dry film thickness 80 microns.

Pre-treatment at Site

Blasting again of the surface to SA 3 and application of the first final coat with a two-component coal tarepoxy based material.

Dry film thickness to 100 microns.

Painting at Site

Touch-up and application of another two coats with the same material.

Dry film thickness of the two coats together 200 microns.

Performance of holiday and pinhole tests and dry film thickness tests. The necessary repairs are then performed and after satisfactory reception the fourth final coat shall be applied with the same material.

Dry film thickness 100 microns.

Total dry film thickness 400 microns.

As shortly as possible before permanently in touch with seawater the antifouling coat shall be applied, color red-brown or similar.

Dry film thickness 40 microns.

Galvanized Steel Surfaces

Galvanized surface requiring to be painted shall be thoroughly treated with mordant solution and before painting shall be given:

1 coat of wash-primer.

1 coat of alkyde based primer.

2 coats of chlorinated rubber coating to an average dry film thickness of 50 microns per coat (minimum 40 microns).

Total minimum dry-film thickness, 120 microns, shall be applied when directed by the Engineer.

General Requirements for Painting at Site

Protruding corners, sharp section edges and places of difficult access shall be pretreated.

The first priming coat shall be applied by brush further coats shall be applied by brush if nothing to the contrary is stipulated in the Specifications. Smaller and specifically shaped brushes shall be used for protruding corners, sharp section edges and places of difficult access.

The Contractor shall inform the Engineer in good time before starting to apply the next coat so that the Engineer shall have the opportunity of approving the previous coat.

Painting work shall not be carried out at temperatures below 15 °C or above 50 °C, in addition, painting work shall not be carried out on surfaces affected by the action of rain, fog and moisture or water of condensation. Work started on such surfaces may not be continued until the surfaces to be painted are completely dry.

Trial coats shall be prepared at the request of the Engineer for all coats differing in shade and structure.

Shop coats shall be checked for good quality. Where necessary, prior to painting or coating operations at site, the Contractor shall clean and repair, including smooth towel, all shop coats which are defective or damaged.

The Contractor shall note the locations where damage to paint work during shipment, storage, building-in and particularly during grouting of the steel lining is unavoidable and the application of all protective treatment shall be programmed accordingly.

Temporary or permanent welding shall not be permitted on areas where the welding will damage paint or other protective coatings, unless such areas are accessible for repairing and inspection. Material which has been painted shall be

handled with care and protected as necessary to preserve the coating in good condition.

The Contractor shall submit full details regarding the extent to which the blasting and painting will be carried out in his workshop, on the site or in-situ after erection. A properly equipped paint shop shall be set up at the site using a specialist organization experienced and skilled in preparation and application of protective coatings to deal with all site protective treatment.

The Contractor shall guarantee for the surface protection on steel for at least five (5) years. Any corrosion occurring within this period shall be made good by the Contractor at no extra costs.

Inspection and Tests of Paint

Certificates from an independent authority or institute acceptable to the Engineer, certifying the quality of the material, shall be submitted to the Engineer prior to execution of the works.

Selection of samples for testing material will be made by the Engineer.

Intermediate inspections are necessary for all painting systems.

- I. After cleaning, de-rusting or blasting, as well as when repairs become necessary: Degree of cleaning.
 - II. After applying the priming coats: Random sample measurements of dry film thickness.
 - III. Before the last final coat: Measurements dry film thickness of possibly no longer accessible surfaces, removal of faults in the coating in order to obtain a clean finish.
 - IV. Before the last top coat: Holiday and pinholes tests with the pinhole detector.
 - V. After the last final coat of all coating systems: Performance of final total dry film thickness measurements and determination of the quality of the surfaces.
- Dry film thickness on steel shall be measured in accordance with BS 3900 Part C5.

The Contractor shall provide the Engineer with a magnetic or electrical thickness gauge for measuring the thickness of the paint.

All tests are to be announced in time and have to be coordinated so that no interruptions in erection work arise, and no waiting period for further painting occurs.

All necessary measuring and testing apparatus is to be maintained in good condition by the Contractor during the erection time.

Steel Doors, Windows and Frames

Power tool clean.

One prime coat.

One intermediate coat.

One finish coat.

Total dry film thickness: 160 to 240 microns.

Masonry Cement Plaster and Concrete Surfaces

All internal walls of grid station buildings shall be painted by oil paint up to 2.2 m height.

Scrape and wire brush clean

One coat of block filler.

One prime coat.

One finish coat.

Total dry film thickness: 160 to 500 microns.

Wood Surfaces

Sanded clean.

One prime coat.

One finish coat.

Total dry film thickness: 140 to 200 microns.

Emulsion Paint

Emulsion paint shall be applied in three coats in accordance with the manufacturer's instructions. The finished surface shall present a satin finish. Where used externally, emulsion paint shall be of external quality.

Gloss Paint

Gloss paint shall be applied in two undercoats and one or more top coats as required to produce a surface which is consistent and unstreaked in finish and color.

Painting of Woodwork

The moisture content of joinery timber at the time of painting shall not be more than 14%. All wrot woodwork to receive a clear varnish finish shall be rubbed down to a smooth surface.

Wrot woodwork for painting shall be prepared and primed in the joiner's shop. Nail holes, cracks or other defects shall be filled and leveled up with hard stopping.

Small knots and pitch streaks shall then be given two coats of knotting. Joints shall be thoroughly primed before assembly.

As soon as knotting is thoroughly dry the whole of the joinery shall be given a coat of priming paint, care being taken to work the primer into all corners and crevices. End grain and surface, which will be concealed upon erection shall be given two coats of primer. Spraying will not be permitted.

After erection on site a further coat of primer shall be applied to all accessible faces.

When the primer is dry, and before applying the undercoats, all cracks, nail holes

etc. shall be stopped. 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 undercoat.

Joinery shall then be given two coats of undercoating paint followed by one or more coats of alkyd resin enamel paint.

Clear Varnish

Polyurethane varnish shall be of an approved manufacturer.

Hardwood described as being polyurethane "clear" or "bright" varnished shall be filled, rubbed down and painted with one priming coat and three finishing coats of polyurethane Clear High Gloss wood finish, all in accordance with the manufacturer's instructions. Woodwork shall be lightly rubbed down between coats and care shall be taken to avoid the presence of dust by wiping the work with a "tack" rag immediately before application of the varnish.

Stained Woodwork

Woodwork to have a stained natural finish shall be rubbed down and prepared to a smooth finish. It shall then be treated with two coats of an approved proprietary brand of stain/wood preservative which will impart a natural timber finish of approved shade to the woodwork. The stain shall be applied in accordance with the manufacturer's instructions to give an even toned finish.

Polishing

Where woodwork is described as polished it shall first be stained with an approved wood stain. First quality button polish shall then be applied; the first two applications may be by brush but subsequent applications shall be by means of a polisher's rubber and shall be continued until the wood grain is completely filled.

Textured Paint

Textured decorative surface coating to contain a tough, flexible copolymer emulsion and coarse hard aggregate of mica and applied strictly in accordance with the manufacturer's printed instructions.

Painting of Exposed UPVC Pipework

Exposed UPVC pipework, fittings and brackets shall be abraded and painted with three coats of emulsion paint.

53.6 COLORS

Submit colors charts for selection by OETC/ Engineer.

54 PLUMBING AND SANITATION

54.1 GENERAL

The intent of this specification is to define the minimum requirement for the supply and installation of complete plumbing and sanitation systems in accordance with the drawings and as specified herein.

The water services and sanitation services installations shall be carried out in accordance with the regulations of the local water and health authorities and to their complete satisfaction.

Design and Drawings

Design

The complete systems shall be designed as per project requirements keeping in view also the requirements of local water and health authorities.

Drawings

Prior to commencement of works, large scale detailed isometric layout drawings shall be prepared by the Contractor and submitted for Engineer's approval. The drawings shall show the size, positions, levels and falls of all pipes and ducts and

the type and position of all fittings. In addition, the details of any builder's work required shall be shown together with pipe fixing positions and details of fixings.

Drawings and submissions shall comply with the general and specific requirements

54.2 CODES AND STANDARDS

Latest editions of British Codes, specifications and Standards form a part of this specification to the extent indicated by the references thereto. In the event of conflicts or discrepancies between this specification and the referenced codes, specifications or standards, the more stringent applicable requirement shall govern.

54.3 BUILDINGS DRAINAGE

General

Buildings drainage shall generally be in accordance with the relevant clauses of Section Five, and shall comply with the BS EN 12056-2 and BS EN 752-1.

Materials

Soil and ventilation pipes above ground shall be of the captive ring seal type to BS 4514 in UPVC and shall be boxed in, to the Engineer's approval.

Underground drainage pipes of 110 mm size and above shall be UPVC to BS 4660 or equal and approved with rubber ring seal joints. Underground drainage pipes below 110 mm size shall be as specified for soil and ventilation pipes, unless detailed otherwise on the Drawings.

Roof Terminal to Vent Pipes

Ventilation pipes shall be provided with a UPVC balloon grating at the roof termination. Gratings shall be fixed 600 mm above roof solar slab level.

Access Pipes

Access pipes shall be provided at the foot of soil vent stacks 300 mm above floor level, and at bends above this level.

Long Radius Bends

A long radius bend shall be fitted at the base of all soil, waste and rainwater stacks. Horizontal bends in pipes below floor slabs shall have a 100 mm radius.

Floor Gullies

All floor gullies shall be of PVC water sealed type and shall be complete with rodding access and stainless steel grating.

Fixing of Above Slab Pipework

Pipes shall be fixed to the structure at 2 m centers for vertical runs and 1 m centers for horizontal runs.

Brackets shall be painted galvanized mild steel and fixings shall be stainless steel screws into rawlplugs.

Expansion

Provision shall be made for expansion by ensuring that spigot and socket joints are put together with the recommended 10 mm gaps.

Testing of Drains

Drains shall be water tested to the first manhole or inspection chamber outside the building by filling to a head of 1.5 m. Tests shall be carried out after joining, after backfilling and on completion. The tests shall be held for ten minutes without a discernible drop in the water level.

Cleaning Drains on Completion

The Contractor shall, on completion of the work and immediately before handover,

cleanse the whole of the drains with rods and accessories, cleanse all traps and gullies, bolt down all access covers etc., and shall leave the whole of the drainage system complete, in sound condition and efficient working order.

54.4 SANITARY PLUMBING

Materials

Waste and overflow pipework shall be of the push-fit ring seal type to BS 5255.

Waste Traps

Sanitary fittings shall be fitted with white traps on waste outlets in accordance with the following:

Washbasins: 32 mm anti-siphon traps with 76 mm seal

Sinks: 38 mm anti-siphon traps with 76 mm seal

Showers: 38 mm tubular "S" traps with 76 mm seal

Traps shall comply with BS EN 274.

Waste Pipe Gradients

Horizontal waste pipes below basins, sinks, urinals and the like shall fall at a uniform gradient of 1 in 45.

Access to Waste Pipes

Ends of horizontal runs of waste pipes shall be provided with access plugs. Blank ends shall have plugs to allow horizontal rodding; 92.5 ° bends, where wastes drop vertically, shall have swept tees or crosses with plugs on the top leg to allow vertical rodding.

Fixing of Waste Pipes

Waste pipes shall be fixed to the structure at 1 m centers with polypropylene pipe

clips, stainless steel screws and rawlplugs.

Test of Waste and Vent Pipes

An air test shall be applied to all waste and vent pipes as follows:

A gauge in the form of a glass U tube shall be connected to the drain plug in the section of pipe until a pressure equivalent of 100 mm of water is indicated on the gauge. Without further blowing or pumping, the pressure shall not have fallen below 75 mm after a period 5 minutes.

The Contractor shall locate and remedy any defects found whilst carrying out the test, and the test repeated until found to be satisfactory.

Cleaning of Sanitary Plumbing Installation on Completion

The Contractor shall, on completion of the installation and immediately prior to handover, thoroughly cleanse and leave the system in sound condition and efficient working order.

54.5 SANITARY FIXTURES

General

Fixture sample of each type designated on the drawings shall be submitted for approval. The approved sample shall be kept protected at all times for comparison purposes until release by the Engineer for removal.

All ceramic fixtures shall be of best quality, regular selection, white porcelain thoroughly fused, producing a white material which, when fractured, shall show a homogeneous mass with close grain and free from pores.

All surfaces coming in contact with walls, floors, or surfaces of other fixtures shall be reasonably flat.

All plumbing fixtures installation shall be in accordance with manufacturer's printed

instructions. The location of each fixture and the fixing method of ceramic fixtures shall be as shown on the approved drawings or as directed by the Engineer.

After all fixtures have been mounted and are ready for use and handing over, the Contractor shall thoroughly clean all fixtures furnished and mounted under this Contract, removing all plaster, stickers, rust stains and other foreign matter or discolorations of fixtures, leaving every part in perfect condition and ready for use.

Any steel accessories for the fixtures shall be adequately protected against corrosion. Dimensions and sizes of all sanitary fixtures shall be subject to the approval of the Engineer.

All basins and sinks shall be provided with the cold and hot water. Exhaust fans shall be provided and installed in all kitchens and lavatories etc.

Lavatory Basin

Wash hand basins shall be white glazed vitreous china to European Standards. Basins shall be completed with 32 mm diameter trap, waste and overflow assembly BS EN 274, rubber or vulcanite plug and chromium plated chain.

Sink Basin

Sinks shall be double bowl type stainless steel to BS EN 13310 of minimum thickness 0.9 mm with satin finish and fixing clamps. Sinks shall be complete with 38 mm diameter trap waste and overflow assembly in accordance with BS EN 274, rubber or vulcanized plug and chromium plated chain.

Taps shall be 13 mm diameter chromium plated pillar taps to BS 1010 (or) unless otherwise required by the Engineer.

Eastern Squatting WC Pan

Eastern type squatting plates shall be provided with "S" or "P" traps and shall be heavy duty glazed vitreous china complying with BS 3402 with integral treads with

a 9 l glazed cast iron flushing cistern to BS 1125. The cistern shall have a ball valve to BS 1212 Part 1 with plastic float and be provided with a 15 mm diameter supply connection and 22 mm diameter waste built through the building wall.

A suitable water draw-off point together with 13 mm hose union tap shall be provided in a position adjacent to each eastern W.C. The squatting plate shall be set 3 mm below the surrounding finished floor level.

Connections to soil pipes shall be with approved caulking compound in accordance with the manufacturer's instructions.

W.C. Set

WC suites shall have "S" trap pans shall comprise a white heavy duty glazed vitreous china pedestal pan to BS EN 33 with a matching 9 l hand operated flushing cistern to BS 1125 and PVC flush pipe. The cistern shall have a ball valve to BS 1212 Part 1 with plastic float and be provided with a 15 mm diameter supply connection and 22 mm diameter waste built through the building wall. The seat shall be plastic ring type to BS 1254. Hose union tap shall be provided in a position adjacent to each W.C set.

Showers

Shower units shall be for hot and cold supply with 13 mm chromium plated mixers to BS 1010 with riser pipe, shower arm and spray head.

Footpaths under showers shall be cast iron white enamel coated, acid and alkali resistance type, size 90x90x15 cm, unless otherwise required by the Engineer.

Bib Taps

Bib taps shall be chromium plated screw-down pattern to BS 1010.

Hose Union Taps

Hose union taps shall be chromium plated screw-down pattern equipped with

threaded hose connection complying with BS 1010. A flexible hose shall be provided with each tap.

Soap Trays

Soap trays shall be of white glazed vitreous china with tongued tip and be recessed into the wall, unless otherwise required by the Engineer.

Toilet Roll

Toilet roll holders shall have chromium plated back plate and side arms with a timber spring roller, unless otherwise required by the Engineer

Towel Rails

Towel rails shall be one piece 20 mm diameter chromium plated brass tube with chromium plated sealed fixing roses at each end for screwing to wall, unless otherwise required by the Engineer.

Mirrors

Mirrors shall be of mirror glass to BS 952, 4 mm thick with polished edges, unless otherwise required by the Engineer.

Glass Shelves

Glass shelves shall be 6 mm thick with rounded polished edges, unless otherwise required by the Engineer.

Water Heater

The water heater shall be of minimum capacity 80 l for providing permanent hot water at any time in kitchens and lavatories.

Exhaust Fans

Wall mounted and window mounted exhaust fans shall comprise a propeller fans directly driven by an electric motor rated for continuous operation and shall be

complete with anti-vibration mounts on radial arms. Each unit shall have a louvered outlet and an automatic shuttered intake. The capacity of each exhaust fan shall be adequate to permit effective ventilation subject to the Engineer's approval.

Floor Drain for Lavatories

Floor drains shall be of heavy coated cast-iron with 50 mm diameter pipe connection and a chromium-plated square cover plate.

Urinal Units

Urinal unit consists of glazed porcelain wall type urinal, siphon action. Well-hung urinal shall have integral traps and china strainers and shall be mounted with bolts to the wall. The cistern shall be high level with porcelain fixed above suspended ceiling. Downpipes to the urinal shall be concealed.

Floor Drains

All indoor areas in which drainage is required shall have floor drains of heavy-coated cast iron connected to the drainage system. The trap shall be covered with grating made of stainless steel. All drains which need to be connected to the neutralization pit shall be acid resistant.

In door areas subject to excessive drainage, the floor drains shall be in the form of channels of adequate size fitted with removable grided covers suitable for heavy traffic and connected to the drainage system. Detailed design and all information regarding the system and materials shall be submitted to the Engineer for approval.

Installation

General

All fixtures shall be suitably matched and installed as per the manufacturer's

installation instructions and laying directions.

All valves shall be installed vertically except where lack of clearance space or where accessibility requires otherwise.

Great care shall be taken in setting out and determining the general levels and falls of drain pipes, so that a fall giving a self-cleaning velocity shall be obtained.

The Contractor shall provide all necessary stoppers, etc. and shall test the drains and pipes in the presence of the Engineer.

Placing of Sanitary Fixtures

During installation of equipment and fixtures the Contractor shall have suitable fixing devices and required tools to provide for convenient removal of the equipment and fixtures for maintenance.

The Contractor shall submit leaflets or catalogues to determine design and shape of accessories, such as sanitary equipment, valves, etc.

Lavatory brackets, cisterns, etc., shall be sufficiently fixed to the walls, subject to the approval of the Engineer.

54.6 WATER SYSTEM

Potable Water

Potable water for the whole complex shall be from the public water supply if available and if not potable water shall be supplied by tankers.

Cold Water Storage (Main Storage)

The overhead cold water storage tank shall be of pre-insulated section GRP modular type to be of size shown on the drawing and shall be mounted on a purpose made structure. The tank shall be provided with an access manhole with hinge lockable cover, drain connection, overflow, incoming connection via ball

valve, and level indicator.

Adequate shading and service access shall be provided for the storage tank.

All internal tie rods and fixtures shall be of stainless steel. All panel joints shall be made externally and be made with galvanized structural steel nuts and bolts.

Synthetic rubber sealant shall be used between all panel joints.

The cold water tank shall be fed from the public water supply and shall have connector for water supply from water tanker..

Distribution

Cold water stored in the overhead tank shall be distributed to roof top tanks on various buildings in the compound as indicated on the drawings.

All pipework, fittings and valves and the installation of services shall conform to the relevant clauses of the pipework specification.

All above ground water service pipeworks shall be of copper and below ground shall be of PVC.

All surface mounted copper pipework shall be with compression type fittings and concealed pipework with capillary type fittings.

Gate Valves

Gate valves to copper pipework shall be brass to BS 5154 with compression ends. Exposed valves on chrome plated pipework shall also be chrome plated.

Copper Pipework Joints and Fittings

Screwed joints, where approved, shall be made with PTFE tape.

Compression joints at valves etc. shall be made with carefully cleaned tube and fittings to ensure water tightness.

A smear of approved proprietary compound may be used to assist the joint.

Pipework Fixings and Supports

Pipework shall be fixed or supported at intervals not exceeding the following:

Copper Pipework

15 mm (1/2") bore:	1200 mm
22 mm (3/4") bore:	1200 mm
28 mm (1") bore:	1500 mm
35 mm (1 1/4") bore:	1500 mm

Exposed copper pipework shall be supported by chrome plated cast brass screw-on brackets with round base plates, fixed with chrome plated screws.

Concealed copper pipework shall be fixed with copper saddle bands and brass screws and wrapped in protective tape.

Pipework Installation

Where appropriate, cold water rising mains shall rise continuously to roof storage tanks. Localized high points which could cause entrapment of air pockets shall be avoided, wherever possible.

Hot and cold water down services shall fall continuously to draw-off points. Where localized low points are unavoidable they shall be provided with drain cocks to allow the complete draining of the system. Automatic air vents shall be fitted on all high points of the systems where air release is required for the efficient venting of the installation. Automatic vents shall be of automatic air eliminator type of an approved manufacturer, and shall be fitted on top of an air bottle formed by a square tee, short nipple and blank cap tapped 15 mm.

Pipe Burr

Cut pipes shall be reamed to completely remove the inside burr. If burrs are found in one small section of the works during installation, the Engineer will require the remaining works to be dismantled for inspection.

Pipe Sleeves

Pipe sleeves shall be fitted where pipes pass through walls, floors and ceilings. Sleeves shall be of PVC, shall be of sufficient diameter to permit free movement of the pipe and shall be fixed in a manner that will ensure that they do not become detached from the building fabric.

At the end of each sleeve the approved set screw pattern CP cover plates shall be fitted. Pipework insulation/vapor seal shall be installed through the annular spaces between sleeves and pipes.

Draw Offs

HWS-s and CWS-s shall be run directly to taps on sanitary fittings etc. The hot tap shall be on the left when facing the fitting.

The Contractor shall connect up the appropriate service to all bib taps, sinks, showers, basins and closets where required and shown on the drawings, and fit valves for isolating purposes on each individual draw-off.

All bib taps and isolating valves are to be approved by the Engineer. All surfaces of bib taps and isolating valves within buildings are in general to be chromium plated. Bib taps located externally shall be in brass or bronze and shall be complete with screw fittings for hose connections.

Float pipes serving one or more draw-offs may be carried through at constant size and terminate with a capped end.

Except where otherwise indicated, rigid pipe connections to basins shall be 15

mm diameter and 22 mm diameter to sinks.

Water connections to kitchen sinks shall be made via cartridge type water filter.

Open Ends

During the progress of the work, open ends of pipes, tees etc. must be closed with metal plugs or copper caps appropriate to the pipe material. Plugs made from paper or other material will not be allowed. Work not protected in accordance with this clause will not be accepted. Storage of pipes on site must be in racks and suitable measures must be taken to prevent corrosion.

Corroded pipework will be rejected.

Protection of Pipework

All pipes buried in screed or chased in walls shall be wrapped with one layer of protective tape and outer wrapped with one layer of PVC tape.

All drops to sanitary fittings to be chased in walls. All high level pipe lines to be concealed in timber bulkheads in accordance with the architect's details.

Cold Water Storage Roof Tank

The roof mounted cold water storage tank shall be of sectional GRP modules to the size as shown on drawing and shall be mounted on purpose made concrete upstands to suit the manufacturers details. The tank shall consist of access hole and hinged lockable cover, drain connection, overflow main water supply connection via ball valve and bowser feed connection. Adequate shading shall be provided for the storage tank.

All internal tie rods, and fixtures shall be of stainless steel. All panel joints shall be made externally and be made with galvanized structural steel nuts and bolts. Synthetic Runner Sealant shall be used between all panel joints.

Cold water tanks shall be fed from the site potable main system. The bowser fill

point should terminate with an isolating valve at 1 m above ground level. The exact route taken by the bowser fill pipework and the point of termination is to be established on site and agreed by the Engineer. The overflow pipework shall be routed to terminate adjustment to the bowser fill point.

All pipework, fittings and valves and the installation of services shall conform to the relevant clauses of the pipework specification.

All above ground water service pipeworks shall be of copper and below ground shall be of PVC.

Water Heater

Water heaters shall be of the automatic electric type for vertical mounting and of the capacities indicated on the Drawings. They shall have titanium-sheathed elements and shall be glass lined.

Cylinders shall be tested to 7 bars, shall be complete with integral insulation jacket and shall be painted with a white stove finish.

Electric elements shall be suitable for the site electricity supplies and be complete with all necessary controls to maintain a flow temperature of 65 °C.

All necessary safety thermostats shall be fitted for high limit cut-out.

Thermostats shall have earth terminals fitted.

Cylinders shall be supplied with all necessary fixings brackets and stainless steel fixings screws. The cylinders shall be installed complete with domestic hot water flow and return pipework, cold feed, open vent and drain down pipework, as required.

Pressure Tests

The test pressure to be applied to the various services shall be as follows, and the pressure gauge readings for these tests shall be taken at the lowest points in the

respective systems:

1. Domestic hot water flow and return lines - 7 bars
2. CWS and cold feed lines - 7 bars
3. Drinking water lines - 7 bars
4. Cold water rising mains - 13.5 bars

All plugs, caps, tees, drain fittings etc. required to enable the tests to be carried out shall be supplied by the Contractor.

System Clean Out

The Contractor shall arrange for the domestic hot water service, cold water down service and mains water systems to be chemically cleaned immediately after the completion of the required flushing out, following the pressure tests. The systems shall be first treated to remove corrosion products, followed by a further treatment to inhibit corrosion.

The Contractor shall allow for the provision of suitable tapping points for introduction of chemicals and all the necessary drain/flushing connections.

To provide a base treatment (after flushing procedures) the Contractor shall introduce an approved chemical treatment for scale and corrosion prevention obtained from specialist suppliers into the cold water storage tanks at the rate of approximately 1 l per 4,000 l of water and agitate the tanks to distribute the chemical evenly.

Chlorination of Water Services

The Contractor shall carry out the chlorination of all main water and drinking water services.

All necessary charging and raining down points shall be provided on the pipework as required to allow the chlorination and flushing out to be completed throughout.

The chlorination of the services shall be carried out in accordance with the method described in BS EN 806 and the requirements of the Water Supply Authority.

54.7 HOLDING TANKS

The dimensions and configuration of the holding tank are as indicated on the drawing but not less than 20 m³.

The holding tank shall be constructed in a manner and using appropriate materials so as to remain water tight at all times and be strong enough to withstand heavy vehicular traffic. It shall be GRP or made of concrete. Openings and covers shall be provided to permit easy access and all covers shall be of the heavy duty type suitable for vehicular traffic. Ventilation shall be provided by a 100 mm diameter ventilation pipe terminating in a copper wire balloon to prevent the access of adventitious matter. The construction and internal configuration of the tank shall be in accordance with the current environmental regulations.

54.8 SOAKAWAY

The Contractor shall supply and install a soakaway system suitable for the designed flow rate of the system taking due regard of the prevailing ground conditions.

Following preparation of the area indicated on the drawings for the soakaway, the Contractor shall carry out percolation tests over a period of time and submit the test results and his recommendations to the Engineer for his approval. The system shall consist of inverted perforated vitrified clay pipes conforming to the Extra strength requirements of BS 65 laid in straight runs at the perimeter of the soakaway area. Additional branches shall be installed to give a "herring bone" layout if ground conditions require. All pipework shall be laid at a 1:100 gradient and shall be readily accessible for cleaning and checking from inspection manholes at the end of each run.

A minimum cover of 600 mm shall be maintained to the crown of all pipework and the manufacturers bedding recommendations followed.

54.9 DOMESTIC GAS

The installation of all gas equipment, regulators, pipework, valves and all associated fittings shall be carried out strictly in accordance with BS 5482-1. All gas pipework shall conform to BS EN 10255 Heavy Duty, BS EN 10216-1 and BS EN 10217-1 Seamless Steel Grade 320. All fittings shall conform to BS EN 10311, BS EN 10224 & BS EN 10241. All welded joints shall be butt or socket welded conforming to BS 2633 & BS 2971. All screwed joints shall conform to BS 21, jointing compounds to BS 5482. Joints shall not be allowed where gas pipes cross the route of other services. Maximum separation is to be arranged between gas and other services. Gas pipework to be colour coded to BS 1710. Where pipelines are buried under floors or otherwise built in, they shall be suitably protected using an approved protective tape. Where pipes are buried or built in, joints shall not be permitted except by permission of the Engineer in circumstances where a joint is unavoidable. Wrapping tape shall consist of one layer anti-corrosion tape outer wrapped with one layer of P.V.C. backed tape. Ball valves shall conform to BS EN ISO 17292 or BS EN 1563. All valves shall be Teflon seated rotary ball valve of an approved manufacturer. All pipes and fittings, excluding regulators, should be prepared and coated with two coats red-oxide and final coating colour to BS 1710. Final connections to appliances shall be with stainless steel braided pigtails conforming to BS 3212, Type-2. Gas cylinders shall be connected to manifolds using stainless steel braided cylinder pigtails conforming to BS 3212, Type-2. 3/8" NB diameter, threaded connections to be BS 21.LHT.

54.10 DRINKING WATER COOLERS

Water coolers shall be of wall mounted type with mounting bracket. The coolers shall be of rugged construction with stainless steel top and cabinet in steel with protection against corrosion.

55 ARCHITECTURAL TREATMENT AND BUILDING PHILOSOPHY

Buildings shall be designed and constructed in compliance with the appropriate safety requirements, building regulations and applicable standards. The architectural appearance of the Substation buildings shall aesthetically meet the requirements of OETC/Engineer and plans of the relevant Planning Authorities.

Landscaping will be included as part of the external finishing to reduce the visual impact of the plant, and soften the appearance of the buildings and plant subject to approval of OETC/Engineer and the relevant Planning Authorities.

The Contractor shall design and detail the buildings. The designer shall be employed by the Contractor under the terms of subcontractor as detailed in Section 4.

The Contractor shall take full responsibility for the design consultant as his subcontractor.

56 BUILDINGS AND ASSOCIATED WORKS

56.1 Basic Requirements

A basic layout of the buildings, rooms and roads is indicated in the Tender Document drawings. The drawings indicate some key fundamental building requirements in terms of rooms and facilities and are intended for the Contractor's information only. They shall only be used as an indicative configuration for design.

As a general principle the assets of OETC and the relevant distribution Company shall be segregated with separate switchgear and control buildings, and separate access and egress arrangements.

The Contractor shall take full responsibility for the building configurations that are taken forward to construction.

The building design must be balanced between both aesthetic and practical considerations. The size and location of fixed light windows/ventilation shall be carefully considered to maximise the utilisation of natural light whilst optimising the efficiency of the air-conditioning and achieving a high quality architectural design.

Multistorey buildings, including their basements, shall have access and egress by stairways.

A separate means of emergency escape shall also be provided in accordance with Omani Building Regulations.

Stairs, ladders and walkways shall be designed in accordance with BS 5395-3: 1985 Code of practice for the design of industrial type stairs, permanent ladders and walkways’.

Suitable safe access facilities for roof inspections shall be provided.

Substation buildings shall have structural frames of reinforced concrete or steel. Selection shall be based as appropriate on such issues as availability of materials, ease and speed of construction, durability, fire safety issues and cost. Floors and roof slabs shall be in solid reinforced concrete.

Infill panels and partition walls of substation buildings shall be of solid concrete block construction and shall, as appropriate, be designed to adequately satisfy any thermal, and fire barrier requirements. External walls shall be double skinned and similarly designed, including resistance to the effects of weather.

Room heights shall be designed to suit safe plant installation, operation and maintenance.

In the switchgear rooms, crane rails and hook height shall provide adequate clearance to switchgear to permit the removal of any item of equipment for replacement, repair or maintenance.

Sufficient clearance between the top of switchgear and the highest position of the hook shall be allowed to permit transfer of equipment over the switchgear, in case this becomes necessary.

Sufficient internal laydown area shall be provided at one or both ends of switchgear rooms for safe plant installation, operation and maintenance.

In sizing the buildings, due allowance for future substation extensions shall be made.

The structural framing for the building, suspended floors and roof slab shall be designed in accordance with BS 8110 for reinforced concrete design, BS 5950 for structural steel design and BS 6399 for dead and imposed loads, including wind. The potential for sand to accumulate of the roof shall be taken into consideration.

For determining wind loads the Contractor shall take particular notice of the Foreword of BS 6399-2 where caution in the use of this code outside the UK is given.

The Contractor shall propose and justify Oman-specific factors of wind data for using BS 6399-2 to the satisfaction of OETC/Engineer at Tender stage and also before using them in the designs.

The switchgear room shall have an appropriately sized main door for vehicles/plant/trailers. This door shall be in grade 43A steel, galvanized, double skinned, roller shutter type, thermally insulated, with the capability of electrical and manual operation from the inside. The dimensions of this door shall allow the passage of the largest permanent electrical equipment on its bogey or low loader. External personnel and fire exit doors shall also be provided to the switchgear building.

External doors to buildings shall be as indicated on the drawings and in the schedule of finishes below. Any external doors used for the installation of equipment shall be double doors of suitable width and minimum height 2.5 m to enable all equipment to be delivered into the building prior to erection. Other external doors shall be normal personnel size. Thresholds and weather seals are to be provided on all external doors.

All doors of the substation shall be fire rated (minimum 2 hours).

All External doors shall be provided with latch panic bar

Internal doors shall be provide vision panel (glass 400 mm vert X 150 mm horiz)

All switchgear rooms shall be provided with latch panic exit doors.

Internal doors to Control/Relay/Switchgear buildings shall be as indicated on the drawings and in the schedule. Where internal doors are to be used to enable the installation of equipment, they shall be double doors hung on double action spring butt hinges with clear openings to match those of the equivalent external doors. Otherwise, single doors shall be normal personnel size. All internal doors shall be grade 43A steel and fire rated type.

Fire rating of all doors shall comply with the recommendations of ROP and the agreed Fire Safety Report produced by the Contractor as part of the substation design.

Sun shading of all external doors shall be provided by means of reinforced concrete canopies

built into the concrete structural frame of the building.

Door closures and labels shall be provided in the all external and internal doors.

Door configuration, locking and access control arrangements shall be as specified in the section of these specifications which specifies the Integrated Security System.

All ironmongery unless otherwise approved or specified shall be brass or stainless steel.

Windows shall be a minimum of 800 mm high. They shall be a fixed type unless otherwise shown on the drawings, with frames and glazing bars of aluminium. The size and gauge of the aluminium sections shall be suitable for the design, loading, sizes and arrangements used. Double structural glazing with solar reflecting glass of minimum 6 mm thick shall be provided, and all windows shall be fitted with security grills and be mounted on precast concrete sills.

All buildings shall be designed to have reinforced concrete or steel frames, with solid block work as detailed below. Internal partitions and dividing walls shall be 200 mm solid concrete block work plastered on both sides, unless otherwise noted. Suitable reinforcement and ties shall be used when the block work wall exceeds 5.0 m in length and 4.0 m in height, or as indicated by the relevant British Standard. The ground beam top level shall be finished a minimum 200 mm above finished floor level.

Particular requirements of substation building constructions and finishes are set out below:

Concrete finishes specified shall be in accordance with the definitions in BS EN 13670 'Execution of Concrete Structures' and the accompanying 'National Structural Concrete Specification for Building Construction' (a Cement and Concrete Industry Publication).

Element Requirements, Features and Finishes Schedule		
Ref	Element	Requirements, Features and Finishes
1	Building frames	Steel, or cast in situ reinforced concrete columns and beams.
2	Slabs	Cast in situ reinforced concrete roof and floor slabs integral with beams. Roof slabs laid to 1 in 80 minimum fall, with minimum 50mm fall, and insulated to give the specified U values

3	Reinforcement	Deformed high yield bar to BS 4449, with a characteristic strength of 500 N/mm ² .
4	Grade of structural concrete	Minimum 35 N/mm ² (cube) or as recommended in the soil investigation or Contractor's design, whichever is the higher.
5	Foundations type	Raft / or as per soil investigation / OETC and Engineer
6	Stairs	1200 mm minimum clear width
7	Walls (external)	Cavity masonry walls. Cavity to have 350mm thick rigid polystyrene boards of minimum density of 25kg/m ³
8	Walls (internal)	Non load-bearing solid block work with soft joint between the top of block work and beam/slab. Where the walls have fire ratings, the soft head joint should incorporate a fire seal of the same fire rating as the rest of the wall. Wall thickness shall not be less than 200mm including plaster finish. All areas except switchgear halls shall have wiring concealed within the wall. In switchgear halls wiring shall be surface mounted.
9	Wall finishes (external)	Rendered block work with painted finish above DPC level. Bituminous paint below DPC level. thermal paint to be applied on the RC structural elements of the external wall including beams, columns and parapets Concrete beams, columns, parapets etc. are to have a plain finish and be painted. The external wall finishes shall be appropriate for any pollution or other aggressive environment there may be in the area.
10	Wall finishes (internal)	Generally painted plaster to all internal wall surfaces. Ceramic tiles for toilet walls (up to ceiling).
11	Ceilings and Suspended Ceilings	Concrete ceilings shall be finished plain, with a painted finish. Aluminium framed suspended ceilings (metal ceiling) shall be used in all areas except switchgear halls , battery room and store.. Suspended ceiling systems shall comply with OETC requirements.

12	Floor finishes (internal cable trenches and basement)	Non-slip, chemical, acid, alkali resistant and anti-dust 5mm thick self-levelling epoxy screed finish on the base, with a minimum of 150 mm skirting skin.
13	Floor finishes, diesel generator room)	Concrete surface steel finish trowel paint
1413	Floor finishes (switchgear rooms	Hardened & sealed floor (epoxy screed) Epoxy screed (min 5mm thick) on cement/sand/aggregate painted with non-slip epoxy overall thickness 50 mm
15	Floor finishing (LVAC/DC rooms 0	Hardened & sealed floor (epoxy screed) Epoxy screed (min 5mm thick) on cement/sand/aggregate painted with non-slip epoxy overall thickness 50 mm
16	Floor finishes, store rooms	Hardened & sealed floor (epoxy screed) Epoxy screed (min 5mm thick) on cement/sand/aggregate painted with non-slip epoxy overall thickness 50 mm
	Floor finishes, fire pump room	Concrete surface steel finish trowel paint
14	Floor finishes (first floor control/relay room and telecommunication supervisory room)	These areas shall have raised access floors. -- Panel Thickness: 34.5mm + 2mm PVC -System weight: not less than 49Kg/m² -Core Material: Inert Calcium Sulphate -Fire Resistance: not less than 60 min -Conductivity: > 1X10⁶ ohms . Where reference is made in these documents to 'The Authority' this shall mean OETC/Engineer. The flooring system shall be fully adjustable to cater for tolerances in the level of the sub-floor. The contractor shall provide full design details. The legs of the flooring system shall be fixed to the floor with anchor bolts. The rooms shall have a 100 mm high timber skirting board. Socket outlet boxes shall be of a design that shall

		maintain the integrity, insulation and stability of the access flooring system during a fire. Any works that would be concealed by a raised access floor shall first be completed, tested, inspected and accepted by OETC/Engineer before any raised access floor work is started.
15	Floor finishes (toilets)	Non-slip ceramic floor tiles over a tanking membrane approved by OETC/Engineer.
16	Floor finishes (stairs)	Non-slip finish with reflected paint (as per HSE Requirements)
17	Windows	Aluminium with powder coated and coloured finish, complete with security grills. All windows double glazed with solar reflecting structural glazing to the approval of OETC/Engineer.
18	Doors (external)	All external doors of substation building, fire pump room and diesel generator room shall be steel doors (except toilet) of grade 43A with min 1.5 mm thickness and be thermally insulated, fire rated door, 120 min, As per R.O.P. requirements. All doors shall be designed as per integrated security system. All doors are to be fitted with door closers and other accessories. Steel roller shutter (thermo, double skinned) doors and personnel steel fire doors for switchgear building and basements shall be in grade 43A steel and they shall be thermally insulated.
19	Doors (internal)	Fire rated steel doors with min 1.5 mm thickness. All internal doors shall be appropriately fire rated for the location with vision panel (safety glass). Steel doors for guard room and thermal insulated type UPVC aluminium doors for toilets shall be used.(referring to clause 47.1)
20	Battery Room	Acid and alkaline resistant ceramic floor and wall tiles (full height) with a low surface permeability shall be used to resist the alkali electrolyte in the nickel cadmium batteries. The tiles shall be bedded on alkali resistant adhesive and be finished with an alkali resistant grout up to ceiling. Floor tiles shall be non-slip.
21	Battery Room (door)	All external doors of substation building, fire pump room and diesel generator room shall be steel doors (except toilet) of grade 43A with min 1.5 mm thickness

		and be thermally insulated, fire rated door, 120 min, As per R.O.P. requirements. All doors shall be designed as per integrated security system. All doors are to be fitted with door closers and other accessories. Steel roller shutter (thermo, double skinned) doors and personnel steel fire doors for switchgear building and basements shall be in grade 43A steel and they shall be thermally insulated.																				
22	Roof System	For concrete roofs an inverted roofing system shall be provided as detailed below.																				
23	Hand Rails (general internal and stairs)	50 mm diameter stainless steel tube type, grade 316.																				
24	External soft areas	Generally the soft areas of substation surfaces shall consist only of 75mm thickness of crushed rock to BS EN 13043 with the following requirements: <table><tr><td>Grading:</td><td>14/20</td></tr><tr><td>Grading Category:</td><td>GC 85/20</td></tr><tr><td>Fines Content:</td><td>F1</td></tr><tr><td>Flakiness Index:</td><td>F120</td></tr><tr><td>Resistance to Fragmentation:</td><td>LA30</td></tr><tr><td>Polish Stone Value:</td><td>PSVNR</td></tr><tr><td>Aggregate Abrasion Value:</td><td>AAVNR</td></tr><tr><td>Shape Index:</td><td>SINR</td></tr><tr><td>Water Absorption Category:</td><td>WA242</td></tr><tr><td>Magnesium Sulphate Soundness:</td><td>MS25 (with water abs' >2%)</td></tr></table> In transformer compounds, 40-70 mm sized washed stone 300 mm thick, acting as a flame trap. Other arrangements shall not be used unless proven by testing.	Grading:	14/20	Grading Category:	GC 85/20	Fines Content:	F1	Flakiness Index:	F120	Resistance to Fragmentation:	LA30	Polish Stone Value:	PSVNR	Aggregate Abrasion Value:	AAVNR	Shape Index:	SINR	Water Absorption Category:	WA242	Magnesium Sulphate Soundness:	MS25 (with water abs' >2%)
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Resistance to Fragmentation:	LA30																					
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Aggregate Abrasion Value:	AAVNR																					
Shape Index:	SINR																					
Water Absorption Category:	WA242																					
Magnesium Sulphate Soundness:	MS25 (with water abs' >2%)																					
25	Paint and Painting	Raw, refined and boiled linseed oils for paints and varnishes shall comply with the relevant provisions of BS EN ISO 150. Stopping for timber shall be a proprietary ready mixed emulsion polymer or oil based type, suitable for internal or external use as appropriate. Mineral solvents for paint shall be Type A complying with the relevant provisions of BS 245. Details of the proposed paint, and manufacturers of the painting materials shall be submitted to OETC/Engineer for approval.																				

		Painting of structural steelwork shall comply with the relevant provisions of BS EN ISO 12944: Parts 2, 4 and 5, and BS 5493. Other painting shall comply with the provisions of BS 6150, and workmanship shall comply with the provisions, recommendations and commentary of BS 8000: Part 12. Preparation of metallic components to receive paint shall comply with the provisions of Annex F of BS EN 1090: Part 2. Sample areas of each type of paint proposed shall be undertaken as a control for colour (gloss type), texture, TOX paint, method of application and workmanship, all for the approval of OETC/Engineer before use. The Contractor shall submit to OETC/Engineer for approval a full description of painting methods and procedures, including testing to show compliance with the specification. Surface preparation of areas that will become inaccessible shall be subject to approval by OETC/Engineer.
26	Rainwater Pipes, Gutters and Catchpits	Rainwater pipes, gutters, fixings and accessories shall comply with the relevant provisions of the following standards and manufacturers recommendations thereafter: Aluminium: BS EN 612 PVC-U: BS EN 607, BS EN 1462 and 12200:Part 1 Pressed Steel: BS EN 612 and 1462 Galvanised Steel: BS 3868 Polypropylene or polyethylene chambers or catchpits shall be bedded on 225 mm thick concrete whilst still wet, before being backfilled around the sides with a minimum of 150mm thick concrete surround.
27	Plumbing, Fittings and Appliances	Design, installation, cleansing and testing of all plumbing shall be in accordance with BS 8558 and BS EN 806 Parts 1 to 5. Plumbing proposals, testing and acceptance of test results shall be to OETC/Engineer approval.

		Fittings and appliances shall be to the appropriate BS or BS EN and all to the approval of OETC/Engineer.
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Special Fire Notes:

1. The fire rating of structures, walls, slabs, doors etc. shall comply with the findings of the Fire Safety Report.
2. Fire escape routes shall be clearly marked with signage in accordance with BS 5499-4 and to OETC/Engineer approval.
3. All requirements, installation and tests for fire doors shall be in accordance with relevant standards, this specification and ROP requirements.
4. All fire doors shall be ROP Certified.

56.2 Inverted Roofing System

The roof build up shall be as follows:

- A slope of 2 % towards rainwater drains shall be incorporated into a light weight concrete screed or cement screed on the roof slab structure.
- The roof slab is to be treated with 1No coat of oxidised bituminous paint of grade 115/15 prior to casting the light weight concrete. The light weight concrete shall be trowelled smooth and receive 2 No coats of waterproofing primer before applying the waterproof membrane.

The minimum properties of the materials used shall be as below:

- a) Light weight screed with a minimum thickness of 50 mm shall be trowelled smooth. Dry density of this light weight concrete shall range between 800 and 1200 kg/m³.
- b) Oxidised bituminous paint shall be grade 115/15 applied directly on the reinforced concrete slab at a rate of at least 2 kg/m². Melting point is to be not less than 115 °C.
- c) Water proofing membrane shall be one layer of at least 4 mm thickness of atactic polypropylene modified bitumen membrane with a minimum of 250 gms/m² of non-

woven polyester spun bond with continuous thread reinforcement and polyethylene film on both sides, The membrane shall have excellent mechanical properties, very high elongation and superb resistance to aging and shall be able to withstand high surface temperatures without affecting the shape stability. It shall be , torch applied and shall have the following further minimum characteristics:

Feature	Criteria	Relevant Standard
Softening Point (R & B) of coating mixture	> 150°C	ASTM D 36
Penetration (DOW) at 25 °C	18 ± 5dmm	ASTM D 5
Water Absorption	< 0.15 %	ASTM D 570
Shape stability at 120 °C	No deformation	UEAtc
Tensile Strength	1200 N/50mm Longitudinal 950 N/50mm Transverse	ASTM D 146, UEAtc CGSB-37-GP-56M
Elongation	55 % Longitudinal 60 % Transverse	ASTM D 146, UEAtc CGSB-37-GP-56M
Load Strain Product	66,000 Longitudinal 57,000 Transverse	CGSB-37-GP-56M
Lap Joint Strength	>1200 N/50mm Longitudinal >950N/50mm Transverse	UEAtc CGSB-37-GP-56M
Tear Resistance	220N (longitudinal) 250N (transverse)	UEAtc
Puncture Resistance	Static L 4 Dynamic I 4	UEAtc
Permeability of Membrane to Water	100 % impermeable	
Resistance to Hydrostatic Pressure	8 bar	DIN 52131
Resistance to Thermal Aging	No signs after test	UNI 8202
Resistance to Aging due to UV	No signs after test	ASTM G 53
Resistance to Thermal-Hydro Shock	No signs after test	ASTM G53

Adhesion strength of the membrane fully bonded to a concrete deck previously treated with derma primer	0.8kg/cm ²	UNI 8202
Dimensional Stability after 28 days at 70 °C	± 0.5 % Longitudinal ± 0.5 % Transverse	

- d) Insulation boards shall be of extruded closed cell polystyrene, at least 50 mm thick and of 32 kg/m³ density with a compressive strength of 250 kPa. The thermal conductivity shall be less than 0.030 W/m K at 24 °C mean temperature.
- e) Geotextile fabric separation layer shall be placed between insulation boards and protection tiles. The geotextile used shall be non-woven type, containing an UV-inhibitor and shall have the following properties:

Properties	Test Method	Limit
Unit Weight	Nominal	150 g/m ²
Thickness under 200 kN/m ²	Calculated Average	0.48 Mm
Elongation at Maximum Load		> 60 %

- f) Tiles shall be (30 x 30 x 3 or 50 x 50 x 5 cm pre-cast, compressed, high quality cement tiles with white cement in order to achieve a light and heat reflective colour. Tiles shall be cement mortar pit laid on the top of the geotextile fabric. Aluminium flashing of 1.5 mm thick and 15-20 cm height shall be provided and pointed with approved sealant and should cover the RC parapet for at least 300mm above tiles.

Water Test for the Completed Roof:

Upon completion of the water proofing membranes as well as on completion of all work proofing work, including the installation of tiles, the Contractor shall make provisions for and carry out water testing. The Contractor shall notify OETC/Engineer immediately upon the

completion of each roof and shall submit a preliminary time schedule of testing for review.

All testing shall be carried out by hose soaking only with drains left plugged and closed at all times. Tests shall be carried out only in the presence of OETC/Engineer or his designated representatives who shall determine starting dates of testing, total time periods of soaking and precautionary measures to be taken for the protection of other work.

The entire roof area including all penetrating items shall be soaked in the following general manner, with final instructions given by OETC/Engineer. Over uninterrupted surface, water shall be applied evenly in a deluging force creating sheeting or blanketing of water over the intersection of new roof construction. Cants including roofing above the high point, pitch-pockets, vents, etc., shall be deluged in the same manner whether on vertical surfaces or not, directing the water into clamping and hold-down devices, trim and flashing stops. Areas of leakage shall be properly marked, recorded, repaired, and tested again by the Contractor to the satisfaction of OETC/Engineer including additional repair to the same area as may be required for acceptance by OETC/Engineer.

Each testing time shall be directed by OETC/Engineer and shall not be less than 48 hours.

The Contractor shall submit a ten year warranty for the roof water proofing system, covering materials and workmanship from the date of handover.

Penetrations of the roof are not permitted.

Roofs shall be insulated to achieve an overall thermal transmittance value not exceeding 0.45 W/m²K

56.3 Required Clearances in Switchgear Rooms and Control Rooms:

It should be noted that clearances in the switchgear room and the final dimensions have to be specified as mentioned in the general requirements in section 1 and confirmed by the Contractor. The Contractor must consider switchgear configuration, type, required space for testing, general maintenance, replacement of components (including circuit breakers), dimensions of specific switchgear bays / components, arrangement of pressure relief openings, etc.

Drawings which clearly demonstrate access to the inspection points, testing arrangements,

maintenance, and replacement of main components shall be provided by the Contractor and they shall be the basis for the building designs.

56.4 Furniture and Fitting Out Requirements

Control Building :

- Provision shall be made for tables, chairs and white boards for ten persons.

Control room:

- Provision shall be made for, 2 No tables, 4 No chairs and 1 No white board for two persons.

Meeting room:

- Provision shall be made for tables, chairs and white boards for ten persons.

Document storage:

- 1 No steel table, 3 No swivel chairs and lockable filing cabinets (as required) to store one set of all the as-built drawings and O&M manuals, all to the approval of OETC/Engineer.

Safety Equipment Storage Room :

- Provide a suitably sized room with steel cabinets and benches for the storage of personal and spare PPE and other essential portable safety equipment for the maintenance of the substation.

For all substation buildings and for individual rooms, suitable nameplates, signs and labels shall be provided to ensure identification, safe operation of plant and warning of danger. The text, which shall be both in Arabic and English, shall be approved by OETC/Engineer. The substation sign board(s) shall be subject to the approval of OETC/Engineer. All the nameplates, signs and labels shall be non-deteriorating and non-warping under aggressive weather conditions and shall be guaranteed for a minimum period of 10 years. Plates will be securely attached using bolts and nuts or screws; adhesive will not be permitted.

56.5 Building Services

For requirements of the following elements, reference must be made to their respective Standard Technical Specification for Electrical Substation Works as titled:

- Lighting and Small Power
- LVAC Switchboard
- Earthing and Lightning Protection
- Fire Protection System
- Heating, Ventilation and Air Conditioning
- Telecommunications
- Integrated Security System

57 APPLICATION OF PVC AND RUBBER WATER STOPS

57.1 General

Whenever possible, complete water stop systems shall meet the specific requirements of the work and ensure easy and economical placement with minimum jointing on site.

Dumb-bell water stops will be suitable for joints where no differential movement is permitted, and movement is only by concrete contraction.

Centre-bulb water stops may be used where it is necessary to accommodate various degrees of planar and differential movement in joints.

The appropriate width of water stop shall depend upon the thickness of the concrete, the size of the aggregate and the position of the reinforcement. The following rules shall be applied to ensure a satisfactory selection:

- The overall width of the water stop shall not be greater than the thickness of the concrete into which it is cast
- The distance from the face of the concrete to the water stop shall not be less than the width of the water stop
- To obtain satisfactory compaction, the width of water stop shall not be less than six times the largest aggregate size

- The water stop shall not be positioned closer to any reinforcement member than a distance equal to twice the size of the largest aggregate, in order to avoid unsatisfactory compaction

The water stops shall be installed so that they are securely held in their correct position during the placing of the concrete, which shall be fully and correctly compacted around them so that no voids or porous areas are left. No holes shall be made through any water stop. Jointing by a means other than welding shall not be permitted.

The overriding requirement of proprietary items is that they shall be selected and installed strictly in accordance with the manufacturer's recommendations.

57.2 PVC Water Stops

The PVC water stops shall be fabricated from virgin polyvinyl chloride, containing no reclaimed or scrap material. The material shall be fabricated and cured in such a manner that it will be dense, homogeneous and free from porosity and other imperfections across the whole cross section.

The PVC material, when tested in accordance with the relevant standards, shall have the physical properties noted below.

57.3 Physical Properties of PVC Water Stops

- Material test shall be carried out at 25 °C
- Durability: Material to be unchanged by oil, water, and exposure to sunlight
- Permeability: Material shall be free of pores and cracks
- Tensile Strength (min) shall be 140 kP/cm²
- Elongation at break (min) shall be 285 %
- Shore Hardness: 42-52 Shore A

58 REINFORCEMENT

58.1 General

Unless otherwise specified, all reinforcement shall comply with BS 4449, 4461, 4482 and 4483 or DIN 488 or other relevant standards. Reinforcing bars shall be tested from time to time in

accordance with BS 4449 or as required by OETC/Engineer.

58.2 Delivery, Acceptance and Tests

The Contractor shall furnish a test certificate from the manufacturer for each consignment of steel reinforcement. The certificate shall show the compliance of tests and analyses for tensile strength, yield strength and elongation in accordance with BS 4449 and 4461 or other relevant and agreed standards. Additional chemical and physical tests may be performed if and as directed by OETC/Engineer, at the expense of the Contractor.

58.3 Closed Loop' Considerations

Air core reactors or similar plant capable of generating large magnetic fields can cause circulating electric currents to be induced in closed metallic loops. This may result in considerable, uncontrollable and damaging heating effects in such elements.

Foundations and other structures comprising components that form closed metallic loops shall not be sited adjacent to such equipment unless outside clearance distances advised by the equipment manufacturer.

Where the integrity or performance of such foundations or other structures necessitates the inclusion of metallic items within areas where they will be adversely influenced by magnetic fields, these items shall be configured such that closed loops are not formed during construction or the subsequent design life of the asset.

For steel reinforcement in concrete, single closed links or loops shall not be detailed and individual reinforcing bars shall be suitably electrically insulated from all other bars including those forming a part of temporary works systems. This may be achieved using a suitable fusion bonded epoxy-coated reinforcement system or through the provision of individual insulation at all bar crossing/touching points or any other agreed method and/or bar configuration.

Such insulating systems shall be sufficiently robust and durable to withstand all construction load effects without impairing their function. They shall provide the necessary level of electrical insulation with no adverse impact on the design life of the asset and without compromising the structural performance of the reinforcement. Bar coating systems shall be in accordance

with the specification particularly the requirement for application by an organisation having UK CARES accreditation or working in accordance with an equal approved quality assurance system.

59 INSTALLATION AND EMBEDMENT OF REINFORCEMENT

59.1 Installing the Reinforcement

Before use, any matter liable to impair the bond, e.g., dirt, grease, organic matter, dust and loose rust, shall be removed from the steel. Particular care shall be taken to ensure that the reinforcing bars are given the shape (including diameter of curvature), length and position conforming to the reinforcement drawings. If internal vibrators are used to compact the concrete, the reinforcement shall have been designed so that the vibrators can be inserted at all necessary points.

The compressive and the tensile reinforcement (main reinforcement) shall be secured to the transverse and distribution bars or stirrups by means of galvanised tying wire. The reinforcing bars shall be interconnected to form a rigid cage and shall be so secured in their specified position by means of spacers, which do not impair corrosion protection, that they are not displaced during the placing and compaction of the concrete.

In pre-cast components, the reinforcement shall, on account of the often very small bearing depths provided, be cut of its correct length with particular accuracy and be installed with great care, especially at bearings and points where hinged connections are formed.

59.2 Concrete Cover to Reinforcement

The bond between reinforcement and concrete shall be ensured by a sufficiently thick and dense covering of concrete over the steel. This cover shall be able to protect the steel permanently from corrosion.

The cover to any bar, including stirrups shall not in any direction be less than indicated in Table 2 below. In each case, the larger value shall be adopted, unless even larger amounts of cover are required by the particular structures.

Table 2 Minimum Concrete Cover to Reinforcement (mm)

Slabs, internal	30
Slabs, external (exposed)	50
Internal walls, columns and beams	40
External walls, columns and beams	50
Concrete subject to aggressive* conditions or for liquid retaining structures, foundations in touch with virgin or backfilled soil	75
Piles	75

* Concrete exposed to alternate wetting / drying, in contact with soil, or underground water, or exposed to abrasive action or subjected to corrosive fumes.

An increase in concrete cover may be necessary e.g. for fire protection. The cover shall, in addition, be increased in the case of very thick components or concrete surfaces with exposed aggregate finish or surfaces, which are to be sandblasted, tooled or exposed to heavy abrasive wear. For this purpose, the depth of action of the finishing treatment and the disruptive effect that it has on the texture of the concrete shall be taken into account.

60 CABLE BASEMENTS

Minimum clear floor to ceiling heights of cable basements shall be as follows:

- 2.8 m for 33 kV switchgear
- 3.5 m for 132 kV switchgear
- 4.0 m for 220 kV switchgear
- 5.0 m for 400 kV switchgear

Where basements are required they shall be continuous for each building (no multiple basements at each building).

Precautions must be taken to waterproof both the walls and the floor slab to ensure that no water can permeate into the basement structure.

Basements shall be divided with fire compartment barrier walls and interconnecting doors if

required. Provisions shall be made for access from the ground floor via stairs only and a means of emergency egress by stairs shall also be provided at an appropriate location(s).

Basement floors shall be laid with a nominal fall of 1:30 towards a drainage channel. Sump(s) of a suitable size shall be provided, serviced by the drainage channel along a long wall. Channel and sumps shall have galvanised steel grated covers.

Where cables enter/exit the basement or building via slots, ducts, trenches or other method, the slots/perforations shall be sealed with a detail which includes appropriately rated and durable fire and water sealing material.

Both ends of all built in ducts shall be bell-mouthed to prevent cable damage by scuffing. Ducts installed empty for future use shall be sealed with waterproof material and PVC end caps. End caps shall be provided only in the outer face.

All ducts passing through external concrete walls shall have puddle flanges or a swelling water bar fitted centrally in the walls, all subject to the approval of OETC/Engineer.

Basements shall be provided with two sumps, each with a pump for removal of water resulting from unforeseen circumstances.

61 CABLE DUCTS AND TROUGHS

Cable entries into buildings will be by ducts or cable troughs. Troughs and ducts shall be laid falling away from buildings to reduce the risk of water ingress. Ducts shall be provided at both ends of internal troughs in the switch room to facilitate routing of feeder cables away from the substation in more than one direction.

Power cables and control cables shall not be laid in the same trough. Separate troughs shall be provided for power and control cables and outgoing feeders shall not be bunched together at the exit point.

Bell mouth ends shall be provided for all built-in ducts and all ducts passing through external walls shall have puddle flanges fitted centrally in the walls.

Cable troughs shall be constructed above ground water table.

Trough covers shall be provided with hot dip galvanized proprietary lifting hooks cast in.

Rebates in trough walls shall be formed with galvanised steel angles, with tangs welded on for casting in.

Inside buildings, trough covers shall be a minimum 10 mm thick galvanized chequer plate set in rebated steel angle frames with tangs welded on for casting in.

Penetrations through concrete walls dedicated to cable entries and cable entries dedicated for future cables that are below ground level are to be sealed and secured using mechanical sealant against water ingress, flooding, humidity, rodents and dust. Cable entry openings shall be sealed by the installation of mechanical cable sealing system. Temporary/ad-hoc/chemical seals like foam, compound, heat shrink; bitumen, cement, grout etc. are strictly not acceptable. The system shall be capable of adapting to cables of different sizes, together with frames and all mounting/fixing accessories sourced from reputed manufacturers, subject to (OETC) approval. Direct contact between the cable and any metal components shall be avoided. Enough seal depth shall be provided to aid with cable retention. Thus, preventing loss of seal when movement occurs on the cable due to ground settlement post backfill, the weight of the cables and the flex during operation. The sealant shall be of IP68 protection rating. The sealant shall be fire rated and vermin resistant.

For other requirements of the civil works relating to underground cables, reference must be made to the OETC Civil Works for Underground Cables.

62 REACTORS INSTALLATION ARRANGEMENT

No metal reinforcement shall be used in the foundations of the phase reactors, fibre glass reinforcing mesh can be used in lieu of steel rebar and there will be no metal fence around the reactor.

If the foundation or floor is not yet constructed, applying short tubes of rubber hose at the rebar crossover points to isolate them (and also avoiding making electrical connection of the bars via the steel wires) will eliminate the closed loops.

When the foundation or floor already exists, the coil must be installed at MC2 height above the foundation or floor to minimize the magnetic field effects.

If sufficient height is not available to allow satisfying the MC2 clearance, Maintain at least MC2 distance to the support structure parts if they form closed loops

63 PATHWAYS

A pathway of minimum width 1.20 m shall be provided around all buildings within the substation, including Fire Pump Room, Diesel Generator Room. The pathway shall consist of interlocked concrete block paving of a type and construction detail approved by OETC/Engineer.

64 BOUNDARY WALLS AND GATES

Reference shall be made to sections of these specifications which specifies the requirements of the Integrated Security System for details of the security provisions to be included in the gridstation.

A pre-cast panelled wall and 1 No or 2 No (as per design requirement) sliding gate for vehicles with motorised control and adjacent 1No hinged single gate for pedestrians are to be provided to the approval of OETC/Engineer at the boundary of the substation. Other gates for emergency exit and within fenced enclosures inside the gridstation shall be as required and specified in the Integrated Security System of the Standard Specification for Substation Works.

The gates are to be to OETC standards as specified in the Integrated Security System section 24 of the Standard Specification for Substation Works.

The wall and gates shall have mounted on the top an electric pulse fence as specified in the Integrated Security System of the Standard Specification for Substation Works.

As well as being secure to OETC/Engineer standards, the wall shall be visually acceptable.

The minimum height of the wall above ground level shall be 3.0 m and the gates shall also be 3.0 m above from the highest finished road/path level. Cast Aluminium Gates shall be constructed in accordance with BS 1722 Part 12 to OETC/Engineer requirements. Gate foundations shall be designed to suit allowable bearing pressure on the sub-soil and take account of the worst combination of dead, live, wind and erection loads. Detailed shop drawings of the wall and the gates shall be submitted to OETC/Engineer for review and approval.

Subject to OETC/Engineer assessment of the local ground conditions, for additional security

to inhibit burrowing, the boundary wall foundations shall incorporate a concrete ground beam of minimum cross section 300 mm x 300 mm.

65 DRAINAGE

Drainage systems generally shall be designed in accordance with the applicable section of the BS EN 752-1, 2, 3 and 4.

Pipelines conveying storm water should be sized so that full flow velocity is not less than 0.8 m/second.

The gradient of 100 mm diameter pipes shall not be less than 1:60, and 1:100 for 150 mm diameter pipes. Gradients shall be sufficient to ensure self-cleaning velocities.

Manholes and catchpits must be provided at all inlets and connections and at all changes of direction.

Drainage pipes shall be laid in straight lines between the respective manholes or catchpits. Approved double sealed cast iron covers shall be provided at all drainage manholes.

66 STORM WATER DRAINAGE

The storm water drainage system shall be separated from the foul drainage system.

Storm water from the roofs of buildings and cable troughs shall be collected by roof gutters / piped trench drains and discharged to the drainage system or suitable sized holding tanks. Roads shall have flush kerbs to allow storm water to run off and disperse into the gravel site surfacing. Areas around building and unpaved areas shall be sloped away from paved areas, where practicable.

A drainage system of site drains covering the whole substation site should be provided if the water table is close to the surface and where site drainage is required to control the groundwater levels for the satisfactory operation of the site and installation of foundations.

The building shall be designed to collect rainwater and discharge it through rain water down pipes to soakaway system(s). Due care shall be taken in surface water drainage design to ensure that ground erosion and flooding cannot occur, particularly around building or equipment foundations. Careful attention shall be given in the design of the works to the effect

that the works may have on the surface water drainage patterns of the area.

Culverts shall be constructed if necessary, particularly when existing natural water channels are affected or blocked by the works (subject to OETC/Engineer and relevant Authority approval). Drainage shall be provided where necessary to prevent ponding and to carry surface water away from buildings, structures and other works, including roads.

Soakaways of adequate capacity and in consideration of the local ground conditions shall be provided for storm water drainage.

Where pumping is found to be required, the arrangement and details shall be to OETC/Engineer's satisfaction.

67 FOUL WATER DRAINAGE

In the absence of a mains foul sewer system local to the site, the foul drainage shall terminate at a suitably dimensioned holding tank having a minimum capacity to be proposed and justified by the Contractor for acceptance by OETC/Engineer. The tank shall be of a watertight construction.

Holding tank effluent shall discharge into a soakaway. Both holding tank and soakaway shall be appropriately located on the site.

Drains shall be laid with regular gradients such that full flow velocity exceeds 0.75 m/sec, and manholes shall be provided at each change in direction and connections. Drains shall be of adequate diameter and manhole covers shall be double sealed.

If in OETC/Engineer opinion it has been adequately demonstrated by the Contractor that it is not possible to provide a suitable soakaway at the particular site, then a suitably sized cess pit shall be provided instead of a holding tank and soakaway. The cess pit shall be alarmed appropriately to alert of the requirement to manually empty.

68 SUNSHADES

Foundations and support structures for sun shields shall be provided power transformers (aluminium sandwich panel) and car parking shades (UPVC fabric) by the Contractor. The contractor shall design and final approval shall be obtained from OETC/ Engineer.

69 FIRE AND BLAST WALL DESIGN REQUIREMENTS

Critical plant and facilities within close proximity (within a fire damage zone determined as part of the Fire Risk and Strategy Report) of power transformers shall be protected by fire barrier walls or housed within a fireproof building. In this way, fire protection shall be provided to other circuits and transformers, control equipment, and third party property appropriate to its proximity to the transformer under consideration.

Fire and blast barrier walls and building fireproof walls shall be designed in accordance with NFPA 850, have 4 hour fire resistance and be resistant to a blast pressure of 0.5 kN/m².

Fire barrier walls shall extend at least 500 mm above the highest oil-containing part of the transformers. However the height shall not be less than the appropriate NFPA recommendation.

Any fire fighting materials that are to be used in the fire fighting system shall be protected from the effects of fire in a dedicated room of the Protection and Control building. This room shall be provided with appropriate ventilation and air conditioning.

The fire pump room and the fire water tank shall be placed adjacent to the entrance of the substation.

Transformers and shunt reactors shall not be located opposite the fire pump room.

The fire pump room and fire water tank(s) must be placed adjacent to each other.

For substations of 132 kV and above, the fire water volume shall be shared equally between two adjacent tanks.

70 DEWATERING

70.1 General

This part of the specification applies to the methods and techniques of ground and surface water control.

Prior to the decision for the method and technique to be applied, a comprehensive knowledge of the soil and ground water conditions has to be obtained from the results of the soil

investigation report in conjunction with the site conditions.

The scope of Contractor's supply includes the installation of all equipment, plants, pipes, machinery etc. and its removal after completion including operating and maintaining the equipment. The procedure and technique of de-watering shall be in accordance with BS 8004: Code of Practice for Foundations.

Prior to the commencement of any de-watering the Contractor shall submit a detailed method statement for the de-watering system to be approved by OETC/Engineer.

The Contractor shall confirm that the design and construction procedure of the de-watering system guarantees the safety of pit sides and slopes against slide and erosion by seepage force.

Where necessary, cofferdams, sheet piles, pump sumps, equipment and channels, troughs, inlet gutters, pipes and other works required for water control and discharge shall be part of the scope of supply. The dewatering system shall be designed and installed in such a way that, if necessary, alterations and extensions can be made any time throughout the operating period. Reserve units shall be kept ready and operational for service in case of failure of any of the installed units.

The Contractor will make provision for the possibility of a temporary failure of the electric power service and shall install emergency power units with sufficient capacity to feed the necessary power to the dewatering system at the moment of failure.

The Contractor shall submit to OETC/Engineer the detailed method of the proposed pumping system for dewatering including the pump capacity and the stand-by reserve units. The Contractor shall adjust the system if required by OETC/Engineer.

The Contractor must ensure that any dewatering works will not cause any interference to his own work and any other work elsewhere on Site or at structures under construction, and any facilities, equipment or assets of third parties outside the substation boundary. Any damage occurring during the above mentioned period shall be made good by the Contractor at his own expense.

70.2 Records

The Contractor shall keep records of all data of importance occurring during operation of the water control system. The records shall be submitted to OETC/Engineer for information and review each day or as otherwise directed.

70.3 Start and Duration of Groundwater Control

The duration of ground water control will be determined according to the agreed construction time schedule and other factors as appropriate.

Pump operations shall not be stopped nor pipes, channels and equipment for water control removed or altered in any way, except with the express permission of OETC/Engineer. OETC/Engineer will consider and agree the time of removal. Until that time the pumps and water drainage facilities shall be kept in good working order.

70.4 Sump Pumps and Channels

Provision of sump pump and channels of the dimensions required for each particular case shall include all necessary excavation of any kind of soil above and below water, backfill and consolidation, sheeting, bracing, stiffening, sealing, and scaffolding accesses, as well as the disposal of water and all auxiliary works.

Routing of channels or pipes for discharge water shall be such as not to impede or obstruct any of the other works and/or operations. The same shall be applicable for sump pumps. Prior to the determination of any arrangement of sump pumps the OETC/Engineer's approval shall be obtained.

Contractor shall execute all dewatering works required for the execution of pipe laying, cable ducts, etc. including all necessary sheet piling works.

70.5 Difficulties Due to Water

The Contractor shall consider all difficulties and additional work due to the presence of water in the case of construction work. Where it is possible to keep off or divert water without special dewatering arrangements or where work can be carried out normally under or in water, such a method may only be applied after approval from OETC/Engineer has been obtained.

70.6 Ready for Service Condition

The Contractor shall maintain ready-for-service and regularly clean all dewatering equipment and accessories and shall keep all access clear so that they can safely be used without risk of accident. Any recommendations made by OETC/Engineer in this matter shall be carried out immediately.

70.7 Leakage

Waterproofing details and the sealing of joints and leaks by appropriate grouting or remedial works shall be the responsibility of the Contractor, details subject to the approval of OETC/Engineer.

71 MISCELLANEOUS

71.1 Treatment against Termites

The Contractor shall design into the facility effective measures to counter the threat of termite attack.

The Contractor shall submit an appropriate report to OETC/Engineer for approval. The report shall assess the risks and propose how the design and construction will address the risks. The proposed methods shall have a proven track record of preventing termite attack, and the Contractor shall provide OETC with a guarantee of 10 years. Any chemicals proposed must be certified non-hazardous to public health and shall have a certificate of approval issued by The Sultanate of Oman Public health Department.

Treatment shall be carried out by an approved specialist subcontractor.

The following shall only be taken as a design guide for the Contractor:

- Treat the ground/backfill before casting concrete against the ground (floor and walls)
- After construction below ground level, treat the inside of walls, around plumbing and inside wall cavities.
- Dig a trench around and adjacent to building and treat the three faces of the trench. Treat the backfill before returning it to the trench and compacting it.

- All entry points (perforations of the building fabric by services etc) should be thoroughly flooded with the liquid treatment.

If during subsequent construction works the chemical barrier is disturbed additional treatment to such areas shall be provided at no additional cost to OETC.

The Contractor shall obtain from the specialist subcontractor a guarantee that buildings shall be free from termite infestation for a period of 10 years. The form of the guarantee to be provided shall be subject to approval of OETC/Engineer.

71.2 Treatment against Weeds

The Contractor shall propose a method of weed propagation reduction and weed killer treatment. Details of any herbicide and pesticide proposed for use shall be submitted to OETC/Engineer for approval.

71.3 Screed

Cementitious screed shall comply with the relevant provisions of BS 8204 Part 1 or Part 3 as appropriate.

The compressive strength of screed shall be designed to be at least as strong as the structural concrete it is laid on.

An approved bonding agent shall be used between the screed and the structural concrete.

71.4 Safety Equipment

All necessary certified safety equipment and Personal Protective Equipment (PPE) other than normal usage PPE such as overalls, hard hats, safety shoes, safety goggles, hearing protectors etc, required for the operation and maintenance of the permanent works shall be provided by the Contractor. An appropriate number of each item shall be proposed by the Contractor for approval by OETC/Engineer. As a minimum this equipment shall include but not be limited to:

- Other PPE or equipment necessary for the inspection and maintenance of the substation, including access of teams into confined spaces and teams working at height.

The Contractor shall produce a schedule of civil works maintenance activities, the associated equipment (including gas monitors, harnesses, mobile winches etc) and the generic PPE necessary for the safe execution of those activities.

72 WARRANTEE/GUARANTEE

The Contractor shall furnish written warranty/guarantees for not less than 10 years against all defects in civil works, material and workmanship covering all works under this project from the date of substantial completion of the works.

The Contractor shall make reference to the warrantee requirements specified in the Tender Documents.

73 AS-BUILT RECORD DRAWINGS

The Contractor shall prepare a record survey of the Site at the commencement of the Works in conjunction with and in a manner approved by OETC/Engineer before any excavations or demolitions are commenced.

During the progress of the Works the Contractor shall prepare record drawings showing the locations, elevations, dimensions and other relevant details of all the permanent work executed under the contract. The Contractor shall include the details and location of all live or abandoned underground services, foundations and other significant features encountered and left in place during construction.

The record drawings shall be prepared as the work proceeds. On completion copies of the drawings shall be submitted to OETC/Engineer for approval. The Contractor shall comply with all requirements of BS 8888 with regard to the record drawings.

All costs incurred by the Contractor in providing the record drawings shall be deemed to be included in the Tender Price. The format of the record drawings shall agree with OETC/Engineer prior to final submission.

Two soft copies (in AutoCad and pdf formats) and two hard colour copies of all as-built record drawings shall be provided to OETC/Engineer by the Contractor.

74 HANDOVER DOCUMENTS

The following full, complete and approved final documentation relating to all aspects of the substation civil, structural and building works shall be handed over to OETC/Engineer within four (4) weeks of the substation commissioning having been completed:

- Drawings and calculations, complete with respective independent check certificates
- As-built record drawings
- Health and Safety Files, including Control of Substances Hazardous to Health (COSHH) data sheets.
- Operation and Maintenance Manuals, including Risk Assessments and Method Statements (RAMS) as appropriate
- Quality Assurance Records, including specific materials test certificates

It is required that since these Civil works are, by their nature, commissioned through QA checks as the work proceeds, that a hard and a soft copy of the documentation shall be collated, batched and submitted to OETC/Engineer for review as the work progresses and elements are completed. Notwithstanding this requirement complete drafts of this documentation shall be handed to OETC/Engineer for comment and acceptance not later than 12 weeks before completion of the substation commissioning.

Two soft (pdf) copies and two hard colour copies of all the above documentation shall be provided to OETC/Engineer by the Contractor on completion of the review and acceptance process.

Warranty Period activities including snagging shall be undertaken as required in accordance with the Standard Conditions and be coordinated with OETC/Engineer.