**EMPLOYER REQUIREMENTS AND TECHNICAL SPECIFICATIONS FOR CIVIL & STRUCTURAL WORKS**

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1. CIVIL AND STRUCTURAL WORKS
   * + 1. Civil and Structural Engineering Design
          1. General

The Contractor shall design and draw all Civil Engineering and Building Works for every structure and item of plant required for all substations of the Project.

* The design of all structures and buildings shall be such that differential and total settlements or other movements shall not exceed acceptable limits and provisions shall be made for expansion joints. The design shall be to the approval of the Employer/Employer’s Representative.
* Structural members subject to flexure shall be designed to have adequate stiffness in order to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant standards and/or limits prescribed by the equipment suppliers.
* Concerning the annexed drawings, these are to be considered as a minimum requirement in sizes and standards.
* The dimensions of buildings shall be such as to provide adequate space for the installation, proper operation, maintenance and repair of all plant and equipment.
* Throughout the floors above rooms containing electrical equipment shall be watertight. No drain pipes or water pipes are permitted to pass these rooms, with exception of the valve hall.
* All materials used in the works shall be of the best quality, obtained from sources and suppliers approved by Employer/Employer’s Representative and shall comply with the tests prescribed by the Standards.
* The works shall be carried out by skilled personnel.
* Suitable access to the roof of buildings by means of galvanized steel ladders shall be provided for maintenance and repair of any installation.
* All rooms with fire hazard shall be provided with suitable emergency exits.
* Proper access roads with footpaths shall be provided to bring and to take out the equipment. The roads shall be suitable to the vehicles which will be used to reach the unloading points of the equipment.
* If a culvert(s), and/or tunnel(s), trenches or any other underground services are crossing roads, these shall be designed as bridges for truck loading without affecting the underground structures.
* All civil designs and drawings, inclusive all steel designs and drawings must be approved by the Employer/Employer’s Representative before start of manufacturing/construction. Starting with production before the approvals will be fully on Contractor´s risk.
* Proper access roads with footpaths shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles which will be used (cars, forklifts, trucks/trailers, etc.) to reach up to the point of unloading of the equipment.
* Safe, convenient and straight forward accesses and means are to be provided to take equipment in and out of all rooms. The dimensions of rooms, doors, etc. shall be designed to suit the transport concept mentioned above.
* Before starting of design works, the Contractor shall submit to the Employer/Employer’s Representative for approval the proposed project design procedure containing the design data, standards and rules and the design criteria intended to be used for the civil works.
  + - * 1. Geographical and Meteorological Conditions

These conditions are specified in initial section of the Employers requirements –Scope and General Technical Requirements. Some data necessary for the design of buildings and structures are described more in detail hereafter in the Section Civil Engineering design.

* + - * 1. Codes, Standards and Regulations

Designs shall be prepared in accordance with the best and most recent engineering practice; with the requirements of this specification; with the latest edition of the appropriate Codes/Standards as referred to herein and with the relevant Kenyan Regulations.

The latest edition of each standard/code shall mean the available edition at the date of signature of the Contract.

* American Standards: ANSI, ASTM, ACI, AISC, UBC, AASSHTO, ASCE, etc.
* European Standards (EN)
* International Organization for Standardization (ISO)
* British Standards
* International Electrotechnical Commission Standards (IEC)
* Institute of Electrical and Electronics Engineers Standards (IEEE)
* Local and National Standards

The standards mentioned here above shall be submitted in the English language.

The British Standards/Euro codes and Codes of Practice specifically referred to in this Specification are listed below for convenient reference. The absence of any relevant standard/code from the list shall not relieve the Contractor of his obligation to comply with such standard as required by this Specification.

Table 1: Standards

|  |  |
| --- | --- |
| Number | Title |
| BS 4 | Structural steel sections. Specification for hot-rolled sections. |
| BS EN 197-1:2011 | Specification for Portland Cement |
| BS EN 13043 | Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas |
| BS EN 295 | Vitrified clay pipes and fittings and pipe joints for drains and sewers. Performance requirements. |
| BS EN 124 | Gully tops and manhole tops for vehicular and pedestrian areas. Design requirements, type testing, marking, quality control. |
| BS EN 771 | Specification for masonry units. Clay masonry units. |
| BS EN 197-1:2011 | Cement. Composition, specifications and conformity criteria for common cements |
| BS EN 295 | Vitrified clay pipes and fittings and pipe joints for drains and sewers |
| BS 405 | Specification for uncoated expanded metal carbon steel sheets for general purposes. |
| BS EN 13808:2005 | Bitumen road emulsions (anionic and cationic). Specification for bitumen road emulsions |
| BS 434-2 | Bitumen road emulsions. Code of practice for the use of cationic bitumen emulsions on roads and other paved areas |
| BS EN 1993-1-1:2005,  BS EN 1993-1-10:2005 | Specification for the use of Structural Steel in building. Metric units |
| BS EN 598:2007+A1:2009 | Ductile Iron Pipes, Fittings, Accessories and Their Joints for Sewerage Applications - Requirements and Test Methods |
| BS EN 752 (Parts 2-14) | Drain and Sewer Systems Outside Buildings |
| BS EN 932 (Parts 1-6) | Testing for General properties for aggregates. |
| BS EN 12620: 2002 + A1 :2008 | Aggregates for concrete |
| BS EN 934-2:2009 (Parts 1-6) | Concreting Admixtures |
| BS EN 13279 (Parts 1 and 2) | Gypsum binders and gypsum plasters. |
| BS 1196 | Specification for clay ware field drains pipes and junctions. |
| BS EN 13139 | Aggregates for mortars |
| BS EN 845 (Parts 1, 2 & 3) | Specification for ancillary components for masonry |
| BS EN 13101:2002 | Steps for underground man entry chambers. Requirements, marking, testing and evaluation of conformity. |
| BS 1377 | Methods of test for soils for civil engineering purposes. |
| BS EN 1401 – 2 & 3 | Plastics piping systems for non-pressure underground drainage and sewerage. Unplasticized polyvinylchloride (PVC-U). Specifications for pipes, fittings and the system |
| BS 1521 | Specification for waterproof building papers. |
| BS EN 1610 | Construction and testing of drains and sewers |
| BS 1722 | Fences. |
| BS EN 771-1 to 6 | Specification for masonry units. |
| BS 4190 | Specification for ISO metric black hexagon bolts, screws and nuts. |
| BS ISO 8992 | Fasteners. General requirements for bolts, screws, studs and nuts |
| BS EN 10080:2005 | Steel for the reinforcement of concrete. Weldable reinforcing steel. General |
| BS 4449:2005 + A2:2009 | Steel for the reinforcement of concrete. Weldable reinforcing steel. Bar, coil and decoiled product. Specification |
| BS 4460 | Specification for unplasticised polyvinyl chloride (PVC) pipes and plastic fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage. |
| BS 4483 | Specification for steel fabric for the reinforcement of concrete. |
| BS 4514 | Specification for unplasticised PVC soil and ventilation pipes, fittings and accessories. |
| BS EN998-1 & 2 | Specification for ready-mixed building mortars. |
| BS EN 10067 | Hot-rolled structural steel sections. Bulb Flat |
| BS EN 10056-1 | Hot-rolled structural steel sections. Equal and unequal angles |
| BS EN 10210-2 | Hot-rolled structural steel sections. Specification for hot rolled sections |
| BS 4987 Parts 1 and 2 | Specification for Coated macadam for roads and other paved areas. |
| BS EN 1995 | Structural use of timber. |
| BS 8500 | Concrete. Specification for the procedures to be used in producing and transporting concrete |
| BS 8500, BS EN 206-1 | Methods for specifying concrete, including ready-mixed concrete |
| BS 9999:2008 | Fire Precautions in the Design and Construction of Buildings |
| BS EN 1996 | Code of practice for use of masonry |
| BS 5911 | Precast concrete pipes, fittings and ancillary products. |
| BS 5930: 1999 | Code of practice for site investigations |
| BS 5950 | Structural use of steelwork in building. |
| BS 6031 | Code of practice for earthworks. |
| BS EN 12056-3:2000 | Code of practice for drainage of roofs and paved areas. |
| BS EN 1991-1-1:2002,  BS EN 1991-1-7:2006 | Loading for buildings. Code of practice for dead and imposed loads |
| BS EN 1991-1-4:2005 | Loading for buildings. Code of practice for wind loads. |
| BS EN 1991-1-3:2003 | Loading for buildings. Code of practice for imposed roof loads |
| BS EN 1339 | Precast concrete flags, kerbs, channels, edgings and quadrants. |
| BS EN 1997-1:2004 | Code of practice for foundations |
| BS EN 1992-3:2006 | Code of practice for design of concrete structures for retaining aqueous liquids |
| BS EN 14161:2011 | Code of practice for pipelines. Pipelines on land: general |
| BS EN 1992-1-1:2004 | Structural use of concrete. Code of practice for design and construction |
| BS EN 752-1:1996,  BS EN 752-2:1997,  BS EN 752-3:1997 | Code of practice for building drainage. |
| BS EN 10210-1 | Hot finished structural hollow sections of non-alloy and fine grain structural steels. |
| BS EN 12056 | Gravity drainage systems inside buildings |
| BS ISO 1461 | Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods |
| BS 8004 which replaces CP 2004 1972 | Code of practice for foundations |
| BS 5573 | Code of practice for safety precautions in the construction of large diameter boreholes for piling and other purposes |
| BS 5930 | Code of practice for site investigation |
| BS 6031 | Code of practice for earthworks |
| ASTM D1143 | Piles under static axial compressive load, testing |
| EN 50341 | Overhead electrical lines exceeding AC 45 kV |
| A.I.S.C. | Specification for the design, fabrication and erection of structural steel for buildings |
| A.I.S.I. | American Iron and Steel Institute |
| ASTM A36, A529 | Structural carbon steel |
| ASTM A441, A572 | High-strength low alloy steel |
| ASTM A242, A588 | Corrosion resistant high-strength low alloy steel |
| ASTM A307 | Common bolts and nuts |
| ASTM A325 | High-strength bolts and nuts |
| A.W.S. D1.1 | Structural welding code. Steel. |
| Eurocode 3 | Design of Steel Structures |
| Eurocode 4 | Design of Composite Steel and Concrete Structures |
| BS 4 | Structural steel sections |
| BS 5400 | Steel girder bridges |
| BS 5950 | Structural use of steelwork in building |
| BS 449 (Part 2) | The use of structural steel in building. Add. No.1. The use of cold formed steel sections in building |
| BS 6399 | Chapter V Loading |
| BS 3692 | ISO metric precision hexagon bolts, screws and nuts |
| BS 419O | ISO metric black hexagon bolts screws and nuts |
| BS 4395 | High strength friction grip bolts |
| BS 4604 | The use of high strength friction grip bolts in structural steelwork |
| BS 499 | Welding terms and symbols |
| BS 639 | Covered electrodes for the manual metal arc welding of mild steel and medium tensile steel |
| BS 709 | Methods of testing fusion welded joints and weld metal in steel |
| BS 4479 | Design of metal articles that are to be coated. |
| BS 4165 | Electric wires and fluxes for the submerged arc welding of mild steel and medium carbon steel. |
| BS 4570 | Fusion welding of steel castings |
| BS 4360 | Weldable structural steel |
| BS 5135 | Metal-arc welding of carbon and carbon manganese steels |
| BS 6323 | Steel tubes for mechanical, structural and general engineering purposes |
| BS 5135 | General requirements for metal-arc welding |
| KS | Kenya Roads Design Manual, Part III - Materials and Pavement |
| AASHTO | Pavement Design Guide 1993 |
| BS 13108 | Bituminous mixtures. Material specifications |
| BS EN 12591 | Bitumen and bituminous binders. Specifications for paving grade bitumen. |
| BS 3690-3 | Bitumen for Building and Civil Engineering |
| ASCE 10 | Design of Latticed Steel Transmission Structures |
| IEC 652 | Loading Tests on Overhead Line Towers |
| IEC 60826 | Design criteria of overhead transmission lines |
| IEC 60652 | Loading tests on overhead line structures |
| IEC 61773 | Overhead lines - Testing of foundations for structures |
| IEC TS 61774 | Overhead lines - Meteorological data for assessing climatic loads |
| IEC 61854 | Overhead lines - Requirements and tests for spacers |
| IEC 62567 | Overhead lines - Methods for testing self-damping characteristics of conductors |
| IEC 62568 | Overhead lines - Method for fatigue testing of conductors |
| IEC 61284 | Overhead lines - Requirements and tests for fittings |
| IEC 61395 | Overhead electrical conductors - Creep test procedures for stranded conductors |

* + - * 1. Design Loads

The following live loads shall be considered for the design of buildings and structures:

Table 2: Design Loads

|  |  |  |
| --- | --- | --- |
| **Area** | **Value** | **Unit** |
| Live load for building roofs, AC equipment to be considered additionally | 1.5 | kN/m2 |
| Sloping Roof-sheets metal construction | 0.75 | kN/m2 |
| Switchgear rooms | 10.0 | kN/m2 |
| Battery rooms | 15.0 | kN/m2 |
| Platforms, walkways | 5.0 | kN/m2 |
| Additional loads for suspended ceilings, pipes, AC, etc. | 1.0 | kN/m2 |
| Control rooms, social rooms, offices | 5.0 | kN/m2 |

Water retaining structures below ground (if any) shall be analysed considering earth outside with ground water up to the maximum assumed level, but no water inside.

Additionally, a surcharge load of 20 kN/ m2 shall be considered for structures located very near to roads, or else a surcharge load of 10 kN/m2 shall be considered.

**Dead load (DL)**

Dead load is defined as weight of all permanent construction including walls, foundations, floors, roofs, etc. and fixed service equipment. For Substations this would include equipment, internal piping, electrical lighting conduits, switchgear, instrumentation, fireproofing, insulations, ladders, platforms, etc. The weight of soils overburden shall be considered as dead loads.

**Live load (LL)**

Live load is defined as the weight superimposed by the use and occupancy of buildings or structures, but not permanently attached to it. Live load can be defined as the load produced by the personnel, movable equipment, tools and other items not permanently attached to the structures. Crane loads are live loads. The loads listed Table 2 shall be considered as minimum live loads. The Employer consent is required for reduction of the specified loads.

**Thermal loads**

Thermal loads shall be defined as forces caused by changes in temperature, especially the forces due to expansion and contraction of individual or entire structures.

**Impact loads**

Any live load that can produce a dynamic effect (i.e. cranes, hoists, etc.) shall be increased by an impact factor.

**Truck load**

Structures accessible to trucks shall be designed to withstand the weight and impact effects of trucks.

**Soil loads**

Soil loads shall consist of lateral active and passive pressures taken from the soil report. The weight of soils shall be considered as dead load.

**Hydrostatic and buoyancy loads**

Hydrostatic load is load due to water pressure. The buoyancy load is equal to the weight of the volume of displaced underground water.

**Wind loads (WL)**

The actual wind load and dominant directions for the calculation of buildings and structures shall be taken from the following standards:

* ASCE 7-2010 for Kenya, CP3 Guidelines, Kenya wind map used by structural Engineers

**Earthquake loads (EL)**

For design purposes an earthquake loading of 0.15g shall be assumed.

Load Combination

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

* + - * 1. Design Requirements
      1. General

The civil works are generally governed by the conditions of the electromechanical part of the specification and/or as stipulated hereafter.

The Tender price offered shall be understood as the total sum for complete civil works to suit the operation, and function of the electrical and mechanical equipment.

Design and choice of construction materials shall consider and ensure the reduction of future maintenance works, and therefore, all civil elements shall be designed to minimize maintenance and to result in a durable construction with a minimum design life of 40 years.

The Contractor shall prepare all necessary design and detailed drawings in accordance with requirements of the Project and according to the international practice for these works.

In doing so, adequate safety clearances, fire compartments, possibilities for extension shall be taken into account. The arrangement of roads shall consider also the requirements and planning if access roads.

* + - 1. Design Guidelines

The following fundamental design criteria shall be followed by the Contractor:

* Securing evidence of existing neighbouring structures to the substation sites
* Consideration of the results of soil investigations
* Consideration of valid and approved Standards and Regulations in the adopted design.
* Load factors and combinations according to the applied standards and the specification.
* Design methods and theories adopted.

The calculation of structural design and basic arrangement drawings shall include the principle framing and load calculations, architectural design, as well as the information concerning the expected maximum forces in the relevant elements of the structures.

Architectural detailed drawings containing the mechanical and electrical equipment, shall contain:

* Plans, elevations, sections, etc.
* Stair case details
* Roofing, water proofing details
* Doors and windows schedules
* Finishing schedules
* Structural detailed drawings, bar schedules

The following notes shall be applied on the detailed drawings:

* All dimensions have to be checked prior to commencement of works and any discrepancy to be reported to the Employer/Employers Representative and resolved.
* All detail drawings submitted for review shall be to scale and of a size not less than 1/25 full size. All-important dimensions shall be given and the material of which each part is to be constructed shall be indicated.
* All dimensions shall be in millimetres (mm) and levels in meter (m).
* All foundations and structural parts in the underground have to be coated with a coal/tar/epoxy coating, thickness min. 200 microns, reaching at least 30 cm above ground.
* Any construction including cable pits, trenches, etc. below ground level, shall be protected by an approved continuous water proof membrane(tanking)
* Blinding concrete min. grade C10/15, thickness min. 50 mm.
* Reinforcement: Should be high tensile deformed steel, all laps shall be 50X smaller diameter or as per standards.
* Concrete covers: As per specification.
* Concrete for structures: Grade C25/30. Cracks no more than 0.20 mm.
* All concrete mixes are subject to the approval of Employer/Employer’s representative.
* All exposed edges of concrete to be chamfered.
* All concrete blocks shall comply with relevant agreed standards, but compressive strength not less than:
  + Average of 10 blocks 7 N/mm2
  + Lowest individual blocks 5.6 N/mm2
* All the soil below all structural elements to be compacted in maximum layers of 200mm and to minimum of 95% dry density.

The Contractor shall prepare detail design drawings for all structural work and get approval from Employer/Employer’s Representative and Local Authority before commencement of any work.

The following detailed structural drawings are required. These shall be based on calculations for the analysis and the design of all members and the full structure:

* Load drawings, showing all dead, equipment and live loads, including line loads from walls
* Detailed structural calculations of all members and structures, respective type of foundations applied
* Reinforcement details, bar bending schedules, following ACI simplified methods for detailing, except where seismic/ductile connections are required. These have to be elaborated and presented in more detail.
* Concrete outline, EJ / CJ details, embedded parts, block outs & recesses, concrete protection details
* Structural steel details of all members / elements, their welds and other connections. Detailed lists of structural steel elements, welds, plates, bolts, and other connections.
* All coatings and corrosion protection details
* Detailed lists of steel structure members, plates, bolts
* Details of sheet metals and claddings for walls and roofs, etc.
* Details of walls, stairs and other members
* Formwork drawings
* Formwork calculations shall be submitted for information.
  + - * 1. General Layout

The General Layout of Suswa 220kV substation is shown in the Annexes:

The detailed configuration of the substations, with various components, arrangement of buildings and structures shall be prepared by the Contractor, subject to the approval of Employer. These have to suit the requirements of the supplied equipment under the consideration of the specific existing situation as well as of all tie-in points with outdoor installations. All access roads (including both external and internal roads) shall be included in the detailed design of the layout plans.

* + - * 1. Buildings

Buildings shall be designed as concrete or steel skeleton structures. Walls shall be made of solid masonry blocks. Except where other indication is given the roofs shall be designed as insulated flat concrete roofs.

Foundations shall be designed according to the findings of the soil investigations.

The dimensions of all the buildings shall be such as to provide adequate space for the safe installation and proper operation, maintenance and repair of all Plant equipment and in accordance to the relevant requirements for work stations.

The design of buildings shall provide adequate sanitary rooms and storage facilities.

Provisions for heating, cooling and ventilation shall be made for all buildings.

Primary access to main operating levels, main service levels and roofs of buildings supporting major equipment requiring frequent attention of operating personnel shall be by stairs and ramp to provide for wheelchair access.

Minimum free height in traffic and escape routes shall be not less than 2.2 m; minimum width 1.00 m.

Adequate number of emergency doors shall be provided according to the firefighting code requirements.

Minimum 2% roof slopes shall be provided for roof slabs.

A minimum slope of 1% on floor slabs and floor drains shall be provided in all rooms.

All basements/cellars and cable trenches to be executed with at least 1% slope towards drainage points or pump sumps, which shall be provided for each section or at least at both ends of the trench or basement.

Normally a recessed flush installation shall be provided for all wall cabinets and panels e.g. for indoor fire hose reels, breathing apparatus, fire extinguishers, CO2, alarm detection, etc.

External walls, roofs, metal claddings, etc. shall be provided with a minimum thermal insulation U=0.4W / (m² x K)

In order to avoid an uncontrolled fire, spread inside a building, which would result in a considerable or total loss of the building and equipment, and to provide safe escape routes for the personnel, the buildings shall be subdivided into various fire areas, also called fire zones, separated by approved fire resistant barriers and elements, such as fire walls, fire resistant ceilings, doors, dampers and fire partitions.

In principle, the following plants and rooms shall be designed as independent fire areas:

* Staircases
* Elevator shafts
* Transformer rooms
* Switchgear rooms
* Control, electronic and computer rooms
* Battery rooms
* Cable floors, shafts and tunnels
* Air conditioning rooms
* Storage rooms

The location and extend of the various fire areas, fire walls and fire rated doors shall be shown on relevant fire areas drawings.

Oil-insulated transformers located outdoors shall be separated from adjacent structures and from each other by fire walls or spatial separation as illustrated in NFPA 850.

Any other walls or ceilings, for which a fire resistance rate is not required or applicable, such walls and ceilings shall be made smoke tight.

Fire areas shall have adequately designed smoke outlets. Smoke exhaust shall be accomplished either by a combined air/smoke exhaust system or by a separated smoke exhaust system.

All the ventilation, air conditioning and smoke exhaust ductwork shall be fire rated wherever necessary.

All control and power cables penetrating openings in walls or ceilings of fire rated walls or boundaries shall be sealed with an approved sealing system, consisting of fire resistant constructions and materials, providing a fire resistance rate consistent with the rating of the fire barrier.

For all cable penetrations, a uniform and international recognized sealing system shall be provided consisting of board(s) of compacted mineral wool, plasticized filling material, fire retardant coating, etc., as required and laid down in the test certificate for the sealing system, issued from an independent approval institute.

All fire doors shall be designed in accordance with NFPA (National Fire Protection Association). The structures have to withstand at least the following fire ratings:

* Concrete structures 180 min.
* External walls 120 min.
* Internal walls 120 min.
* Fire rated doors 90 min.

The minimum size of single leaf doors shall be 1.00 x 2.10m, double leaf doors 2.00 x 2.50m. All external doors shall be steel type security doors.

Foundations and floor slabs shall have projecting galvanized earthing flags to enable connection to the earthing grid of the Station.

All substation metalwork including transformer tank, cable screens, feeder pillar, doors and any internal structural steel work shall be securely bonded together so that a firm metallic connection existing between each of them and the substation earthing terminal.

The application of windows and glass panels as well as the general architectural concept of the buildings are subject to the approval of the Employer. The observations and requirements of the Employer are no reason for additional claims by the Contractor.

Any part of basements or wall below ground level or reaching into groundwater, as well as foundations reaching into or being located less than 0.5m above ground water, shall be protected by means of an approved continuous water-proof membrane (tanking), taking into consideration possible water pressure at relevant depths. Cable pits, trenches, etc. must also be made completely water-proof by water proofing membrane (tanking).

Dimension of switchgear rooms, control rooms and any other shall be determined under full consideration of the equipment requirements.

Pipes, lighting installations, air conditioning ducts have to be located in a way that sufficient (shadow-free) lighting is provided after completion of all installations

* + - * 1. Design of Concrete Works

Reinforced concrete design shall be carried out in accordance with BS EN 1992-1-1: “Structural use of concrete. Code of practice for design and construction”; ACI 318, “Building Code Requirements for Reinforced Concrete” BS 8110.

* + - * 1. Design of Foundations

The design of foundations for all structures and equipment shall not exceed allowable limits. Where ground improvement methods or piling are considered, these shall be submitted to the Employer/Employer’s representative for approval. Where foundations are supported on piles they shall be adequately and properly tied to the pile heads.

If foundations on piles are considered, the Contractor shall include in his scope the provision of preliminary test piles to be placed and tested during design and before any construction, in order to obtain suitable working loads for the proposed piles.

For non-piled/shallow foundations, the Contractor shall provide evidence to support the value for bearing capacity used in the design.

Where ground improvement methods or piling are considered these shall be submitted to the Employer/Employer’s representative for approval.

Concrete where necessary shall be reinforced and shall be designed, detailed and constructed, using design mixes to BS 5328 (BS EN 206-1 AND BS 8500), in accordance with BS 8110 or other equivalent approved standard.

All steelwork below ground except reinforcement bars, whether part of the tower or part of the foundation shall be galvanized and be completely covered with encasing concrete not less than 75 mm thick from a point 300 mm above ground down to the main foundation block, or, for rock foundations, down to the rock. Where necessary, the encasing concrete shall be keyed to the steelwork or to the main foundation in an approved manner. Cover over the reinforcement bars shall not be less than 50 mm.

Where the Contractor wishes to use rock or ground anchor array foundations, he shall provide evidence of his previous successful use of anchors in rock and in ground (if such anchors are proposed) for overhead line foundations and of their satisfactory service life. He shall provide a Method Statement defining procedures to be used for design and installation of the anchors, including specific details about quality controls and the actual equipment which will be used for drilling and grouting. The Contractor will be expected to carry out sufficient testing of his proposals, in the presence of the Employer’s representative, to confirm that his methods for design and installation will produce anchor foundations that are fit for purpose, prior to approval by the Employer’s representative of the system.

Design and/or proof testing to IEC 61773 shall be carried out for all anchor foundations; a suitable proposal and work programme shall be submitted by the Contractor for the Employer’s representative’s approval together with the initial submission to use anchor foundations.

* + - * 1. Design of Masonry Walls

All walls shall be of sufficient strength and thickness and adequately secured to the structural frame to withstand self-weight, superimposed loads and wind pressures without cracking or distortion.

All walls shall be designed and constructed with expansion joints as to prevent cracking or distortion through thermal movements. The expansion joints are to be covered with approved flexible metal closer strips.

* + - * 1. Thermal Requirements

Designs shall meet all thermal requirements of the related Building Regulation and/or Standards with respect to walls, roof, floors, windows, slabs, beams, columns, etc.

* + - * 1. Fire Resistance

The Contractor shall make provision in the design of the building structure, walls and fire wall (if any) for minimum periods of fire resistance in accordance with the requirements of Kenyan Building Regulations and/or Standards. Fire rating shall be up to 4 hours.

* + - * 1. Fire wall Design Requirements

Equipment, structures and/or buildings within close proximity of power transformers shall be protected by fire walls and should not be located within the downwind of a transformer fire risk zone.

The fire wall height shall be a minimum of 500mm above the highest part of the transformers. The fire wall shall extend 500mm horizontally beyond any transformer component.

Fire walls and building fireproof walls will be designed for 4-hour fire resistance and a blast pressure of 50 kN/ m2.

The fire wall and its foundation must be designed for wind loadings, general installation and maintenance loadings. While determining the wind loads, shielding from adjacent transformers or structures must not be taken into consideration.

* + - * 1. Design Submission

The Contractor shall be responsible for the complete design of the works.

The Contractor shall submit all complete civil and structural design drawings, calculation reports, bill of quantities (list of quantities of civil works materials), specifications, construction method statements and documents required for civil work constructions. The Contractor shall produce individual sets of calculations and drawings for each section of the works. All sets shall be bound, titled, given unique numbers, indexed and signed by the designer.

Where required, the Contractor shall provide an explanation together with evidence to validate computer programs used for design calculations.

Calculations and drawings shall always be submitted with a full detailed transmittal sheet indicating identification number, revision suffix and date of issue.

All drawings shall be to scale and fully detailed. Dimensions shall be given in metric units. A scale bar shall be included on each drawing.

Drawings shall have an identification number unique to this Contract with a suffix to indicate revision status and with accompanying revision notes that shall detail the nature of each revision.

* + - 1. Execution of Civil and Structural Works
         1. Surveying and Setting Out
      2. General

The Contractor shall be responsible for the true and proper setting out of the work and for the correctness of the positions, levels, dimensions and alignment of all parts of the work and for the position of all necessary instruments, appliances and services in connection therewith.

If, at any time during the progress of the work, any error should appear or arise in any part of the work, the Contractor shall rectify all such errors at his own cost and to the satisfaction of the Employer/Employer’s Representative. The inspection of setting out and/or levelling by the Employer/Employer’s Representative shall not in any way relieve the Contractor from his responsibility for the correctness thereof.

The Contractor shall carefully protect and preserve the bench mark pegs, etc. used in setting out the work.

Prior to commencement of works, the Contractor shall undertake the check survey of the reference data and satisfy himself as to their accuracy. Should he have any objections to these data, he shall inform the Employer.

The Contractor shall perform all calculations, surveys and setting-out necessary to establish the accurate location of the structures and shall carry out all necessary surveys to verify the topographical data made available.

Prior to any setting-out works associated with all principal project features, the Contractor shall submit to the Employer/Employer’s Representative for approval, a description of the method and procedures he intends to use in establishing bench marks and base lines.

The Contractor shall carry out topographical surveys of the ground surface in each portion of the Works.

The Contractor shall entrust the surveying works only to persons who by their training and experience have sufficient qualifications and knowledge to ensure proper fulfilment of the survey tasks assigned to them. For the performance of the survey, the Contractor shall provide a sufficient number of reliable and accurate instruments.

* + - 1. Bench Marks and Triangulation Stations

Existing survey control points, bench marks and base lines shall be verified and new bench marks and base lines established as necessary to construct each portion of the Works.

Permanent survey control points shall be established prior to starting the work and such permanent points shall be preserved during and after construction.

A minimum of two (2) permanent bench marks shall be established for each major structure, and referenced to data established by survey control points. The location of such points with horizontal and vertical data shall be recorded on the construction record drawings by the Contractor.

From the primary survey control points, the construction surveys shall be performed as required to locate, layout and construct each portion of the Works.

Complete and adequate logs of all control and survey work shall be maintained as it progresses. Such logs shall be available for inspection by the Employer/Employer’s Representative's at all times.

The Contractor shall protect, preserve and keep accessible the bench marks and triangulation stations of the basic survey and those provided by himself.

Any damage or removal of bench marks and stations, including those belonging to other parties shall be prevented. This shall immediately be brought to the attention of the Employer/Employer’s Representative and shall be repaired at the cost of the Contractor.

Bench marks shall be of stainless steel or cast iron. In softer soil, the steel/iron bolt shall be embedded in a block of concrete of suitable size and shall be absolutely stable. Inscriptions shall be durable and clearly legible.

Subordinate points may be marked by steel pipes or pegs, subject to the approval of the Employer/Employer’s Representative. Every newly fixed point shall be checked, as far as possible through other elements other than those which served to establish the point.

* + - 1. Accuracy of Surveying

Horizontal distances shall be measured with optic or electronic distance measuring instruments. Chaining with metallic tape shall be restricted to measuring of short distances. Elevations shall be determined by differential horizontal levelling. Angles shall be measured by theodolite.

* + - * 1. Geotechnical Investigation
      1. General

The purpose of this section is to define the scope of work to be undertaken by the Contractor to determine factual geology and subsurface features of the allocated land plots.

The extent of the subsoil investigations shall be such as to permit the satisfactory determination of the geotechnical conditions and to allow reasonable foundation proposals.

* + - 1. Scope of works for geotechnical investigations

The purpose of the Site Investigation is to accurately capture, sample and in-situ test within the substation areas including site reconnaissance, site geology.

The Contractor shall comply with all local laws, rules and regulations applicable to the works. The investigation procedure shall be governed by standards and codes, in the latest edition

Anticipated work activities breakdown is summarized in, but not limited to, the following:

* Conduct site reconnaissance, in-situ geophysical and geotechnical exploration including open trial pits, boring, in-situ borehole and open pit testing, piezometer installation as per planned exploration program
* Collect disturbed and undisturbed soil samples and extract water samples from boreholes and open trial pits
* Select proper collected samples and perform geotechnical lab tests to classify soils and assess their geotechnical behaviour
* Compile in-situ data collection, in-situ test results, lab test results and desk studies accounts
* Produce a comprehensive factual report of resources, procedures, acquired data, site works and lab tests, desk study, data processing and conclusions
* Liaise with topographic survey for interchange of information to be superposed on topographic survey maps or to obtain topographic survey information useful in setting out Site Investigation works.
  + - 1. Field works

Boreholes

Exploratory boreholes shall be sunk at the locations approved by the Employer’s Representative. The boreholes shall be 10 cm in diameter.

The depth of boreholes shall not be less than 10 m unless rock is encountered, in which case the thickness shall be proved to be greater than 1.5 m. Where weak soils are encountered, boreholes shall be continued down to a loadbearing stratum with a minimum thickness of 3 m proved.

The boreholes shall be drilled by local trained drillers under the direct supervision of the Contractor, according to the established instructions and specifications. Casing shall be used where necessary to prevent the collapse of the borehole wall.

An appropriate boring method with continuous recovery of soil samples shall be used. Disturbed and undisturbed samples shall be collected for visual examination and laboratory testing.

The soil stratifications encountered in the boreholes shall be logged during drilling and the borehole logs shall include at least the following information:

* The soil stratification
* The number, depth and type of soil samples
* The corrected penetration resistance
* The groundwater levels
* The grain size distribution
* The index and Employer’s representative properties of representative samples collected from different strata
* The spt values
* The drilling method, coring, casing.

Standard penetration tests (SPT)

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

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

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

Sampling

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

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

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

Rock coring

When rock is encountered, it shall be cored into using a core barrel with a diamond bit and a reamer, which is to be fitted onto the lower end of the drilling rods. The core diameter shall be 89 mm. The rock sample shall be examined, classified and kept in clearly labelled core boxes for further examination, to determine, for example, the core recovery and rock quality designation (RQD) and fracture index. The rock strength shall be classified by means of unconfined compression tests. The coring results shall be entered in the borehole logs.

Groundwater level measurement

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

Cone penetration tests (CPT)

CPT shall also be carried out as a second method of soil investigation (after borehole sinking) at the locations approved by the Employer’s Representative.

CPT shall be carried out using static penetrometers (Dutch core apparatus) for determination of the soil type, density and consistency.

CPT shall measure both, skin fiction and tip resistance. Doing so, a continuous profile of the ratio of frictional and cone resistance shall be plotted,

The results of the CPT shall be presented in CPT.

Test (trial) pits (TP)

Test or trial pits down to 1.5 m shall be used as a third method of soil investigation in order to visually identify the top strata and its sequence as well as to proof suitability of dredgers. The Contractor shall obtain at least one disturbed and one undisturbed sample of each stratum encountered. The samples shall be sent for laboratory tests as described in Clause “Sampling” here above.

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

General soil characteristics

A general soil/subsoil description shall be made for all investigation sites, comprising:

* Soil conditions at the surface
* Expected soil conditions below the surface (slopes, etc.)
* Inclination of the ground surface, inclination and orientation of cracks and fissures as well as their stratification, evaluation of slope stability, in case there is a potential for sliding.

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

The contractor shall be required to submit a detailed methodology of geotechnical investigation for approval by the project manager.

If soil reports from the first phases of works exist and are available for the Contractor, no more new investigations have to be performed by the Contractor.

* + - 1. Laboratory tests

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

Natural moisture content

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

Atterberg limit tests

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

Grain size distribution tests

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

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

Unconfined compression tests

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

Consolidation tests

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

Chemical analyses

The groundwater and the soil shall be analysed and classified with regard to their aggressive action on concrete. The classification shall comply with DIN 4030 or recognized standards.

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

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

Electrical resistivity tests

Shall be made for 4 samples.

* + - 1. Results of geotechnical investigations

The report shall be complete and shall contain, but not be limited to, the information specified below.

Description of the scope of work carried out containing:

* Work program
* Methods and systems (equipment) used
* Works carried out (field investigations and laboratory tests)

Layout location plan of soil investigations, showing:

* The area
* The general layout plans
* Locations of boreholes, soundings, trial pits and plate tests (if any) carried out
* Comprehensive map surrounds

Logs, tables

* The subsurface conditions, for example the sequence of the strata, the nature and properties of the individual strata as well as the groundwater conditions shall be determined and described in the borehole logs. The results of the laboratory tests and the diagrams of the test results shall be included in the report.
* Borehole logs, trial pit logs and surroundings logs shall include:
* Actual ground level and reference to the local Datum
* Description and limits of various soil layers
* Samples taken
* SPT results
* Water levels
* Depth of borehole/pit/sounding

Soil profiles (cross-sections)

* The results of the subsoil investigations shall (in addition to the borehole logs) also be shown in the form of cross-sectional drawings with a vertical scale of 1:100 showing, e.g.:
* Actual ground level and plant datum at the points of investigations
* Results of boreholes including standard penetration test (spt) graphs
* Trial pit profiles
* Cpt diagrams
* Proposed foundation levels
* Limit lines of soil layers (soil strata)
* Groundwater level
* Legend (key)

Soil classification

The soils shall be classified according to British Standard BS 3882, USCS or to the German DIN 18196 standards.

Groundwater classification

After the chemical analysis, the groundwater shall be classified according to its aggressive action on concrete. The classification shall comply with ASTM standards or equivalent codes.

Foundation Proposal

Admissible bearing pressures of different types of foundations shall be advised. Type and engineering values of proposed pile foundations - if necessary - shall be given. Explanation of recommended soil improvement methods shall be made. Geotechnical restrictions of earth works (cut and fill, slopes, etc.) shall be advised.

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

* + - 1. Reporting

A comprehensive investigation report shall be produced in two stages. Within six weeks of completion of the soil investigation field work, the Contractor shall submit the draft final report to the Employer/Employer’s Representative for comments and approval. The draft report shall be complete and shall contain, but not be limited to, the information specified above. A final revision shall be issued after incorporation of comments and requirements.

The report shall clearly have distinct sections listing all referenced literature, technical papers and international practice codes and standards.

The Geotechnical Report shall have two distinct parts:

1. A comprehensive geological and geophysical report with proceedings, findings and recommendations for site development, concerns and suggested resolutions
2. A comprehensive factual geotechnical investigation report with proceedings, site and lab works, findings and recommendations and test results presentation

All report deliverables, documentation, maps and drawings shall be compatible with Microsoft Office 2016 suite. Data to be interchanged with topographic surveyor shall be in electronic format for further electronic processing.

* + - * 1. Earthworks
      1. General

This section applies to all earth and rockwork required for the construction of buildings, structures, foundations and burying service lines in the ground. It includes all the necessary work of the excavating, importing, placing, disposal and compaction of earth, as required by the drawings and specifications for the proper execution of the works.

The Contractor shall satisfy himself as to the ground conditions on the site including the nature of the strata to be excavated, obstructions, possibilities of flooding and shall allow for all provisions necessary to carry out the work in the most suitable manner when submitting his Bid.

Generally, all buildings and structures must be founded on bearing strata which means that all excavation work for foundations shall meet the requirements of structural analysis based on the results obtained from the soil investigation and /or of the available information and instruction given by the Employer / Employer’s Representative. Furthermore, this division applies to excavation works in connection with pavement, roadwork and landscaping.

Excavation shall be done to the required dimensions and shall be finished according to the specified lines and slopes, in a way acceptable to the Employer / Employer’s Representative.

* + - 1. Water removal

The lump sum prices shall include the costs of control and removal of water during and/or after excavation. The Contractor shall provide all facilities and take whatever action is necessary to keep the excavation clear of water at all times of the execution.

* + - 1. Fill materials

The fill materials used are to be examined by the Contractor and approved by the Employer / Employer’s Representative.

The fill material shall be placed in horizontal layers of no more than 15 cm in 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 watering of soils. The foregoing shall be confirmed by tests.

The fill material shall be compacted by vibratory roller (min. weight 20t). The minimum required degree of compaction shall be as defined under item "Tests and Properties" here in below.

Select fill

Select fill shall have the following properties:

* Well-graded, non-cohesive and nearly silt free, salt free, soils free of organic matter.
* The material shall be of such nature and character that it can be compacted to the specified densities. It shall be free of plastic clays, of all materials subject to decay, decomposition or dissolution or other materials which will corrode piping or other metal.

The intention is to use select fill below structures, roads, parking areas etc.

Ordinary fill

Ordinary fill shall have the following properties:

Natural inorganic soils: salt content not greater than 5%, organic matter less than 3%.

The intention is to use ordinary fill for non-built areas.

Special fill

Special fill material shall be gravel or crushed rock.

The intention is to use special fill e.g. as sub-base material for open-air switchgear areas and roads, excavations near buildings and structures, etc.

* + - 1. Execution of excavations

The works shall be excavated either by hand or by use of mechanical excavating equipment.

Excavation by hand may be required close to existing installations and/or underground services, but subject to special instruction of the Employer / Employer’s Representative.

The Contractor shall carry out earth- and rockwork for the following works as defined hereafter:

* Site Clearance
* Excavation of top soil
* Open cut excavation
* Backfilling
* Safety precaution during earthwork
* Underground excavation (if required)
* Grading
* Replacement of material
* Trench excavation for service lines
* Embankments
  + - 1. Safety precaution

The Contractor shall be responsible for all necessary safety measures.

Proper strutting, sheeting and bracing, including re-arrangement of the installations when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides, etc. shall be considered by the Contractor.

* + - 1. Over excavation

If somewhere, and for any reason, excavation is executed beyond the established lines and without the Employer / Employer’s Representative 's previous approval, the Contractor shall at his own expenses backfill with approved material (including required compaction) or with lean concrete to Employer / Employer’s Representative’s approval, the volume corresponding to over-excavation. He shall not receive payment for over-excavation not ordered.

* + - 1. Stockpiles and disposal

Excavated material from the Works selected by the Employer / Employer’s Representative for re-use shall be placed immediately in its final position, if possible, or otherwise may be stockpiled or deposited on Site as directed by the Employer / Employer’s Representative.

The Contractor shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Employer/Employer’s Representative.

* + - 1. Preparation of foundations

All surfaces on which or against which concrete is to be poured shall be carefully cleaned and roughened to the Employer / Employer’s Representative's satisfaction.

The rock surface shall be free of oil, stagnant or running water, mud, loose rock, residue and impurities or any other improper material. Immediately before concrete placing, all rock surfaces shall be thoroughly cleaned.

All earth surfaces against which concrete is to be poured, shall be clean and free of any detrimental impurities, organic matter or unsuitable material. Immediately after excavation, all such surfaces shall be moistened and treated as directed by the Employer / Employer’s Representative and then protected by means of a lean concrete layer, 5 cm in thickness.

The effective bearing capacity of the soils have to be confirmed before pouring of concrete by a qualified soil specialist.

* + - 1. Backfilling

Foundations and structures shall be back-filled as with approved material compacted in layers by suitable equipment until optimum stability has been obtained to the satisfaction of the Employer / Employer’s Representative. Compacting shall be carried out with special care by means of pneumatic or mechanical rollers or other compactors of a type previously approved by the Employer / Employer’s Representative.

Density requirements shall be as follows by tests per modified AASHTO (American Association of State Highway and Transportation Officials) T-180 Method D, at optimum moisture content

* Under buildings and structure foundations and slabs - 97%
* Under roadways and parking areas - 95%
* Under transformers and other major foundations - 97%
* Embankment - 95%

The thickness of fill layers, number of passes and type of equipment to be used shall be proposed to the Employer / Employer’s Representative after compaction tests have been made.

Surfaces receiving fill layers shall, if smooth, be previously scarified to obtain a good key between the new fill layer and the subgrade.

* + - 1. Soil replacement

The material to be used for replacement of soil shall not contain soluble or swelling components such as clays, or organic matters. Sand gravel mixtures of favourable grain size distribution shall be used in exchange.

The replacement material shall be placed in horizontal layers of no more than 15 cm in 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 watering of soils. The foregoing shall be confirmed by tests.

The replacement material shall be compacted by vibratory roller (min. weight 20t). The minimum required degree of compaction shall be as defined under item "Tests and Properties" here in below.

* + - 1. Protection of existing utilities and services

During construction the Contractor shall provide all protection for existing utilities and services as may be required by his construction operations. Permanent protection of certain items shall be as included under other sections or as instructed by the Employer / Employer’s Representative.

Test and properties

The Control of working and tests operations shall be carried out by the Contractor in the presence of the Employer / Employer’s Representative.

The Contractor shall prepare sheets for statistical analysis of the field and laboratory tests, and shall submit the sheets to the Employer / Employer’s Representative for approval. Controlling will consist of field and laboratory tests, such as compaction and density tests, grain-size distribution, and shear tests.

If not otherwise specified under relevant items, the following min. tests have to be carried out.

* One (1) test analysing the ingredients of the water used for performance of the work
* Three (3) tests for specific gravity of soil
* One (1) test for bearing capacity of soil for loads
* Three (3) tests for grain size analysis of soils, if "Replacement of Material" is required
* Three (3) tests for density of soil in place of sand cone method for each second layer of "Backfilling and/or replacement of material and/or roadwork"
* Proctor tests as asked by the standards

Tests shall be performed for each 500m3 of fill but not less than once per shift.

* + - 1. Compaction equipment

The Contractor may use any compaction equipment or device which he finds convenient or economic. The thickness of the fill layers to be compacted depends on the chosen compaction equipment, but the compacted thickness of one layer shall not be more than 15 cm.

* + - 1. Site Finishing

Weed killer

Weed-killer of an approved type suitable for local conditions shall be spread over areas to be covered by site surfacing before such surfacing is laid. The weed-killer shall be of type which does not cause corrosion of metals and shall be used strictly in accordance with the manufacturer's instructions.

Switchyard surfacing

Site surfacing shall consist of 200 mm clean, hard, natural, gravel or crushed stone graded from 10 to 30 mm. It shall be spread after installation of service and cable earth strips, electrical equipment, etc.

* + - * 1. Slope protection

Work under this section includes all labour, materials, equipment and services required to protect the slopes either excavated or those of fill and backfill material. The Contractor shall place the various items specified herein as protection to slopes to the lines and thicknesses and in the locations shown on the construction drawings. or as directed by the Employer.

* + - 1. Stone paving

Fragments of rock for "Dry Stone Paving" and "Stone Paving in Mortar" shall be selected from required excavation or quarries. They shall be chosen such that they have a reasonably flat upper surface when laid, Stones for dry rock paving shall not have a round or spherical form and shall be of regular shape. Stones for rock paving in mortar shall be not less than 20 cm thick and not less than 30 cm2 in area.

Bedding material for dry rock paving shall consist of a mixture of sand and gravel well graded. Mortar for rock paving in mortar shall comprise 3 parts of clean fine aggregate to one part of cement by volume. Fine aggregate and cement shall comply with the requirements specified in the section "Concrete Works",

**a) Dry Rock Paving**

The Contractor shall place dry stone paving on a bedding of sand and gravel of minimum thickness of 15 cm. The nominal thickness of this paving shall be 40 cm. of which 15 cm for bedding and 25 cm for stones

**b) Rock Paving in Mortar**

The Contractor shall place selected pieces of rock on a mortar bed and fill the joints with mortar. Prior to placing, the rock shall be cleaned of all adherent soil. dust and earthy or organic impurities and wetted sufficiently to saturate it but leaving the surface in a damp condition,

Rocks shall be placed on a mortar bed of minimum thickness of 5 cm and carefully arranged in such a way that the minimum of voids remain between rocks, no continuous horizontal or vertical joints exist and the largest rocks are evenly distributed

After rock placing, the joints shall be completely filled with mortar.

Finished surfaces shall be adequately protected against rainfall until the mortar has set. Joints and weep holes shall be provided.

The nominal thickness of this paving shall be 30 cm, of which 5 cm for mortar bedding and 25 cm for stones.

* + - 1. Gabions

Gabions are rock-filled wire cages which are strong. heavy, flexible and permeable. Gabions shall have a volume varying between 1 and 4 m' depending on the local requirement. They shall be rectangular in shape made of double twisted galvanized mild steel while formed into a hexagonally shaped mesh. Placed together and filled with stones. The mesh area shall be between 50 and 80 cm'. Corners shall be reinforced with larger diameter galvanized wire.

Gabions shall be either prefabricated or assembled at the required place of installation, and then filled with cobbles or rock fragments.

Wire netting for gabion construction shall comply with ASTM Specification A 116, and wires shall have the following minimum diameters:

Net and tension rods 3 mm

Wires for Corner reinforcement 5 mm

Seam wires 2 mm

Zinc coating shall meet or exceed the requirements of ASTM A 641-71A.

Fill material shall comprise cobbles or rock fragments that are dense, sound and resistant to abrasion, Cobbles and rocks shall be free of cracks, seams and other defects that would increase their susceptibility to destruction by erosive action Individual cobbles or rock fragments shall be rounded and graded in size between 120 and 200 mm. Flat rock fragments Shall not be used.

Gabions shall be used for heavy retaining structures. They shall be; assembled. laced together with wire of the same quality as the cage and filled as herein.

Foundation surfaces upon which gabions are to be placed shall be smooth and even, with excessive high spots removed and voids filled with small rock fragments. Gabions to be placed at the toe of slopes shall be laid in a trench at least 25 cm deep.

Gabions shall be secured in position by tying to adjacent gabions and where laid on slopes, shall be fixed to the slope surface by 2 m long hardwood stakes driven through the gabions into the ground at 2 m interval. Internal galvanized wire tension rods shall be provided to reduce distortion of the cages.

They shall be securely tied together continuously at their corners over their full height, and filled by hand with cobbles and rock fragments as specified. Once full, the cage lid shall be placed in position and securely tied around its whole perimeter.

Further gabions to be added. either above or adjacent to those already placed, shall be securely and continuously tied to existing gab Ions along all edges of contact before filling.

* + - 1. Masonry walls

The stone for wet masonry walls shall be natural or crushed stone having sufficient strength and durability required for Its use. not less than 20 cm thick. The rock shall be of suitable colour and appearance. The rocks in the exposed face shall be approximately flat.

Mortar for wet masonry walls shall comprise 3 parts of clean fine aggregate to one part of cement by volume. Fine aggregate and cement shall comply with the requirements specified in the section "Concrete Works".

Stones shall be moistened and hand-placed with uncoursed close Joints onto a bedding of 20 cm thick drainage and 15 cm thick filter layers. Spaces between stones shall be filled with mortar. Surface joints shall be finished struck.

Weep holes of 50 mm diameter PVC pipe shall be installed through the wall. The upper surface of the walls shall be finished smooth with trowelled layer of 10 cm capping concrete

* + - 1. Riprap

Material required for riprap shall be obtained and selected from the quarry approved by the Employer.

Rock for riprap shall be sound. dense. resistant to abrasion and weathering and free from cracks. seams and holes. Rock fragments in riprap shall be nearly rectangular in shape and not slab like. Riprap shall be dumped in place or placed by backhoe or drag line. It need not to be compacted. but shall be roughly graded to the specified thickness in such a way as to ensure that larger rock fragments are uniformly distributed. with the smaller rocks filling the remaining spaces. Pockets of small stones shall be removed and replaced with larger material such that the required grading is achieved. Placing operations shall be such that the riprap layer Is well- keyed, uniform and dense.

* + - 1. Landscaping

The Contractor shall furnish all plants. labour. materials, tools and equipment necessary for the performance of all landscaping as directed by Employer.

The Contractor shall prepare the ground for loading transporting, placing. spreading and rolling the selected topsoil material, Watering the areas, furnishing and planting approved seed, furnishing. And spreading mulch, furnishing and spreading approved fertilizer.

The topsoil shall be placed and seeding performed as protection of excavated surfaces.

* + - * 1. Drainage
      1. General

The surface water and foul drainage systems shall be separate and shall be designed in accordance with BS EN 752 Parts 1 to 4 "Drain and sewer systems outside buildings". Manhole and chamber covers shall be heavy duty throughout. The Contractor shall be responsible for determining the adequacy of the drainage systems. He shall prepare calculations for submittal to the local authorities and to the Employer/Employer’s Representative that take into consideration the estimated sewer flows.

All drainage ditches shall be lined, either with concrete or stone pitched walling. The entire open drainage system shall also be fitted with open steel gratings that shall be recessed into the top edge of the concrete walling. The gratings shall be of flat bar on edge, galvanized after manufacture, with openings sufficient to allow the passage of surface water but not stones or rubbish, and shall be capable of taking superimposed loads from foot traffic (but not vehicular traffic). The gratings shall be arranged to present a neat appearance with all sections to a standard size, and edges properly finished. The gratings shall be arranged in short sections for ease of removal and refitting.

Where the drainage system passes under roads it shall be in shall be in reinforced pipework or pipes laid within concrete ductwork.

The gradients to which all sizes of drains and sewers shall be laid, shall be completely sufficient to ensure self-cleaning velocities in the pipes.

Minimum self-cleaning velocity shall be taken to be:

* In pipes up to 225mm diameter 0.75m/sec to 0.9m/sec
* In pipes between 225mm and 600mm diameter 0.75m/sec
* Maximum self-cleaning velocity shall be taken to be:
* 1.8m/sec under reasonable circumstances and
* 3.0m/sec absolute maximum
  + - 1. Manholes and Inspection Chambers

Manholes and Inspection Chambers shall be constructed in accordance with BS EN 1917:2002. They shall be built in masonry or concrete with galvanized step irons and cast iron covers and frames. Heavy duty cover and frames shall be used for trafficked areas.

* + - 1. Drainage during Construction

The Contractor shall maintain all existing drains and drainage channels in good order during the period of the works, and also cut any additional temporary channels which may be necessary to prevent flooding of the Site until the permanent drains have been laid. Particular attention shall be directed to dealing with ground and surface water before, during and after construction as these may present problems during the rainy season.

* + - 1. Waste water drainage

All waste drainage shall be taken to a septic tank. A septic tank is a type of settlement tank intended to provide quiescent conditions for settlement of sludge and the development of anaerobic conditions for the decomposition of organic matter. Raw sewage is fed to the tank, and settled sewage is discharged to the soak away by means of an overflow pipe. The capacity of the septic tank shall be sufficient to cater for the load arising from the sub-station.

A soak away pit of adequate capacity shall be constructed as part of the sub-station development. It is essential that the soakaway walls shall be built with solid concrete blocks in mortar which contains lime putty to which an approved waterproofing agent has been added. All joints in blockwork shall be well filled with mortar. The liquid effluent from the septic tank shall be drained to the soakaway pit. The soakaway pit shall be covered by a reinforced concrete slab with access through a manhole cover. The dimensions of the soakaway pit shall be determined by the percolation characteristics of the local soil as determined by a standards test and the result expressed as minutes/mm reduction in surface level.

* + - 1. Stormwater Drainage

The capacity of the surface water drainage system shall be designed in accordance with an international standard using a storm return period of 1 in 5 years. The surface water drainage shall include all necessary gutters, down pipes, gullies, traps, catch pits manholes etc. All water likely to contain oil shall be passed through approved oil separators before passing into the drainage system. The quality of the discharge shall be acceptable in all respects to the local water and environmental authorities.

The stormwater system for drainage from buildings shall comprise down pipes into gullies and buried pipes discharging into existing water courses and channels. Where it is not possible to obtain sufficient cover to bury the pipes the water shall be conveyed in reinforced concrete channels, laid to falls which shall ensure that the channels are self-cleansing. The drainage channels shall be covered with an open grid galvanized grating as specified above.

The stormwater system for the Site general shall consist of lined channels (concrete or stone pitched walling) or pipework, manholes and stand traps that shall discharge to open ground outside the site boundary. Discharged water shall not be permitted to pond within 50m of the site boundary.

* + - 1. Pipes for Stormwater Drainage

**Concrete pipes and fittings**: These shall conform to BS 5911, and shall be obtained from an approved manufacturer. They shall be suitable for flexible jointing unless otherwise approved.

**Porous concrete pipes**: Porous concrete pipes shall be used where indicated on the Drawings and shall conform to BS 5911-114:1992. They shall be wholly porous with ogee joints.

The structural design of pipework shall be in accordance with the pipe manufacturer’s recommendations in respect of pipe grade, trench dimensions and pipe bedding.

* + - 1. Bends, Gullies and Fittings

All bends, gullies and fittings used in the drainage systems shall be of the same materials and of equally high quality as the adjacent pipework.

* + - 1. Catch pit Covers

Where concrete slabs covers are required they shall be pre-cast and have a strength of 35N/mm3 after 28 days. Where cast iron covers are required they shall conform to BS EN 124. Covers to be watertight and prevent ingress of surface water.

* + - 1. Step Irons

Manhole step irons shall comply with BS EN 13101:2002 or be of equal strength and dimensions. They shall be galvanized or coated with best quality bitumastic composition.

* + - 1. Inspection of Pipes

All pipes and fittings shall be examined before laying and any found to be damaged, defective or otherwise unsound shall not be used in the works.

* + - 1. Excavation and Backfill

Trench excavations for drains shall be carried out with the minimum disturbance to adjacent ground and in such a way that existing or new work shall not be undermined. Where trenches are to be backfilled with hardcore, gravel or the like, or where open channels are to be constructed, excavated material shall be removed immediately after excavation. No backfill shall be placed until pipes, etc. have been inspected, tested and approved. Backfill shall be carefully placed by hand tools round pipes etc. and rammed in layers not exceeding one hundred (100) millimetres thick in a manner which will not cause damage. When a minimum thickness of three hundred (300) millimetres above the pipes has been so placed, normal methods of backfilling and ramming may be adopted.

* + - 1. Laying of Pipes

Pipes and fittings shall be of the types, qualities and sizes specified by the designer. They shall be laid to the lines and levels shown, and the barrel of each pipe shall bear firmly and uniformly on the trench bottom or prepared foundation bed, any projections in the trench bottom which could cause damage to pipes being first removed. Pipes shall be kept clean during and after laying, and open ends shall be provided with temporary plugs to prevent entry of foreign matter. Each pipe shall be accurately boned to gradient between sight rails and drain laying shall commence at the lowest end and proceed uphill. Pipes shall be laid with the sockets leading uphill.

* + - 1. Jointing of Pipes Generally

The jointing of pipes shall be carried out as specified below. The pipes to be jointed shall be accurately centred and butted together, and joints shall be made only by experienced drain layers using the special tools recommended for the particular type of joint. Joints shall generally be of a flexible type.

* + - 1. Flexible and Proprietary Joints

The joints in concrete, asbestos cement, unplasticized PVC and pitch fibre pipes designed for flexible jointing shall be made in accordance with the manufacturer’s instructions and relevant British Standards. Unless otherwise directed or agreed, the joints in concrete and asbestos cement pipes shall be of the compressed rubber ring type, and when loose collars are used these shall be accurately located over the centre of the joints.

* + - 1. Rigid Jointing of Spigot and Socket Pipes

Concrete, asbestos cement or salt glazed ware spigot and socket pipes for rigid jointing shall be used only where specified or directed. They shall be jointing by inserting and caulking one complete ring of tarred gasket which shall centre the pipes and prevent mortar from entering the pipes. The joint shall then be completed by filling with mortar which contains lime putty. The mortar shall be well rammed into the joint and finished with a 45o bevel. Joints shall be undisturbed and kept covered with wet sacking for 7 days.

* + - 1. Porous Pipe Joints

Joints in porous pipes shall be made by butting the pipes tightly together so that no soil or the like can enter the pipes. If, due to minor changes of line or gradient, a joint cannot be completely closed, it shall be wrapped with bituminous felt and surrounded with weak concrete.

* + - 1. Concrete Surroundings

Where required the pipes shall be bedded on or surrounded by Grade 12/15 concrete with an aggregate size of 20mm.

* + - 1. Catchpits

Details and sizes of bases, benching, covers and manholes generally shall be obtained from typical manhole details shown on the Drawings. Unless otherwise directed catchpit, walls shall be built with solid concrete blocks as specified in subsection 2.6 in Grade B mortar to which an approved waterproofing agent has been added. All joints in blockwork shall be well filled with mortar.

Catchpits deeper that (1) metre shall be provided with step irons. Precast concrete relieving blocks manufactured with Grade 25/20 concrete shall be provided and set in the blockwork walls over each pipe.

* + - 1. Testing of Drains

All drains, other than open channel, stone filled drains and porous drains, shall be of watertight construction, and all waste water and surface water drains shall be subjected to a water test before backfilling of trenches is commenced. Drains may be tested in sections, and catchpits may be tested separately. The Contractor shall submit to the Employer/Employer’s representative for approval his proposals for testing. The drains shall withstand, without leakage, a water pressure of not less than one and one half (1.5) metres at any point for a period of 20 minutes or such other time as the Employer/Employer’s representative may direct. All necessary plugs, temporary connections and other equipment and all labour required for the tests shall be provided by the Contractor and at the expense of the Contractor. For testing of pipes in areas where an adequate supply of water is not readily available, the Employer/Employer’s representative will accept an air (smoke) pressure test, always provided that the method of testing is approved. Further testing may be called for after backfilling of trenches to ensure that pipes have not been damaged during that operation.

Open drainage channels shall be tested to ensure that they are completely self-draining, with a continuous fall and no ponding of water in the base.

* + - 1. Regulations

The regulations and recommendations of any relevant drainage or sanitary authority shall be fully observed, and the Contractor shall be responsible for acquainting himself with any such regulations.

* + - * 1. Concrete Works

This chapter applies to all concrete and reinforced concrete works required for all kinds of foundations, sub-structural and super-structural works and any other structure and/or structural member made of concrete.

Concrete and reinforced concrete shall be placed either in-situ or by prefabricated units.

* + - 1. Composition

The concrete will be composed of fine and coarse aggregates, water, cement and admixtures. The proportions will be designed to obtain a workable mix, suitable for the specific conditions of placement and a product which, after proper curing and adequate setting time, will have durability, impermeability and the required strength.

* + - 1. Materials

Cement

“Ordinary Portland Cement (CEM I) or Portland Composite Cement (CEM II), of strength class 42.5 N/mm2 meeting the requirements of KS EAS 18-1:2001, BS 12, BS EN 197-1 or any other standard approved by the client shall be used in case of normal soil.

Blended cements which offer resistance to chemical attack will be required if the soil contains active chemicals that attack Portland cement.

All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties.

The manufacturer's test certificate shall normally be accepted as proof of compliance with the General Technical Requirements/Particular Technical Requirements. If required, confirmatory tests are to be conducted by a recognized quality control organization.

The following information shall be provided for all cement shipments (either whole or part) which are intended for delivery to site: date of manufacture, date of original loading, destinations en-route, and date of unloading, intended date of delivery to site.

Cement which has been manufactured for longer than 6 months on the proposed date of delivery to the site shall be inspected, sampled and tested for approval purposes before delivery to the site.

The Contractor shall obtain and provide to the Employer / Employer’s Representative the manufacturer’s Bulk Average Test Certificate for each consignment of cement to the works.

Samples shall be taken from each consignment of cement and tested as directed by the Employer / Employer’s Representative in an approved independent laboratory.

All bagged cement shall be stored in a weatherproof building which shall be kept swept clean at all times.

Cement shall be adequately protected against rain, humidity and dewfall, and all charging and discharging points shall be properly sealed.

The Contractor shall provide and submit to the Employer, 30 days before the use of cement in the permanent works, a typical mill test report regarding the control tests performed at the factory, including the physical and chemical properties of the cement to be used for the concrete, mortar or grout.

The Contractor will receive with each shipment of cement, a certificate by which the cement is guaranteed to comply with the requirements of the specifications. In particular, the following tests will be annexed to the certificate:

* Soundness as per BS EN 196-3 or ASTM C151
* Time of setting as per BS EN 196-3 or ASTM C191
* Compressive strength as per BS 196-1 or ASTM C109
* False set as per BS EN 196 or ASTM C451
* Fineness test as per BS EN 196-6 or ASTM C184

The certificate will also indicate the quantity shipped, and the identification of the silo, lot or bin at the factory where the cement came from.

The Contractor shall carry out tests on the cement at the site laboratory or at an approved laboratory (to be approved by Employer/Employer’s Representative) in order to check the data of the certificates supplied by the manufacturer.

No cement shall be used in permanent works until the cement has been verified to be in compliance with the requirements. If the test results show that the cement which has been delivered to the site is not satisfactory, being not in compliance with the requirements, it shall be replaced at the Contractor's expense.

The Employer/Employer’s Representative reserves the right to take samples and to perform independent tests of the cement that the Contractor intends to use. The Contractor shall provide the Employer/Employer’s Representative with cement samples from site storage as required for independent testing purpose. No cement shall be used until the Employer/Employer’s Representative has established that it is in compliance with the specified requirements.

The cement to be used in the work is to be delivered in sacks/bags or in bulk at Contractor's convenience. The cement in sacks/bags shall be delivered to the work site in factory waterproofed sealed paper containers and shall not be broken or damaged. The content of all of the sacks shall be uniform and equal to the standard weight adopted in Kenya.

The transportation of bulk cement shall be performed in tanks with clean weather-tight compartments, sealed and adequately designed to protect the cement from exposure to moisture.

The method of transportation of cement in sacks/bags shall equally assure the full protection against moisture.

Immediately upon arrival at the Site, the cement shall be stored. All storage facilities shall be subject to the review and approval from the Employer/Employer’s Representative. Cement in sacks will be kept in closed stores. The floor of the stores shall have a wooden deck at least 30cm above the ground and covered with waterproof membrane. Storage on the ground of cement in bags will not be permitted. The height of the stacked sacks in stores shall not exceed 1.50m.

When necessary, cement shall be properly covered with tarpaulins or other effective waterproof coverings.

The bulk cement will be kept in airtight silos which will be emptied for cleaning at regular intervals.

Cement shall be used in the same chronological order as its delivery to the site store to avoid storing some stocks for too long a period. Any cement found unsuitable to be used for the works shall be rejected.

The cement shall neither contain lumps nor show deterioration at the moment of use. Cement which has become stale, or otherwise unsuitable through absorption of moisture from the atmosphere or otherwise, shall be rejected and immediately removed by the Contractor.

Aggregate

The Contractor may choose any quarry or borrow area, provided that the aggregates are of suitable quality and grading, and this shall be subject to Employer/Employer’s Representative's approval.

Sand (Fine Aggregates)

The term “sand” (fine aggregate) is used to indicate the part of the aggregate having the maximum dimensions of 4.75mm (3/16") as per AASHTO M 43, or any solid material passing a 75 µm BS 410 sieve as per BS 882.

The sand shall be clean, strong, hard, compact, unalterable and free from adherent coating, clay, loam, alkali, organic material, flaky particles or other deleterious substances.

Either natural or manufactured sand can be used in the concrete works. The sand shall be prepared by proper screening and washing plant suitable to remove all deleterious substances and objectionable amounts of other foreign matter, while separating the sand grains into the required size fractions.

The sand shall meet the current requirements of relevant parts of BS 882, BS 812, BS EN 932, BS EN 12620, ASTM C33 or equivalent Standard approved by the Employer/Employer’s Representative.

The grading of the sand used for concrete mixtures shall conform to BS 410 or ASTM E11 sieves and BS 812, BS 1377, BS EN 932 or ASTM C136 procedures, or equivalent Standard approved by the Employer/Employer.

The sand shall be stored in covered silos or bins or under approved shed. All storage facilities shall be subject to the Employer/Employer’s Representative's approval and shall be such as to allow easy access for inspection.

Coarse Aggregates

The term "coarse aggregate" is referred to that part of the aggregates with a minimum size of 4.75 mm (No. 4) as per AASHTO M 43, BS 882, BS EN 12620 or equivalent standard.

Coarse aggregates shall consist of hard, strong, clean, compact, unalterable rock fragments free from:

* Flaky rock particles
* Adherent coating of any material
* Lumps of clay, loam, roots, sticks and other organic matter, and
* Alkali or other deleterious substances

Coarse aggregates shall meet the current requirements of BS 882, BS 1377, BS 812, BS EN 12620 or ASTM C 33, or equivalent Standard approved by the Employer/Employer’s Representative.

The grading of the coarse aggregate within the separated size groups shall conform to BS 410, or ASTM E11 test sieves and ASTM C 136 or BS 812: Part 103 procedure or equivalent Standard approved by the Employer/Employer’s Representative.

When crushed and uncrushed aggregates are mixed, they shall be blended uniformly, and the crushing and blending operations, as well as the amount of crushed material blended, shall at all times be subject to the approval of the Employer/Employer’s Representative.

Fine and coarse aggregates shall be stored separately at the site of the work, in such a manner as to prevent inclusion or intrusion of foreign matter, or the intermixing of various sizes in the bins.

Mixing Water

The water used for mixing, rinsing and curing concrete and/or processing concrete aggregates, shall be clean and free from oil, salts, alkali, silt, clay, mud, organic matters or other deleterious substance and shall be as cool as is practically obtainable.

Water shall be obtained only from sources approved by the Employer/Employer’s Representative. It shall be clean, free from deleterious materials and chemically neutral which shall be verified through relevant laboratory tests.

Admixtures

Admixtures shall consist of chemical products specifically formulated for use in concrete works, which shall comply with BS EN 480, BE EN 934, BS 5075, ASTM C 494 and ASTM C 260, or equivalent Standard approved by the Employer/Employer’s Representative. Admixtures containing calcium chloride will not be permitted.

The admixtures shall have uniform quality in the different stocks, and will be supplied along with Manufacturer's test certificate.

Liquid or powdered admixtures shall be stored in such a way that they can be used in the chronological order of the delivery to the Site.

Admixture which has been in storage at the Site for longer than six months shall not be used until re-tests prove to be satisfactory.

If two or more admixtures have to be used in a Class of concrete, such admixtures shall be supplied by the same manufacturer.

The type and quantity of admixture to be used in the various concrete, mortar and grout will be established by laboratory tests to be performed by the Contractor according to the Employer/Employer’s Representative's instructions.

The Contractor shall submit to the Employer/Employer’s Representative the relevant documentation and samples from manufacturers with recognized world-wide reputation in concrete admixtures for each type of admixture to be used.

The Contractor shall execute a set of compressive strength tests using the admixtures he proposes. Based on the test results, the Employer/Employer’s Representative will approve for use the admixtures which have supplied the best technical result.

* + - 1. Concrete Classification

The Contractor shall either install a testing laboratory on site and the facility will be checked for correctness by the Employer/Employer’s Representative and the relevant National Authority or propose a laboratory within the vicinity of the project, which shall be approved by the Employer/Employer’s Representative.

The concrete to be used for the works shall conform to the following classification:

In general, concrete class A shall be used for structures that require high compressive strength e.g. precast units, etc., whereas class B shall be used for other structures. Class C shall be used for lean concrete.

The method to be used in sampling, making, curing and testing the concrete samples will be in accordance with:

British Standard (BS):

* BS 1881, Testing concrete.
* BS 1881-101, Methods for sampling fresh concrete.
* BS 1881-108 Method for making test cubes from fresh concrete.
* BS 1881-111, Method for normal curing of test specimens (20 °C method).
* BS 1881-114, Methods for determination of density of hardened concrete.
* BS 1881-115, Specification for compression testing machines for concrete.
* BS 1881-125, Methods for mixing and sampling fresh concrete in the laboratory.
* BS 5328, Methods for specifying concrete, including ready-mixed concrete.
* BS 5497, Precision of test methods.
* BS 5497-1, Guide for the determination of repeatability and reproducibility for a standard test method
* Eurocode:
* BS EN 12350, Testing fresh concretes
* BS\_EN\_12350-1:2000 Testing Fresh Concrete. Sampling.
* BS EN 12504, Testing concrete in structures
* BS EN 12390, Testing hardened concrete
* BS EN 206. Concrete. Specification, performance, production and conformity

American standards:

* ASTM C172, C31, C192, C39 and C42,

or equivalent Standard approved by the Employer/Employer.

Tests shall be carried out in the laboratory by the Contractor in the presence of the Employer/Employer’s Representative.

* + - 1. Proportioning and Consistency

Proportioning shall mean the process of determining the proportions of the various ingredients, to be used to produce concrete with the best workability and durability.

In view of obtaining the best results, the type of the structure concerned and the pouring procedure involved shall be taken into consideration during proportioning.

After completing the initial tests, the Contractor shall submit to the Employer/Employer’s Representative for review, a report detailing all tests performed to establish the proportioning of mixtures to be adopted for the various classes of concrete. After the Employer/Employer’s Representative's review, the Contractor shall be fully responsible for producing and maintaining concrete with quality and compressive strength not inferior to the specified one. No concreting for permanent works will be permitted until the results of these initial tests are available.

The water/cement (W/C) ratio shall be determined by the requirements for specified strength, durability and impermeability. In general, the W/C ratio will be between 0.40 and 0.60.

Once the proportion of a mix including its W/C ratio has been determined and specified for use in a structure, it shall be maintained constant during the concrete works.

Concrete shall be of a consistency and workability suitable for the conditions on the job. For most concrete a "plastic" mix is required, which will not crumble, but will flow sluggishly when vibrated, without segregation.

Slump tests shall be performed to determine the consistency of concrete and they shall be made in accordance with BS 1881, BS EN 12350-2 Testing fresh concrete. Slump-test, ASTM C 143 "Standard Method of Slump Test for Consistency of Hydraulic Cement Concrete". The maximum slump shall be 75 mm. Wherever these tolerances for working slump limits are exceeded, the concrete shall be rejected and disposed of at the Contractor's expense.

* + - 1. Concrete Control

All tests for concrete quality control will be carried out by the Contractor in presence of the Employer/Employer’s Representative. The methods to be used in sampling, making, curing and testing the concrete samples, either in the field or in the laboratory, will be in accordance with the appropriate BS, EN, ASTM Standards, or equivalent Standard approved by the Employer/Employer’s Representative.

Apart from the samples taken from the batching plant, to check the uniformity production of the same, all samples taken in the field will be made from concrete immediately before being poured in the form.

When the results of the tests taken in the field do not comply with the specifications, the Employer/Employer’s representative shall have the right to order the strengthening or replacement of all or part of the entire volume of hardened concrete represented by the test failure, or any other part of the work, whose safety, in the opinion of the Employer/Employer’s Representative, is prejudiced or whose strength is impaired.

The following minimum number of tests shall be carried out:

* Cement:
  + One (1) setting test according to vicat needle-test method per car-load
  + One (1) boiling test per car-load
* Aggregates
  + One (1) sieve analysis per 100 m3 of compacted concrete
* Water
  + One (1) chemical water analysis at start of concrete proportioning/mix design of concrete.
  + Thereafter, one (1) chemical water analysis every three months of construction.
* Admixtures
  + One (1) of each kind of admixture and additive before use in concrete mix.
* Concrete
  + One (1) set of test cubes or test cylinders per 20 m3 compacted concrete. One (1) set consists of 6 numbers of cubes or cylinders.

The compression strength test shall be carried out after seven days for the first two cube of each set, after twenty eight days for the rest of the cubes of each set.

Two (2) slump tests daily or as per the Employer/Employer’s Representative's direction, provided concreting is proceeding.

* + - 1. Batching and Mixing

The Contractor shall provide automatic batch-type mixing plant(s), with minimum rated capacity stated by the manufacturer as required to meet the construction schedule of concrete works.

The equipment shall be capable of combining the specified proportions of coarse and fine aggregates, cement, admixtures and water into a uniform mixture, without segregation. Plants shall be designed to batch several classes of concrete in sequence, without undue delay.

Prior to placing the purchase order or transporting the equipment to the Site, the Contractor shall submit to the Employer for review drawings showing general plant arrangement, site installation and detailed description of the equipment which he proposes to use. Review of plant, equipment and their operation shall not, however, waive or modify any provision or requirement contained in this Specification.

Telephone or radio-telephone communications shall be set up between each concreting site and the batching plant, so that it can be possible to settle quickly any problem arising from the quality or consistency of the concrete or any other relevant matter.

The plant shall include provisions and devices to facilitate the inspection of all operations and sampling of materials at all times.

Next to the operator of the mixing plant, the composition of one batch of concrete shall be legibly displayed indicating the amount of aggregates, cement, water and admixtures, if any, in kg per m3 of concrete.

There shall be a room in the mixing plant with an area of not less than 10 m2 to house some control testing equipment, (slump, temperature etc.). The recorders, scales and batching plant control equipment shall be installed in this room as to ensure protection against exposure to excessive dust and other elements.

The concrete mixing plant shall be installed, tested and ready for operation prior to the scheduled date of the initial placement of the concrete.

* + - 1. Batchers

Individual weight batchers shall be provided for each material for all works requiring the use of more than two separate size groups of coarse aggregates. Cumulative weight batchers may be provided for work requiring the use of not more than two separate size groups of coarse aggregates provided cement is weighed and batched separately from the aggregates liquid materials which may be batched by volume. The batching plant shall have an automatic control capable of ready adjustment to compensate for the varying moisture content of the aggregates as well as to change the weights of the materials being batched.

The batching equipment shall have adjustment for calibrating the amount of "free-fall" to head bins into the batchers at the time of cut-off by automatic devices.

**Weighing Units**: Every delivery point of aggregates and cement into the mixer charging hopper shall have a weighing unit and shall include a visible, spring less, direct reading dial in kilogram units.

**Measuring Water**: Water shall be measured by weight or by volume. The mechanism for measuring and delivering water to the mixers shall not permit leakage when the valves are closed. The filling and discharge valves for the water tank shall be interlocked so that the discharge valves cannot be opened before the filling valve is fully closed.

The line bringing water to the mixing plant shall be adequately insulated, to limit the pick- up of heat in hot weather.

**Dispenser for Admixtures**: The batching plant shall include dispensing devices to measure and deposit the admixtures into each mix. The dispenser shall be interlocked with the batching and discharging controls of the water, so that the batching and discharging of the admixtures will be automatic. The device shall be capable of ready adjustment to allow varying the quantities of the admixture to be batched.

**Recording Devices**: An accurate autographic recorder shall be provided. The recording units shall be all in kilogram units, and completely housed in a single cabinet which shall be capable of being locked. The chart or tape shall be so marked that each batch may be permanently identified so that variations in batch weights can be readily observed.

* + - 1. Mixers

The components of the concrete shall be mixed in proven-type mixers. Mixers shall be mechanically-operated stationary mixers, of either the tilting or non-tilting type. Mixers shall be capable of combining the materials into a uniform mixture, without segregation.

The Contractor shall perform mixer efficiency tests on each class of concrete, as soon as the equipment is in operating condition. At the end of the prescribed mixing period, three samples of concrete shall be taken; one at the one-quarter point, one at the mid-point and one at the three-quarter point of the batch.

The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened mortar. Should any mixer, at any time, produce unsatisfactory results, leak mortar, cause waste of materials or its use shall be promptly discontinued until it is repaired.

* + - 1. Transportation

Concrete shall be conveyed from the mixer to the place of final deposit and finally poured as rapidly as is practicable by approved methods, which will prevent segregation, loss of ingredients or damage by exposure to the atmospheric agent, and shall be deposited as near as is practicable to its final position.

Conveying method shall be such as to ensure a practically continuous supply of concrete at the point of placement. The maximum height from which the concrete shall be dropped shall not exceed (1.5m) one and a half meters, except where the use of suitable equipment to confine and control the falling concrete is specifically authorized by the Employer.

The transportation equipment shall be approved by the Employer.

* + - 1. Formwork

Forms shall be used whenever necessary to confine the concrete. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete, and shall provide smooth concrete surfaces.

Forms shall be sufficiently tight to prevent the loss of mortar from the concrete.

The Contractor shall submit to the Employer for review, prior to the start of any concrete construction, the detailed design he proposes to adopt for formwork, the review of the drawings shall not relieve the Contractor of his responsibility for their adequacy.

The form surfaces in contact with the concrete shall be treated or protected to avoid chemical reactions or discolouring in the concrete surface.

The use of forms with bruises, irregularities and encrustations shall not be permitted. Should any of the elements show signs of deformation during the pouring, they shall be immediately replaced in order to guarantee the perfect outcome of the work.

Forms shall be placed so that the joint marks on concrete surfaces are, as much as possible, in alignment both horizontally and vertically.

The support for forms shall be such that no bending occurs under the weight of wet concrete or other loads.

**Cleaning and Lubricating**

At the time of concrete placement, the inner surface of the forms, the contacts and connections shall be free from any encrustation, mortar, grout or other foreign matter that may contaminate the concrete. Prior to pouring, the surface of the forms, with the sole exception of those made of rough wood, shall be smeared with a bond-breaking compound such as emulsified oil or with refined mineral paraffin oil designed to prevent concrete from adhering to the surface of the forms.

Oil treatment shall be made in such a manner as to avoid spillage on previously placed concrete. All excess oil on the form surfaces and any oil on the concrete, metal or other parts to be embedded in the concrete, shall be carefully removed.

**Removal of Forms**

The removal of the forms shall be carried out when the concrete has reached sufficient strength so that no damage will be caused by their removal.

No forms shall be removed within 16 hours after the end of concrete placing. As a guideline the following minimum times will be taken into account:

* Mass concrete: 16 hours
* Piers and thick walls: 24 hours
* Columns and thin walls: 36 hours
* Beams and slabs: 7 to 14 days

After the established time for form removal has elapsed, the forms shall be removed as soon as practicable to avoid delay in performing the specified curing of concrete and also to enable the earliest practicable repair of possible surface imperfections.

Methods of form removal likely to cause overstressing of the concrete or injury to the concrete surfaces shall not be used.

Forms and their supports shall be removed in such a manner as to allow the concrete to take the stresses due to its own weight gradually and uniformly.

**Form Requirements for Various Finishes**

The type of form sheathing or lining shall be in accordance with the following minimum requirements for the formed surface finishes as specified in Sub-Paragraph “Finishing”:

Where Finish F1 is specified, forms may be any grade of steel and wood sheathing, free from great surface roughness or irregularities.

Where Finish F2 is specified, forms shall be pressed fiberboard, ordinary lumber, plywood or steel sheathing, free from surface roughness or irregularities.

Where Finish F3 is specified, forms shall be hard pressed fiberboard, first class timber, plywood or steel sheathing, with plate not less than 1.5 mm thick with smooth surfaces. Forms with steel linings are not permitted.

Where concrete Finish F4 is specified, forms shall be 20 mm thick plywood, 30 mm thick first class timber or steel sheathing with plate not less than 2 mm thick, with very smooth and uniform surfaces. Steel lining shall not be permitted. Forms for the bottom outlet tunnel shall be only steel forms except for transitions and discontinuous cross sections where timber is admitted.

The first class timber used in the forms shall be free from warp, and wooden forms shall be made of dressed lumber of uniform thickness and width, which is free from loose knots, decay, or other defects.

Steel sheathing shall be defined as a steel plate supported by structural steel shapes. Steel lining shall be defined as thin steel sheaths, supported by a backing of wood boards.

* + - 1. Finishing

The surface of the concrete shall be smooth, uniform in colour and texture, free from irregularities, holes, honeycomb and encrustations.

Except for occasional special finishes, formed and unformed concrete surface finishes will be designated by use of symbols F1, F2, F3 and F4 or U1, U2 and U3, respectively.

The length of the template for testing irregularities in concrete surface is 1.5 m (5').

In case surface irregularities for F4 finish exceed the specified limits, the off-sets shall be completely eliminated by grinding and the irregularities shall be remedied by means of chiselling and epoxy mortar. Grinding level shall be 1 to 20 (ratio of height to length).

**Formed Surfaces**

The requested classes of finishes for formed surfaces are the following:

**Finish F1**: This finish concerns surfaces whose aesthetic appearance is unimportant and whose roughness is not objectionable, as well as for surfaces which will be hidden from sight. These surfaces shall not be subjected to any special treatment, except for the repair of defective concrete and the filling of tie rod and formwork holes etc., or the correction of such irregularities that would impair the homogeneity of the concrete.

**Finish F2**: This finish concerns surfaces exposed to sight, but without particular aesthetic requirements. Surface irregularities shall not be permitted to exceed 10 mm if they are abrupt and 15 mm if they are gradual.

**Finish F3**: This finish concerns surfaces exposed to the sight, whose contour must be accurate and without irregularities. Surface irregularities shall not be permitted to exceed 3 mm if abrupt and 6 mm if gradual.

**Finish F4**: This finish concerns surfaces whose smoothness is of the utmost importance. Abrupt surface irregularities shall not be permitted if transversal to the direction of flow; while those not transversal to the direction of flow shall not exceed 3 mm. Gradual surface irregularities shall not exceed 6 mm.

Unformed Surfaces:

The requested classes of finishes for unformed surfaces are the following:

**Finish U1**: This finish concerns surfaces that will be covered by backfill and shall also be used as the first stage of U2 and U3 finishes. Finishing operations shall consist of sufficient levelling and screeding to produce even, uniform surfaces. Gradual surface irregularities shall be such as not to impair the structural properties of the work.

**Finish U2**: This finish concerns surfaces not permanently concealed by backfill and shall be used as the second stage of U3 finish. Floating shall be started as soon as the screeded surface has stiffened sufficiently, and shall be done at least to the minimum amount necessary to produce a surface that is free from screed marks and is uniform in texture. A light brooming of the surfaces will be required to provide a non-skid surface. If U3 finish is to be applied, floating shall be continued until a small amount of mortar without excess water is brought to the surface, so as to permit effective trowelling. Gradual surface irregularities shall not exceed 5 mm. Joints and edges shall be tooled where shown in the drawings or as directed.

**Finish U3**: This finish concerns surfaces where an accurate surface is required. When the floated surface has hardened sufficiently to prevent excess fine materials from being drawn to the surface, steel trowelling shall be started. Steel trowelling shall be performed with firm pressure, such that it will flatten the sandy texture of the floated surface and produce a dense and uniform surface free from blemishes and trowel marks. Gradual surface irregularities shall not exceed 2 mm.

* + - 1. Placing of Concrete

The Contractor shall furnish the Employer with a detailed concreting programme which shall be subject to approval.

All concrete placing equipment and methods shall be subject to the approval of the Employer. Concrete placing shall not be started until formwork, reinforcement, embedded parts, foundation preparation and construction joints involved in the placement have been inspected and approved by the Employer. The Contractor shall give sufficient notice as required by the Employer and allow a reasonable time for inspection before beginning placing activities. Extreme care shall be devoted to placing the concrete around embedded parts such as linings, frames, pipes, anchors, instruments, etc., to ensure that unbalanced loading and impact from placing concrete will not cause distortion and/or dislocation of parts.

* + - 1. Vibration of Concrete

Concrete shall be compacted with mechanical vibrating equipment, supplemented by hand spading and tamping, to a maximum practicable density so that it is in complete contact with the forms, reinforcement and other embedded parts.

The vibration shall be carried out by means of immersion type high-frequency vibrators, of the electrically driven or compressed air types, or by means of engine driven vibrators.

No new layer of concrete shall be placed before the underlying one has been thoroughly vibrated. Immersion points for the vibrators shall be adequately spaced so as to make sure that every part of the concrete has been properly vibrated.

Excessive vibration, causing segregation and laitance and tending to bring water to the surface, shall be avoided.

Vibration or disturbance of concrete, which is partially hardened, shall not be allowed.

* + - 1. Curing of Concrete

Curing provisions shall be made so that:

Hydration of cement is developed gradually and completely;

Concrete does not quickly pass from plastic state to elastic state;

Concrete is not cracked or damaged by high differential temperature, or rapid changes in temperature;

Surfaces of concrete are not damaged by traffic, nor discoloured by chemical agents.

The methods and materials used in the curing process shall be, at all times, subject to the review of the Employer. All equipment needed for adequate curing and protection of any concrete pour shall be ready to be installed before actual concrete placement begins.

Moisture Control The loss of moisture from concrete shall be prevented by water curing or by membrane curing, up to 10 days after placing. Water curing shall start as soon as the concrete has hardened sufficiently to prevent damage and continue during the period when concrete is protected by the forms. Water curing shall be accomplished by keeping all surfaces of the concrete continuously (not periodically) moist by sprinkling.

Water for curing shall meet the requirements of water for concrete mixing.

Membrane curing may substitute the water curing, in locations where the concrete cannot be affected. Membrane curing shall consist of an application of a sealing compound, which forms a water retaining membrane on the surface of the concrete. The sealing compound shall be white pigmented, except the compound used on surfaces that will be exposed permanently to view, which shall be grey-pigmented. Sealing compound shall not be used on concrete surfaces, to which additional concrete or other material is to be bonded. Curing concrete compounds shall conform to the requirements of ASTM Specification C 309.

When sealing compound is used on unformed concrete surfaces, application shall commence immediately after pouring. When sealing compound is to be used on formed concrete surfaces, the surfaces shall be moistened with a light spray of water immediately after the forms are removed and shall be kept wet until the surface will not absorb more moisture. Special care shall be taken to ensure ample coverage with the compound at edges, corners and rough spots of formed surfaces.

Concrete shall be protected against abrasion, vibrations or damage from traffic during the curing period, by independently supported walkways, or an effective cover of sand, or other types of covering. Coverings shall not be applied over membrane-cured surfaces for at least twenty-four hours after the sealing compound has been applied.

Unhardened concrete shall be protected from heavy rains, flowing water, direct sunlight and wind.

* + - 1. Joints

Where directed by the Employer, flexible PVC water stop shall be placed in the joints. Water stops shall be joined and fixed in place in accordance with manufacturer's recommendations to form a continuous watertight barrier. Water stops shall be flexible neoprene or polyvinyl chloride (PVC) type.

* **Construction Joints**: Any surface resulting from a sufficiently prolonged interruption in the pouring, the hardening of which does not allow the penetration by a vibrator, is to be considered a construction joint. Whenever work is suspended on any section for more than one hour, concrete surfaces shall be considered as a construction joint.
* **Expansion or Contraction Joints**: All joints that allow possible displacement of a concrete structure with reference to an adjacent one, due to expansion, shrinkage and different settling of the respective foundation, are to be considered expansion or contraction joints.

Construction Joints

The shape and position of all construction joints shall be established by the Contractor and reviewed by the Employer.

In the initial stage of setting but before the final setting of the concrete, the surface of the joint shall be washed with water and compressed air jets with the purpose of eliminating the mortar from the surface, removing semidetached parts and laying bare the large aggregates, without however removing them.

If the surface of a lift is congested with reinforcement steel and is relatively inaccessible, or, if for any other reason, it is considered undesirable to disturb the surface of a lift before it is hardened, surface cutting by means of air-water jets will not be permitted and the use of wet sand blasting will be required.

When employed in the preparation of construction joints, wet sand blasting shall be performed immediately before placing the following lift.

The operation shall be continue d until all unsatisfactory concrete and all laitance, coatings, stains, debris and other foreign materials are removed.

Immediately before pouring is resumed, air and water jet cleaning will be repeated, until the washing water remains quite clear; the Contractor shall discharge the water employed in washing carefully, away from the pouring zone, leaving the surface wet, but without water puddles.

The air pressure used in the jet shall be not less than 6 kg/cm2 and the water pressure shall be just sufficient to have a similar cleaning effect as produced with air.

When construction joints are not covered with concrete within 30 days after their formation, the Contractor shall sandblast or chisel the surfaces using light type jackhammers before starting the pouring operations.

The use of form for the formation of the construction joint shall not be allowed. Where necessary, the joints shall have keyed surface. The surfaces of the first stage concrete, where a second stage concrete has to be placed, shall be thoroughly roughened and cleaned to ensure an effective bond between the two structures. Roughening and cleaning shall be carried out with hand breakers and/or chisels and pressure air-water jets. The roughening shall be considered satisfactory when at least 20 mm of the first stage concrete has been removed from the whole surface.

Expansion or Contraction Joints

Joints shall be provided at the designed locations. In no case shall any fixed metal embedded in the concrete be continuous through an expansion or contraction joint.

The expansion or contraction joints can be of the smooth and even or keyed type, to guarantee the contact of the structures. The opposite faces which form the joint shall be completely separate.

The Contractor shall undertake the pouring of the second surface only after the first one is thoroughly hardened.

When shown on the Drawings, a sheet of plain premoulded joint filler or other accepted material may be placed in contact with the first pour before starting the second pour.

Formed surfaces of expansion or contraction joints to be grouted shall be cleaned of all accretions of concrete, or other foreign material, by scraping, chipping or other effective means.

* + - 1. Repair of Defective Concrete

Any indentation, irregularity and bulge occurring beyond the specified tolerance, or any voids and honeycomb fractures, or deviation from the established lines, or other damage, shall be re paired as soon as possible after the removal of forms. Repairs shall be performed by skilled workmen and the Contractor will inform the Employer before starting the repair works. Materials, procedures and operations used in the repair of concrete and also the finished work, shall be done in accordance with the Employer's instructions.

Existing concrete at the point to be repaired shall be removed down to sound concrete and at least down to a depth behind the reinforcement steel, sufficient to provide complete embedment of the reinforcement steel in the concrete replacement. Voids to be filled shall be provided with anchors, keys, welded wire mesh, or dovetail slots, whenever necessary, to attach the new material securely in place. Cut out areas shall be thoroughly cleaned. Holes left by the removal of tie rods shall be thoroughly moistened and filled with dry pack mortar thoroughly tamped into place. The colour of replacement concrete and patching mortar shall match the surrounding concrete. For bonding new concrete to older one, a bonding medium of epoxy, formulated for this purpose, shall be used in accordance with manufacturer's instructions.

Alternatively, a neat cement paste may be used. A paste of Portland cement and water mixed to a thick cream consistency shall be applied to damp, clean concrete. The concrete shall have no free water on the surface.

Concrete and mortar used for patching and repairs shall be cured in the same manner as specified for general concrete work.

All repair work shall be finished to the same standard as the surrounding concrete, and shall be adequately cured.

Minor areas of defective concrete: The Contractor shall drill a hole of such diameter in the defective area into sound concrete, that the defective concrete is completely removed. The hole shall then be reamed out such that the diameter at the bottom of the hole is at least 20 mm larger than the hole at the surface. Finally, the hole shall be cleaned and washed out, the surplus water removed, and then filled with concrete incorporating a non-shrink agent approved by the Employer.

Large areas of defective concrete: concrete which contains defective areas too large to be repaired as described above shall be cut to the far face of surface reinforcement or further if necessary to remove all the defective material, and the edges undercut. The fresh concrete surface shall then be cleaned, washed down and thoroughly soaked with water until the concrete becomes saturated. The concrete surface should be damp. Finally, the hole shall be filled with concrete incorporating a non-shrink agent approved by the Employer.

* + - 1. Pre-Cast Concrete

The pre-cast concrete units shall be manufactured and cured in a properly equipped casting yard or shop. The facilities shall be subject to the Employer's inspection and approval.

Details of the design, concrete components and mixes and test results shall be made available to the Employer.

Each unit is shall be cast in one continuous operation and no construction joints shall be permitted.

Care shall be taken during storage, hoisting and handling of precast units to prevent cracking or damage. Units damaged by improper storing or handling shall be replaced by the Contractor.

Pre-cast units shall remain undisturbed until the concrete has developed at least 70% of the required compressive strength at 28 days and shall not be installed until the unit has developed the full required strength at 28 days.

Ready-mix concrete - Use of ready mix concrete is subject to approval by the Employer/Employer’s representative.

* + - * 1. Piling Works

These specifications cover the requirements for the materials, the installation and the realization of bored cast-in-place concrete piles with grouting at the base and driven cast-in-place piles.

* + - 1. Scope of work

The piling work includes:

* The preparatory works, the installation of the working-site and all the temporary works requested for the piling
* The drilling of the piles using a temporary casing (bentonite or slurry drilling shall not be used)
* The steel reinforcement
* The concreting
* The grouting at the piles bases (if required)
* The cut-off
* The tests on the materials and the piles and any soil testing that the contractor decides to perform for the works
* The inventory of fixtures, its costs and the costs resulting from the eventually damages caused by the piles execution, the contractor is fully responsible for all the damages to any buildings or constructions resulting from the piling
* The cleaning of the working site, including the evacuation of any debris, temporary backfill, soil produced by the piling.
  + - 1. Documents to be submitted

The following documents shall be submitted by the Contractor to the Employer/Employer’s representative in due time and are to be approved before starting the piling works:

* References concerning pile foundations carried out by the Contractor for similar structures and soil conditions, list of qualified staff
* Detailed descriptions of the plant, equipment, materials and procedures proposed for every type of piling operation that is to be undertaken; these descriptions will include plant and equipment specifications, pile constructions sequence, protective systems, detailed construction or installation procedures, tests procedures
* A proposal of piles record book and pile record sheets (see item “Piling Record”)
* Piles drawings and calculations notices of the piles with the following information:
  + Number and location of the piles
  + Working loads acting on the piles
  + Bearing pressures, settlements, horizontal displacements of the piles (isolated pile and groups of piles)
  + The “useful” length of the piles with cut-off level and base level
  + Diameters of the piles
  + Steel reinforcements of the piles
* A general planning of the piling works
  + - 1. Applicable standards and recommendations

The piling works and design shall be in accordance with the latest editions of internationally accepted Codes and Standards such as: 'Recommendation No. 174' of Building Research Establishment Digest: 'Concrete in sulphate-bearing soils and groundwater'

Other internationally accepted standards which ensure a quality equal to or higher than the EC Codes and standards can be submitted to the approval of the Employer but only if these are submitted in English language edition. If any standard contains a provision which is inconsistent with a provision in another standard, the more stringent shall apply.

* + - 1. Soils characteristics

The detailed soil and rock characteristics and accurate levels shall be provided by the confirmatory soil investigation made by the Contractor at the beginning of the works.

* + - 1. Piles characteristics and design criteria

Grouting of the rock below the piles has to be considered if dictated by soil conditions.

The piles bases have to be embedded in the rock level, determined by the soil investigations made at the beginning of the works by the Contractor.

The net vertical pile capacity computed from the soil investigation report is used to determine the maximum test load in case of piles testing.

The net compressive stress within concrete shall not exceed 5 MPa. The net tensile stress within steel reinforcement shall not exceed the allowable values furnished in the standards and norms.

* + - 1. Materials (quality, delivery, handling, storage)

Materials

All materials to be used for the piling works shall meet the requirements as specified under clause "Concrete Works" herein.

The origin and quality of steel reinforcement, cement, aggregates, mix water, grouting, and eventual admixtures, shall be approved by the Employer/Employer’s Representative and have to conform to all applicable standards.

Concrete-composition

The proportioning of the concrete mixed by the Contractor to obtain the specified characteristics and an adequate workability has to be submitted to the approval of the Employer/Employer’s Representative.

The concrete shall be as per clause “Concrete Works”.

Concrete composition, production, transport and control testing shall conform to relevant British Standards. The workability measured by standardized procedures should be adequate for the method of placing used.

The water/cement ratio shall not exceed 0.42

Steel reinforcement

The piles shall be longitudinally reinforced on the whole length. The pile reinforcement drawings for execution shall be submitted by the Contractor and approved by the Employer/Employers Representative.

Steel reinforcement used for cast in situ concrete piles consists of high yield steel conforming to clause "Reinforcing steel" of clause "Concrete works" hereafter.

The concrete cover to reinforcement shall be not less than 75 mm and not more than 100 mm.

The minimum ratio of longitudinal bars is 0.8% of the pile cross section, with a minimum of 6 bars not less than 12 mm in diameter. The minimum spacing between longitudinal bars is 15 cm.

Helical binding shall be used with a minimum diameter of 10 mm and a maximum pitch of 15 cm.

**Reinforcement cage**: The stirrups shall fit tightly to the longitudinal bars and be fixed to them by steel wires or by welding.

When the reinforcement cage of a pile is constituted of several parts, the assembling of these parts has to be made before or during the installation within the tube, taking into account the necessary overlapping between the parts.

The reinforcement cage shall be perfectly cantered within the borehole so that the cover over all reinforcement, including binding wire, is not less than 7.5 cm of concrete. The longitudinal bars may be held apart by spreader forks not more than 1.5 m apart. In any case, the spreader forks and the cantering pieces have to be of the same corrosion resistance as the pile steel reinforcement.

Before installation of the reinforcement cage, the Contractor checks the complete cleaning of the bottom of the hole. All disturbed soils and debris have to be removed from the hole.

The reinforcement cage is put into the hole in only one operation. The cage must remain stable during concreting and removal of the temporary casing. The handling of the cage during loading, unloading and installation within the holes has to be made with care in order to reduce the deformation and to avoid the breaking of the welding or the binding wires.

* + - * 1. Execution (assembling, installation)
      1. Program

The program of piling work is to be submitted for the approval of the Employer/Employers four weeks before the start of the piling works. Sequence of piling shall be stated.

Three working days before the end of each week, the Contractor shall submit to the Employer/Employers Representative the detailed piling program for the next week, including adequate notice of his intention to work outside normal hours and at weekends.

* + - 1. Staking-out tolerances

The landmarks to be used for the implementation of the piles must be effective, solid and well protected.

The method of location of the piles is a duty of the Contractor. The setting out has to be carried out from the main grid lines of the proposed structures.

The maximum allowed deviation of the piles centre from the theoretical location shown on the setting out drawing is 50 mm in any direction. The maximum permitted deviation of the completed pile from the vertical is 20 mm per meter (2.0%).

* + - 1. Cut-off

The piles are to be concreted up to a minimum of 60 cm above the cut-off level.

The cut-off must eliminate all polluted or poor characteristics concrete at the top of the pile and should be carried 10 cm into sound concrete. When this sound concrete is found below the cut-off level, the Contractor must realize, at his own expenses, a new concreting up to the cut-off level with a full connection to the pile. Any repair must be approved by the Employer / Employers Representative.

The concreting of the raft may start only after the cut-off of the pile and after obtaining a satisfactory resistance of the pile concrete.

The cut-off must be carefully performed according to a method approved by the Employer/Employers Representative. The concrete in the head of the pile shall be carefully broken away from the reinforcement which shall then be cleaned and bent as shown on the drawings or as directed. The concrete surface at the cut-off level shall be horizontal, plane and free from all loose aggregate.

* + - 1. Working platform

The areas where piling operations are to be carried out is to be levelled and kept clear of water to provide a dry stable working platform for the plant and equipment operation.

After completion of the piling works the project site is to be cleaned and all excavated material due to these works is to be removed by the Contractor.

* + - 1. Rejection

If a pile is rejected by the Employer/Employers Representative, the Contractor has to replace it by others in the vicinity of the rejected pile at no expense for the Employer/ Employers Representative.

The Contractor shall bear the cost of:

* Re-design of pile caps
* Extra cost of construction involved due to unsatisfactory or incorrectly positioned piles.
  + - 1. Concreting

Before starting concreting, the Contractor has to check the implantation of the driven tube and verify that no water or soil is present within the tube. A special procedure must permit to execute this control at any moment.

The poured concrete volume needed by the concreting of each pile has to be measured and noted in the piling record.

In case of successive pouring of dry concrete with tamping, a minimum thickness of concrete must be maintained within the tube to avoid any insertion of soil or water at the base of the tube. In any case, this thickness must be larger than the half-diameter of the tube.

In case of continuous pouring of concrete, the concrete has to fill the tube in order that the pile is continuous up to the top level when the tube is removed. If the tube is not long enough to contain a sufficient concrete volume, the complement of concrete is added after raising of the tube over the needed length. The basis of the tube is always 1m below the concrete level except at the cut-off level.

The concreting curve is usually drawn up by the Contractor for one pile by each 50 piles. If the concrete consumption is not normal (under-volume or more than 30% of over volume), special procedures will be taken by the Contractor in agreement with the Employer / Employer’s Representative.

In case of successive pouring with tamping, the concreting curve is drawn up by measuring the quantities of each pouring of concrete (max. 0.5 m3) versus the top level of concrete into the tube.

In case of continuous pouring over the full length of the tube, the concreting curve is drawn up by measuring the concrete top level every time the tube is raised over 2 m.

The concrete needed by the concreting of a pile has to be supplied regularly. The waiting times between the concrete trucks may not exceed half an hour. No concreting interruption will be tolerated.

Before starting the concreting, the bottom of the hole has to be cleaned. All loose or disturbed soil will be removed from the base of the hole. This operation is to be executed immediately before starting the concreting. It means after the introduction of the steel reinforcement cage and not only at the end of the drilling.

If the checking at the base of the pile shows a penetration of sediments between the rock and the end of the steel casing, the Contractor must submit to the approval of the Employer/Employer’s Representative any method in order to ensure the sealing of the casing within the rock.

All concrete is to be placed by tremie pipe; the starting of the concreting by this method has to be particularly well executed. The good quality of concrete at the base of the pile is of main concern with this operation.

When the top of concrete is below the level of the working platform, the corresponding hole is immediately filled by gravely sand after the end of concreting.

After concreting of each pile, the concrete volume will be checked in relation with the theoretical bore- hole volume; for this purpose, a concrete-curve is drawn up for each pile, truck by truck. A complete concrete curve is established from the measurements of concrete consumption every meter on the length of the pile for 1 pile each 50 piles. The concrete-curves (truck by truck and meter by meter) have to be daily provided to the Employer / Employer’s Representative and joined to the piling record.

If the concrete consumption is not normal (under-volumes or more than 30% of over-volumes), special procedures will be taken by the Contractor in agreement with the Employer / Employer’s Representative.

Water level within the hole must be permanently higher than the groundwater level during concreting.

The hopper and pipe of the tremie will be clean and water-tight (also the joints between elements). The inner diameter of the tremie pipe is at least equal to 4 diameters of the concrete aggregates and is never smaller than 15 cm.

The length of the tremie pipe is equal to the length of the pile. Before concreting, the pipe will reach the bottom of the hole and is then raised in 15 cm steps. The pipe must never be located less than 1.5 meter below the level of workable concrete within the pipe.

At all times, a sufficient quantity of workable concrete shall be maintained within the pipe to ensure that the pressure from it exceeds that of the water.

During the extraction, the base of temporary casing must be located at least 1 meter below the level of fresh concrete.

* + - 1. Concrete control

The compression strength of 15 cm side concrete cubes has to reach the minimal values of 30 N/mm2 after 28 days.

For each group of 5 piles, 6 representative cube samples will at least be taken, 3 will be tested after 28 days, and the others will be stored for other tests to be specified by the Employer / Employer’s Representative.

All costs relative to these control tests are under the scope of the Contractor.

* + - 1. Piling record

For each pile, a piling record book giving the main checked values during execution shall be drawn up and updated by the Contractor with all the work hazards and incidents. That record book shall be submitted daily to the approval of the Employer / Employer’s Representative as the execution proceeds.

This record book shall include for each pile details on:

* Location, reference number (corresponding to the number fixed on the drawing), type and diameter of the pile;
* Length of the temporary casing;
* Date and hour of start and end of each operation drilling, reinforcement setting, concreting;
* Level from which the pile is bored or driven (platform level);
* Level at the pile base;
* Top level of the concreted pile before the cut-off operation;
* Used materials (driving or drilling tools, concreting equipment);
* Cleaning results of the bottom of the hole before putting down the reinforcement cage and before concreting;
* Nature and description of the encountered soils;
* Poured concrete volume and theoretical volume (measured concrete curves);
* Behaviour, workability, fluidity of concrete, results of the compression tests;
* Water level within the hole before concreting;

For driven piles, the refusals corresponding to the three last sets of blows (10 hammer blows) will be noted for each pile; for one pile from each 20 piles, a driving diagram will be drown up; type of boring-chisel, lengths of piles where chisel has been used.

Records shall be submitted in duplicate to the Employer every following working day until 9 a.m.

The Contractor shall submit to the approval of the Employer a proposal of piling record sheets including all the details mentioned above.

Test piles. Static loading tests

The Contractor shall execute static loading tests in the following quantity:

* up to 10 working piles 1 tests
* up to 30 working piles 2 tests
* more than 30 working piles 3 tests

The pile(s) to be tested shall be approved by the Employer/Employer’s Representative. The procedure to be followed is provided by ASTM D 1143 or by BS 8004 art. 7.5.5.

The maximum test load shall be 2.5 times the working load for preliminary piles (total settlement is not exceeding 7 mm after 24 hours of full load application) and 1.5 times the working load for work piles (total settlement is not exceeding 5 mm after 24 hours of full load application).

Integrity tests are to be performed on 100% of the piles.

The loading materials and equipment, the measurement devices and procedures have to be submitted by the contractor for the Employer’s approval.

All tests will be carried out only under the direction of an experienced and qualified supervisor familiar with the test equipment and test procedure. All personnel operating the test equipment will have been trained in that field.

The number of increments of load shall be at least four, with a decreasing of load down to zero after each increment.

If tests prove unsuccessful, the Contractor shall propose all necessary adaptation to the foundations. These proposals shall be submitted to the Employer/Employer’s Representative. All costs requested to perform the foundation adaptation shall be at the Contractor's expense.

* + - * 1. Steel Structures and Assembly Material
      1. General

Under steel structures are to be understood all overhead line towers and substation gantries, with their body and leg extensions, additional cross arms – if required, the foundation stubs, and stub setting templates.

Under assembly material are to be understood all bolts, screws, rivets, nuts, washers, locking devices which are necessary for the assembly of the steel structures and their accessories as well as, for the assembling and mounting of the line equipment like insulator sets, conductor and earthwire / OPGW accessories.

* + - 1. Steel structures

Generally, the design and stress calculation shall conform to a consecrated code or standard given in Table 1.

The material to be used for the structures is high tensile – and mild steel sections and plates, according to internationally recognized standards (ISO 630 or equivalent).

All structural steel shall be protected against corrosion by hot dip galvanizing.

The Contractor has to design, prepare and submit the complete shop drawings to the Employer/Employer’s Representative to get the approval before start of the fabrication.

Structural steelwork and testing shall comply with the relevant clauses of the following Standards (further standards are applicable as appropriate) unless otherwise specified:

All steel shall be carefully stored and handled so that pieces are not subjected to excessive stresses or damage.

Drawings shall show the number and sizes of all bolts, complete details of welds, type of electrodes, welding procedure, and any other relevant information.

The steelwork shall be manufactured by a specialist firm prior approved by the Employer/Employer’s Representative. As much of the work of manufacturing of the steelwork as is reasonably and technically practicable shall be executed in the manufacturer's works, and facilities for inspection by the Employer/Employer’s Representative must be provided.

All steelwork before and after manufacturing shall be smooth, undeformed, straight and free from cracks, twist and burrs.

All steelwork shall be cut and fabricated to a tolerance of +1.5 mm in its length. Each plate shall be truly at right angles to the longitudinal axis of the section. No work shall be painted, packed or dispatched from the manufacturer's works until it has been tested, and complies with, or has been certified to comply with, all the tests and requirements of the standard applicable to the material specified and until it has been inspected and passed by the Employer/Employer’s Representative.

* + - 1. Assembly material

All necessary bolts, screws, rivets, nuts, washers and locking washers shall be included in the scope of supply of the Contractor with sufficient spare to cover for losses.

Members of lattice steel structures including stub setting templates shall be secured by means of metric threaded bolts together with a flat washer, a spring washer and nuts. All bolts and nuts shall conform to ISO 898, BS 4190, BS EN 20898 or other approved standard and shall be to metric standards.

Bolts and nuts shall be of steel, with hexagonal heads. Screw threads shall not form part of the shearing plane between members; any thread in the bearing plane shall be to the approval of the Employer’s representative. Nuts – except lock nuts – shall be full bearing on one side.

Minimum size of bolts for all structural connections shall be 12mm. The quality of bolts shall not be less than 5.6 according to ISO 898, BS 4190, BS EN 20898 or other approved standard. Bolts of any given diameter shall be of one grade of steel and marked for identification.

All bolts and screwed rods shall be galvanized including the threaded portions. All nuts shall be galvanised with the exception of the threads, which shall be oiled. Where for any type of tower high tensile steel bolts are employed then bolts of this type shall be used for all connections for every type of tower on that line in order to avoid the use of mild steel bolts in error where high tensile type should be employed. High tensile steel bolts shall bear a mark on the head to allow identification of grades.

The nuts of all bolts attaching insulator set droppers, U bolts and earth conductor clamps to the towers shall be locked in an approved manner.

All washers shall be included under this contract, including locking devices and anti-vibration arrangements, which shall be subject to the approval of the Employer / Employer’s Representative. Taper washers shall be fitted where necessary.

Nuts shall be finger tight on the bolt and will be rejected if they are, in the opinion of the Employer / Employer’s Representative, considered to have an excessively loose or tight fit. Bolts with threads re-dyed after galvanizing will be rejected. Nuts and bolts of the same type shall be interchangeable and supplied from the same manufacturer.

When in position, all bolts or screwed rods shall project through the corresponding nuts, for a minimum of two full turns but this projection shall not exceed three threads or 10mm, unless more length is required for adjustment. Suitable bolt grip tables shall be provided to demonstrate compliance with the above requirements.

All bolts shall be supplied with nuts, spring washers and flat washers. The Contractor shall supply the net quantities plus 10% of all permanent bolts, screws, nuts and other similar parts and materials required for installation of the works at the site. Any such assembly material which is surplus after the installation of the equipment has been completed, shall become spare parts and shall be wrapped, marked and handed over to the Employer.

* + - 1. Deflection criteria

The following deflection limitations shall be strictly followed in designing the steel structures:

* The vertical deflection in the design of main frame beams/girders shall be limited to Span/350.
* The lateral displacement of the column end nodes in the design of main frame columns shall be limited to system height/200, the lateral deflection in the column span between the end nodes shall be limited to system height/240. For columns related to wall panels containing, e.g. glass elements, etc. the limitation shall be increased to at least height/500.
* The criteria under item “2” above shall be applied to braced structures as well.
* The vertical deflection in the design of roof purlins shall be limited to Span/240.
* The deflection in any direction the design of wall girts shall be limited to Span/250.

Any member where deflections will be aesthetically unacceptable or long span members (>8 m) shall be cambered for full dead load. The design and engineering must be state of the art in accordance with all relevant codes and standards, functional and complete as mentioned above.

* + - 1. Standard material specification

The following listing summarizes material standards and specifications, as well as minimum requirements according to which the steel structure components have to be designed, manufactured and erected:

The absence of any relevant standard from the list shall not relieve the Contractor of his obligation to comply with such standard as required by this Specification.

The latest edition of the appropriate standards shall be used.

Table 3: Steel Structures Material, Design and Erection Specification

|  |  |  |
| --- | --- | --- |
| MEMBER | STANDARD | MATERIAL |
| Built-up Members | BS EN 10025 | S235JO and S355JO or better \*\* |
| St37-3U and St52-3U, or Fe360C and Fe 510C or better \*\* |
| Hot Rolled Members | BS EN 10025 | S235JO and S355JO or better \*\* |
| St37-3U and St52-3U, or Fe360C and Fe 510C or better \*\* |
| Tubes | BS EN 10025 | S235JO and S355JO or better |
| Bolts and Anchor Bolts | BS 4190, BS EN 20898 or other approved standard | 5.6 (fy ≥ 300 N/mm²) |
| High Strength Bolts | BS 4190, BS EN 20898 or other approved standard | 8.8 (fy ≥ 640 N/mm²)  10.9 (fy ≥ 900 N/mm²) |
| Stud Bolts | BS 4190, BS EN 20898 or other approved standard | 4.8 (fy ≥ 320 N/mm²) |
|  | St 37-3 per DIN 17 100, (fy ≥ 350 N/mm²) |

\*\* for miscellaneous steelwork, all steel grades S235 and S355 as per DIN EN 10 027-1 or equivalent may be proposed for approval by the Employer / Employer’s Representative.

* + - 1. Materials

As far as possible standard steel profiles shall be used.

If steel members like columns and beams should be oversized and coated with a corrosion protection system instead of the generally galvanizing, the Contractor shall do a corrosion protection study and calculation to work out the necessary over-sizing of the profiles.

Minimum plate thickness for steel structures shall be 6 mm for webs and 8 mm for flanges respectively.

The following standards may further apply to Structural Steel Works:

Table 4: Additional Standards - Steel Works Specification

|  |  |  |
| --- | --- | --- |
| MEMBER | STANDARD | MATERIAL |
| British Standards | BS 449  BS 5950 | Structural steel in buildings  Structural use of steelwork in building |
|  | BS 4 | Structural steel sections |
|  | BS 3692 | Bolts, screws and nuts |
| Eurocodes | BS EN 10067 | Hot-rolled structural steel sections. Bulb Flat |
| BS EN 10056-1 | Hot-rolled structural steel sections. Equal and unequal angles |
| BS EN 10210-2 | Hot-rolled structural steel sections. Specification for hot Rolled sections |
| BS EN 10210-1 | Hot finished structural hollow sections of non-alloy and fine grain structural steels |
| BS EN 1994 | Design, fabrication and erection of structural steelwork |
| BS EN 1993 | Design of steel structures |
| DIN | 4114 | Steel Structures, stability |
|  | 15018 | Cranes |
|  | 4132 | Crane runways |
| Welding shall be in accordance with Structural Welding Code of American Welding Society (AWS D1.1) ASTM A-325 for high strength friction bolts and ASTM A-307 for other bolts may be considered | | |

The Contractor shall provide all technical information and a complete list of all parts to be galvanized.

Steel shall be coated by the hot-dip process in molten zinc, producing a continuous coating of uniform.

Coating shall be of best commercial quality free from injurious, flux and uncoated spots.

* + - 1. Execution/workmanship

Tolerances

Care shall be taken to ensure that the tolerances specified on the drawings or the relevant standards BS 449 Part 2 are worked to. The erection tolerance for cleated ends of members connecting steel shall not be greater than 2 mm at each end.

Connections

Field connections shall be friction-type connections with ASTM A-325 or equivalent- bolting with heavy hexagonal head bolts. Connections at building expansion joints must be slotted with shoulder bolts with locknuts. The slots shall be of sufficient length to permit movement of sliding, member in both directions from the neutral position, of 25 mm.

Where no reactions or moments are called the connections for indicated sections shall be designed with maximum number of fasteners of M22 minimum diameter.

Beam Connections of AISC Manual of Steel Construction or equivalent, unless governed by material thickness or otherwise detailed on the drawings. No connections shall have less than two bolts.

Diagonal bracing shall be properly drawn by shortening the member 1.5mm every 3m of member length. The connections at end bracings shall develop the force due to the design load, but not less than 50 percent of the effective strength of the member. If no load is indicated, the latter condition shall govern.

In accordance with the structural design, the steel structure may be either a frame structure and/or a braced structure.

The steel structures shall be fabricated in a workshop according to the approved shop drawings.

The size of construction members shall be of the maximum admissible size for the transport to and handling at SITE. Fabricated steel structures shall be pre-assembled in the workshop to such an extent to ensure proper field erection, and shall be dismantled (non welded/bolted members only) for transportation. The steel structure shall be suitable packed, cover or coated, and any damage and corrosion during.

Where possible, torque wrenches shall be used for tightening of bolt connections. Structural steel members delivered to the site shall be evenly supported and stacked on timber to avoid deformation.

Bolts, nuts, washers, rivets and other identical items of structural steel required to be incorporated into concrete shall be delivered to the site well in advance.

All metal parts shall be interconnected to the Station earthing by an approved method in electrical specifications.

Tolerances shall be kept in accordance with the relevant stipulation of BS 449 and within the specified limits on the drawings.

Cutting

Cutting may be by shearing, cropping, sawing or machine flame cutting. Hand flame cutting is subject to the approval of the Employer/Employer’s Representative.

Cut edges on rolled products must be given a finishing operation by a metal cutting method (e.g. by planing, milling, grinding or filing). Notches and cracks are to be eliminated in the same way.

Small surface defects such as grooves and other types of unevenness may be removed by grinding. The use of welding to fill in defects is not permitted.

Bolt holes

All holes are to be drilled and not punched after the members are assembled and tightly clamped or bolted together. Punching may be permitted before assembly, provided the holes are punched 2 mm less in diameter that the required size and reamed after assembly to the full diameter. The thickness of material punched shall not exceed 10 mm.

For tolerances the requirements of BS 449 Part 2 should be observed.

Bolting

The threaded portion of each bolt shall project through the nut at least one thread. Approved high strength friction grip bolts, preferably the type with indicated load are to be used where specified and are to be tightened strictly in accordance with the manufacturer's instructions and the pertaining regulations. The surfaces in contact shall not be painted and shall be free from oil, dirt, loose rust, burrs and other defects which would prevent solid seating of the parts or interfere with the development of friction between them.

When connections are made using high strength friction grip bolts the "provisional directions for the calculation, execution and structural design of friction grip bolted fastenings (high strength friction grip fastenings)" prepared by the German Committee for Steel Construction are to be observed.

Welding

The execution and testing of welding shall be in accordance with British Standards BS 5135. All welds, unless otherwise stated are to be continuous minimum 6 mm fillet weld and shall be dressed smooth, free from porosity, cracks, and holes and finished to match adjacent surfaces. When welding operations are completed, all welding flux shall be removed without delay. After welding, the components should possess the shape planned for them preferably without any subsequent dressing. The cooling of welds must not be accelerated by any special measures.

Site welding is to be restricted to the absolute minimum. The examination of welded work and the inspection of welds during and after manufacture is to be carried out by responsible specialist welding engineers. Welding shall be carried out by expert tradesmen and in strict accordance with the current code of practice.

For the further processing of weatherproof structural steels, such as hot shaping, and for welding and flame-cutting, the "Directions for the supply, working and application of weatherproof structural steels - DA ST-Ri-007" shall be taken into account.

Welding on site will be allowed in exceptional circumstances. Normally metal arc welding shall be carried out.

For site welding, all welders shall be obliged to pass qualification tests to determine their ability to perform such type of work. They shall provide necessary certificate from specialized agencies.

The Contractor shall carry out X-ray tests for at least of 10% of all welds.

Galvanised Work

All iron and steel structures and components intended for use outdoors shall be galvanised.

All materials to be galvanised shall be of the full dimensions shown or specified and all punching, cutting, drilling, screw tapping and the removal of burrs shall be completed before the galvanizing process commences.

All galvanising shall be done by the hot dip process with spelter, not less than 98% of which must be pure zinc and in accordance with BS EN ISO 1461:1999 or BS EN 10244-2:2001 as applicable. No alternative process shall be used without the approval of the Project Manager. Bolts shall be completely galvanised including the threads, but the threads shall be left un-coated in the case of nuts.

The Hot Dip Galvanising facility shall be subject to inspection and approval by the Project Manager.

The facility must have seven tank pre-treatment process with relevant parameter like temperature, concentrations, etc. monitored as per standard requirements. Necessary tests to establish the weight, thickness and uniformity of the coating, purity of the zinc, etc. shall be carried out before acceptance of each lot of the material.

The zinc coating shall be uniform, clean, smooth and as free from spangle as possible.

Galvanised wire shall comply with the requirements of BS 182, and the thickness of the coating and testing thereof shall comply with BS EN 10244-2:2001. Nuts and bolts and small components shall be tested in accordance with BS EN ISO 1461:1999. The Project Manager may select for test as many components to be weighed after pickling and before and after galvanising as he may think fit.

Galvanised steel structures shall be treated after galvanising with Sodium dichromate or other approved solution.

All galvanised parts shall be protected from injury to the zinc coating due to abrasion during periods of transit, storage and erection. If, in the opinion of the Project Manager, the extent of the damage found on Site to a galvanised part appears to be capable of repair the Contractor may, after receiving such agreement, attempt to effect a repair by approved methods. The agreement to attempt the repair shall not bind the Project Manager to accept the repaired part when this is re-offered for inspection.

Should any emergency arise on Site necessitating drilling, cutting or any other process likely to damage the protective zinc surface, this will be permitted only in extreme circumstances and with the Project Manager's express authority. In such a case, the bared metal will be coated with an approved zinc dust paint or other approved flake metallic compound.

Painting

Surface treatment and painting before and after delivery to site shall be in accordance with the clause “Corrosion Protection and Painting”.

Parts to be encased in concrete shall not be painted or oiled. Surfaces inaccessible after shop assembly shall receive the full specified protective treatment before assembly.

Erection

The Contractor must prepare and submit to the Employer/Employer’s Representative for approval a delivery and erection schedule of all structural steel work on site.

The Contractor shall supply all suitable plant, hoisting gears and tackles for the erection of the steelwork and shall provide all temporary tie ropes, struts, shores etc.

Approval by the Employer/Employer’s Representative of any of the construction and erection methods or plant shall not in any way relieve the Contractor from his responsibilities under the contract.

The positioning and levelling of all steelwork and the accurate placing of every part of the structure shall be in accordance with the approved drawings.

During erection, the work shall be securely bolted or otherwise fastened and if necessary temporarily braced, so as to make adequate provision for all erection stresses and conditions. Neither permanent bolting nor welding shall be done until proper alignment has been obtained.

The Contractor shall supply all necessary falsework and staging, tools, temporary connections, erection plant, service bolts, nuts, washers, anchorage cables, bracing and all other materials necessary to carry out the work and shall remove the same as the progress of the erection permits.

Execution & erection

In accordance with the structural design, the steel structure may be either a rigid frame structure or a braced structure. Following notes shall be considered during execution and erection of structural steel works:

* Co-ordination of the design of the structural steel members with the design of related concrete structures
* Checking of anchor bolts and their setting prior to casting pedestals/foundations
* Complete erection of the steel structure in accordance with the approved erection drawings and manufacturer’s instructions/recommendations

The steel structures shall be fabricated in a workshop according to the approved shop drawings. The size of construction members shall be of the maximum admissible size for the transport to and handling at site. Fabricated steel structures shall be pre-assembled in the workshop to such an extent to ensure proper field erection, and shall be dismantled (non-welded/bolted members only) for transportation, during which the Contractor shall reasonably protect the steel structure from damages. The steel structure shall be suitable packed, cover or coated, and any damage and corrosion during transportation shall be the responsibility of the Contractor and shall be rectified to the satisfaction of the Employer / Employer’s Representative.

Bolts, nuts, washers, rivets and other identical items of structural steel required to be incorporated into concrete shall be delivered to the Site well in advance. All metal parts shall be interconnected to the Station earthing by an approved method.

The Contractor has to provide all necessary guys and braces to insure the alignment and stability of the structural steel members until these are properly connected. Temporary guys and bracings must be capable to carry all dead, wind, seismic and erection loads. After erection, no column shall have a deviation from the vertical exceeding 1 to 1000 of the total height of the column.

The following members shall be stored inside closed stores: Bolts, pins, packing, tools, insulation material, electrical parts, motors, parts with electrical devices, attached instruments, welding equipment and material, etc.

* + - 1. Tests and properties

The following tests are at least required:

* Tests for each galvanized steel member as per the relevant standard/code
* X-ray tests for each heavy load bearing structure member, min. For 20% of all welds.
  + - * 1. Small Non-Structural Steel Parts
      1. General

This sub-clause refers to the specification covering the provision of all materials and labour in relation to the supply, manufacture, on site of articles made of steel or cast iron.

All steel structures and parts specified under this sub-clause shall be hot dip galvanized and painted.

The list of small items to be furnished shall contain but not be limited to the following:

Steel sections, bent plate sections and square bars for construction of:

* structural steel stairs, platforms and walkways,
* railing for stairs, platforms, walkways and protection around floor openings,
* corner and edge protection for concrete steps and concrete,
* support of any equipment foundation,
* joint covers,
* anchors, ties, hangers, inserts, slots, embedded steel parts, etc.
* steel pipes and plain round bars for making guard rails and ladders
* steel plates, chequered and/or flat, for fabrication of removable covers
* open steel grating for metal steps, platforms, walkways.
  + - 1. Steel sections and plates

Steel sections may be required in various standard profiles and shall comply with the relevant standards. In general, these sections must be straight, with exact measurements and made of mild steel as described under clause "Structural Steel" above.

Where required, mild steel plates shall be bent to special profile forms. These bent plates shall be used particularly on stairs, and also on doors and window frames.

All necessary care and precautions shall be taken in shipping, transporting and erection of all metalwork to avoid damage to the priming and finishing paintwork. Surface treatment and painting before and after delivery to site shall be in accordance with the requirements.

* + - 1. Chequered Plates

Chequered plates for floors and platforms shall be at least 8 mm thick, heavy duty type and hot dip galvanized. Removable Chequered plates shall be of a size permitting easy handling and shall be provided with two lifting holes. Chequered plates shall be provided with fasteners and shall rest flat on their supports without rocking and their deflection shall not exceed 1:250 of the span.

All edges of Chequered plates shall be round or cut smooth and straight leaving 3 mm clearance between plates. Where and if required, not braced Chequered plates shall be stiffened with angles. Chequered plates fitted to supporting members shall normally be secured by countersunk, flat-head bolts or screws. Cut-outs and openings required in chequered plates shall be shop formed and adequately reinforced as per the approved drawings or instructions from the Employer / Employer’s Representative.

The Contractor shall furnish banding strips or angles for openings required to be cut in the field, as well as all other necessary accessories for chequered plate installation at site. The type of chequered plates to be installed shall be subject to approval by the Employer / Employer’s Representative.

* + - 1. Metal flooring

The thickness of chequered plate or construction of grating shall be sufficient to bear the load of applicable equipment or traffic and shall in every case be capable of bearing a uniform load of not less than 500 kg/m2. In addition to the minimum requirements of strength, a minimum chequered plate thickness of 8 mm and a grating member minimum thickness of 3 mm shall be guaranteed.

Metal flooring shall in all cases be supported by a properly formed steel kerb running continuously throughout the supported length. The chequered flooring shall be provided with proper and adequate lifting eyes.

The arrangement of panels, unless otherwise prescribed, shall allow the ready removal of every unit by not more than two men.

* + - 1. Duct covers

Where duct runs are required in concrete, properly designed duct covers are to be used. Duct covers shall have securely fixed kerbs with lugs for building into the concrete. The covers must have a minimum load-carrying capacity of 500 kg/m2 and must be capable of supporting the loads of adjoining machinery or traffic. The covers shall have properly shaped and formed keyholes for lifting and must be divided into convenient lengths for handling without damage. The top of the covers shall be flush with the finished surface of the floor.

* + - 1. Railings

Pipe railing shall consist of standard steel pipe with flush, continuous, welded joints, ground smooth hot dip galvanized and powder coated.

Steel pipe railing shall always be installed on both sides of all walkways, stairs and platforms, and shall be made of steel pipes of 32 mm internal diameter and minimum thickness of 4 mm. The top rail shall be at a height of not less than 1100 mm from the walkway or platform level. Rails over stairs shall have the top level at a height of 1100 mm above the nose of the tread. Two intermediate rails shall be installed between the top rail and the toe plate or channel. A pattern of symmetry shall be accomplished when locating pipe posts and the distance between pipe posts shall not exceed 1500 mm.

Stands on concrete shall be set in pipe sleeves, not less than 10cm deep, with the sleeves cast into the concrete and of a size fitting snugly around and thus rigidly supporting the pipe or stands shall have a flange on the foot secured to the concrete by countersunk, flat-head machine screws in expansion metal sleeves.

Wall pipe and handrail shall be returned to a wall and be provided with necessary secure anchors. The Contractor shall provide necessary handrail brackets of malleable iron and anchors. All accessories such as floor flanges, etc., required for pipe railing shall be furnished.

Installation of pipe railings shall be done in a substantial and rigid manner. Stands on concrete shall have a flange on the foot secured to the concrete by countersunk, flat head machine screws in expansion metal sleeves.

Stands on metal shall have a plate or flange welded to the foot and secured by counter- sunk, flat head machine screws tapped into the supporting members, or as indicated on the drawings.

Removable sections shall be made in sections as above specified. On concrete, stands shall be set in pipe sleeves, not less than 10 cm deep, with the sleeves cast into the concrete and of a size fitting snugly around and thus rigidly supporting the pipe. On steel, foot plates shall be welded to the stands and fastened with cap screws.

Alternative fixing methods may be proposed for the Employer / Employer’s Representative’s approval.

* + - 1. Rails for track

All steel sections for rails and tracks shall be of an approved type, obtained from an approved manufacturer to meet the performance requirements stipulated in this specification clause.

* + - 1. Metal parts embedded in concrete

The embedded items (anchor bolts, fixing elements, etc.) for outside conditions and for inside conditions with seawater wetting etc. shall be of stainless steel (material No. 316 Ti conforming to AiSi).

The embedded items for inside conditions (without corrosive climate) shall be hot dip galvanized and shall be epoxy painted in addition.

All anchor bolts shall have a concrete cover of at least 10 cm.

* + - 1. Steel Grating

Steel grating shall be welded type of rectangular pattern of parallel bearing bars of 45 mm depth and 5 mm thickness and at 30 mm centres with twisted cross bars at 100 mm distance, unless otherwise instructed by the Employer / Employer’s Representative.

Gratings shall be hot dip galvanized after fabrication. All grating indicated as removable shall be bolted or clipped to supports. Sizes of grating shall be such as to afford easy handling. The Contractor shall cut, as shown on all certified drawings, neat, circular or square openings for the passage of pipes, ducts, etc., through gratings. The Contractor shall provide toe plates at all unprotected open sides at ends of grating and where shown on drawings and the Contractor shall weld bands made of steel plate matching the toe plate height at all openings. All gratings shall be arranged so that bars in either direction are aligned.

Bearing bars shall be of depth required to support the design loads at allowable stresses and a deflection not exceeding 1/250 of span length.

* + - 1. Ladders

The Contractor shall provide all ladders to heights and accesses as required in the design, e.g. to reach roofs, basements, emergency exits, cable trenches, manholes, etc. Side-rails of ladders shall consist of 65 x 12 mm flat bars, or angles L 60/8 or L 75/10 according to the approved design. Rungs shall be of 25 mm diameter ribbed bars, tenoned into the side rails and securely welded. Rungs shall be 0.4 m long between side-rails and spaced 28 cm. All ladders shall be hot deep galvanized.

Ladders shall be securely fastened at top and bottom into the wall and shall have intermediate clips or flats and fastenings spaced not more than 2.0 m apart. Clips or flats shall be riveted or welded to the side.

Ladders exceeding 2.5 m in height shall be equipped with safety cages starting 2.50 m above ground or floor, and extending over the full height of the stringers with an unobstructed inside diameter of at least 0.7 m.

The safety cage shall be constructed from 55 x 6 mm flat steel bar hoops, bent to the specified radius and spaced uniformly and horizontally at a maximum of 1.5 m and 5 equally spaced 40 x 6 mm vertical flat bars, welded to the inside face of hoops to provide a smooth and snag-free interior of the cage.

Ladder shall be constructed staggered with landings at every 10 m in height.

* + - 1. Steel Stairs

Steel stairs shall have an inclination not exceeding step heights of 190 mm with a depth of not less than 250 mm. The height of all steps within one flight shall be the same. The maximum height of one flight shall be 18 steps.

* + - 1. Toe Plates

100 mm-high toe plates shall be provided at the perimeter of all platforms and stair landings.

Around floor openings for permanent equipment, and where the clearance between the edges of the flooring is greater than 50 mm, but less than 150 mm, toe plates are also to be provided. Clearance of more than 300 mm requires railings and toe plate around the opening. On structures with flooring subject to spillage accumulation, toe plates shall be spaced 25 mm above the floor to allow catalyst to escape.

* + - * 1. Control Building

The general construction features for the civil construction works of the buildings shall be as follows:

* + - 1. Foundations

All foundations shall be placed in-situ on the ground prepared as defined in chapter "Earth Works".

One layer of 5cm thick lean concrete shall be placed prior to casting of foundations. The requirements for the foundation concrete and lean concrete are specified in chapter “Concrete Works”.

All foundations and structural parts of basement foundation walls that are below the water table shall be protected with a waterproof cover against percolation of water on the bottom and on the outside of the walls, considering the pertinent water pressure at the relevant depths.

* + - 1. Structures

The main body of the buildings shall be constructed as a reinforced concrete frame structure consisting of columns, beams and slabs and some parts of concrete walls. Any concrete to be used for these structures shall be made of sulphate resistant cement (type V cement).

The control building shall be located in the substation plot to ensure full view of the switchyard by the operator while seated in the operator room.

The height of the control room shall provide minimum 1.2 m clearance over the top of the tallest cabinets/panels to the bottom of ceiling.

Ramps shall be constructed for entry of material handling equipment (e.g. forklifts) into store room and battery room for loading and unloading of the equipment during maintenance period. A ramp shall also be provided to the main entrance of the control room for movement of persons with disabilities. The ramps shall have a maximum gradient of 1:12.

The Control Building shall house the following in separate rooms:

* Control and Protection Panel room
* Battery room
* Auxiliary services room
* Telecommunication room
* Office room
* Meeting room
* Separate washrooms for Ladies and Gents
* Store room
* Furnished Kitchen
* Operator room
* Crèche/Lactation room

The control building shall be placed in positive pressure environment to secure from dust accumulation. The design of this system shall be approved by the Employer/Employer’s representative

The Control building\* layout shall be as per the bid drawings provided.

The sizing of the Control building shall consider space for installation of control and protection panels for the future extension works.

* + - 1. Control and Protection Panels room

The floor finishing shall be concrete floor and walls with anti-dust paint to raised floor elevation and 500mm raised floor.

The wall finishing shall be cement plaster with white flat emulsion paint finish. The door shall be fitted with a panic lock and shall open to the outside.

* + - 1. Battery room

The battery room shall only have external access. This external door shall be fitted with a panic lock and shall open to the outside.

All electro-mechanical installations shall be explosion proof.

The battery room shall have no windows.

Ventilation louvres shall be fitted on the external wall. The battery room shall also be fitted with an extractor fan and ventilation louvres appropriately mounted to allow sufficient flow of air. This shall be included in the design to be approved by the Employer.

A suitable eye wash shall be provided inside the battery room. The eyewash design shall be subject to Employer/Employer’s Representative’s approval. It shall be installed at a height of 1.5 m above finished floor. The floor area around the eyewash shall have a bund to collect splashed water, if any. Plumbing for supply of water and drainage shall be provided.

The floor finishing of the battery room shall have battery electrolyte resistant tiles.

The wall finishing of the battery room shall have battery electrolyte resistant tiles to a height of 1500mm above the floor. The section above shall have cement plaster with white flat emulsion painting.

* + - 1. Auxiliary services room

The floor finishing shall be concrete floor and walls with anti-dust paint to raised floor elevation and 500mm raised floor.

The wall finishing shall be cement plaster with white flat emulsion finish.

* + - 1. Telecommunication room

The telecommunication room shall have windows that only let in natural light and not air from outside into the room. The room shall be placed in positive pressure environment to secure from dust accumulation. The design shall be approved by the Employer/Employer’s representative. The floor finishing shall be concrete floor and walls with anti-dust paint to raised floor elevation and 500mm raised floor. The telecommunication room shall be EMI shielded.

The wall finishing shall be cement plaster with white flat emulsion finish.

* + - 1. Office and Meeting room

The Contractor shall provide an office and a meeting room.

The floor finishing shall be tiled flooring with a matching skirting as per the Employer/Employer’s representative requirements.

The wall finishing shall be cement plaster with white flat emulsion paint finish.

* + - 1. Washrooms for Ladies and Gents

The Contractor shall provide separate washrooms for Ladies and Gents. Each washroom shall be fitted with WCs, washbasins and one bathroom. Urinals shall be fitted in the Gents washroom.

The shower units in the bathrooms shall be fitted with adequate plumbing including mixers to accommodate/suitable for solar water heating system.

The washrooms shall be fitted with windows to allow for adequate ventilation and natural light. An extractor fan may be provided, if need be, subject to the Employer/Employer’s Representative’s approval.

The floor finishing shall be non-slip ceramic floor tiles.

The wall finishing shall be ceramic wall tiles up to 200mm below ceiling level. The remaining section shall be cement plaster with white flat emulsion paint finish.

* + - 1. Store room

The store room shall be located, reference to the road, in manner to allow for movement of equipment with large enough turning radius. It shall have both external and internal access.

The floor finishing shall be terrazzo/tiled/painted flooring with a matching skirting as per the Employer/Employer’s representative requirements.

The wall finishing shall be cement plaster with white flat emulsion paint finish.

* + - 1. Furnished Kitchen

The floor finishing shall be non-slip ceramic floor tiles with matching skirting.

The wall finishing shall be ceramic tiles to a height of 1500mm above the floor. The section above shall have cement plaster with white flat emulsion painting.

The kitchen shall be equipped with a sink with hot and cold running water, a refrigerator, counters and kitchen cabinets arranged according to a modular design. The kitchen shall also be equipped with a microwave, an electric kettle, a combined gas and electric free standing cooker and a cooker extractor hood

The kitchen sinks shall be fitted with adequate plumbing including mixers to accommodate/suitable for solar water heating system.

The kitchen shall have a dining area section equipped with dining set enough for at least four people.

The cabinets shall be made of wood veneers adhered to plywood or furniture-grade particleboard. The kitchen shall have granite countertops.

The fittings in the kitchen shall be subject to approval by the Employer/Employer’s Representative.

* + - 1. Operator room

The operator room shall be located such that it allows for full view of the switchyard by the operator.

The operator room shall be equipped with furniture subject to approval by the Employer/Employer’s Representative.

The floor finishing shall be tiled flooring with a matching skirting as per the Employers requirements.

The wall finishing shall be cement plaster with white flat emulsion finish.

* + - 1. Crèche/Lactation room

The crèche room shall be furnished with a minimum of two (No.) 3-seater sofa sets and a coffee table. It shall also be fitted with a minimum 170-liter refrigerator. All these shall be subject to approval by the Employer/Employer’s Representative.

The floor finishing shall be terrazzo/tiled/painted flooring with a matching skirting as per the Employers requirements.

The wall finishing shall be cement plaster with white flat emulsion paint finish.

* + - 1. Walls

All walls to be erected between the concrete columns shall be of solid masonry blocks. All external walls shall be painted with at least two coats of synthetic resin paint.

The contractor shall make provision for all electromechanical and plumbing installations before placing the finish.

* + - 1. Flat Roof

The control building shall have a flat roof made of reinforced concrete and the Contractor shall ensure water resistance. It shall be covered with a 1200-gauge polythene vapour barrier having sealed laps. On top of this shall be sand/cement screed of minimum thickness of 75mm sloped towards the gutters at a minimum gradient of 2%. The roof shall be finished with continuous two–layer bituminous felt or other approved waterproof membrane. Solar protection shall be provided by light coloured tiles bedded in bitumen with 75mm wide strips between tiles filed with rounded shingle.

The contractor shall make provision for all electromechanical and plumbing installations before casting the roof slab.

* + - 1. Ceilings

The ceiling finishing shall be cement plaster with white flat emulsion paint finish. The contractor shall make provision for electromechanical and plumbing installation before casting the roof slab.

The design should incorporate all services that shall be located and/or passed through the ceiling.

* + - 1. Suspended ceilings

Double-grid acoustic suspended ceilings shall be made from square type aluminium panels of a type and colour as approved by the Employer / Employer’s Representative. Minimum panel thickness shall be 0.80 mm. Adequate and integrated light fittings (including emergency lighting) have to be provided as well.

* + - * 1. Flooring
      1. Materials (Quality, Delivery, Storage, Handling)

Flooring shall cover the following:

* bonded cement screed
* PVC flooring
* terrazzo flooring
* tiled flooring
* raised floor
* Epoxy painted floors

They shall meet the following requirements as specified hereafter.

* + - 1. Bonded cement screed

Materials for bonded cement screeds shall consist of:

* Portland cement as specified for the relevant location or as instructed by the Employer/Employer’s Representative.
* Sand with following gradation:

Sieve Percent passing

9.00 mm 100

4.75 mm 100

1.18 mm 65

0.30 mm 15

0.15 mm 5

* Coarse aggregate with following gradation:

Sieve Percent passing

12.50 mm 100

9.00 mm 100

4.75 mm 60

2.36 mm 5

Dry weight proportion of mix shall be 1-part cement 1-part sand and 2 parts coarse aggregates.

All technical requirements shall be as specified under specification “Concrete Works”.

* + - 1. PVC flooring

PVC flooring material shall have the following properties: Waterproof, abrasion-resistant, flame-proof, pigment or colour proof to light, evenly coloured throughout, resistant to chemicals, fats, slight acids and alkaline, be odourless, easily laid and flexible, non-porous and slip-proof.

* + - 1. Terrazzo Flooring

The surface of floors exposed to extremely heavy wear and tear shall be improved by additives against abrasion and shall receive a plastic based (two components) paint finish or shall be covered with plastic (PVC) tiles. Terrazzo finish shall be used instead of screed is also acceptable.

* + - 1. Tiled Floors

This is subject to approval by the Employer/Employer’s Representative.

* + - 1. Epoxy painted floors

All epoxy coated floors shall be oil and water resistant and easy to clean. The epoxy floor will provide high-performance, smooth and durable surface that can withstand heavy loads. The concrete floor will be fully cured before placement of the epoxy coating. All major cracks and chips in the concrete surface to be repaired and grease removed before application of the epoxy coating.

* + - 1. Raised floors

The raised floor system shall consist of panels, pedestal and stringers. The raised floor system shall be non-combustible and fire proof. It shall also have high dimensional precision and strong loading capacity.

Raised floor systems shall be as per the specifications below:

Pedestals

The pedestals shall be made from galvanized steel. The pedestals shall be round tubes of minimum 2.5cm diameter welded to a steel base and shall allow for vertical adjustment.

The pedestal head shall be prevented from uplift by a threaded connection to the pedestal tube. The head shall be adjustable for vertical height and a lock nut provided for height adjustment only. A gasket shall be placed on the pedestal head and shall be made from anti-static plastic material.

The pedestals shall be installed in a 600mm by 600mm grid pattern. The pedestal base shall be secured to the building floor with galvanized steel anchor bolts. Adhesive bonding shall not be acceptable because of the limited strength of adhesive and the reduction of performance with aging. The pedestal base shall have a tapped hole for earthing connection.

The overall floor height shall be measured from the surface of the building floor to the top surface of the access floor panel. The standard floor height shall be a minimum of 500mm.

Stringers

Stringers are used to interconnect pedestals in a 600mm by 600mm grid for greater stability and to provide support for floor panels.

Stringers shall be made of galvanized shaped and designed to be secured to each pedestal head with a threaded screw. The screw head shall be recessed into the stringer. The stringers shall be provided in 1.2m lengths for the majority of the floor area. Shorter stringer lengths are acceptable along the perimeter of the floor area, against building structural components and against equipment platform stands.

The stringers shall always be secured to the pedestal heads.

Floor panels

The floor panels shall be designed to be removable by lifting them upwards and out of the stringer grid revealing the space under the floor.

The floor panels shall have anti-static properties in accordance with IEC 610000-4-2 and rated at minimum 5 kN concentrated load capacity. The panels shall be of maximum size 600x600x40mm. The tiles shall be made of reinforced calcium sulphate panels with steel sheet bottoms and High Pressure Laminate (HPL) top finish or other material approved by the Employer/Employer’s Representative. The surrounding edges of the panels shall be chamfered and have protection against damage and humidity.

The following tolerances shall be observed:

* 0.2 mm width and length
* 0.3 mm diagonal
* 0.2 mm thickness

Loading for Raised Floors

The maximum allowed deformation shall be 2 mm under 5 kN point load.

Minimum height of the free space between subfloor and raised floor surface for control room 0.80 meter, except if noted otherwise in the execution drawings.

* + - 1. Installation

All materials and structural components shall be processed in accordance with manufacturer’s instructions.

Prior to the start of his operations under this section, the Contractor shall verify that all conditions are suitable for the timely and effective performance of his work.

Work shall be carefully laid out to ensure symmetry about centrelines of the area involved and to obviate the use of less than half pieces of tiles, slabs, etc.

The work shall be executed with the highest degree of precision and according to the drawings and specifications.

* + - 1. Preparation of surface

Before surfaces are covered with tiles, flags or mosaic to be set in normal mortar bedding, a sprayed coating of cement mortar shall be applied to the base unless otherwise specified.

Where no adequately even surface is available for work involving thin beddings, special provisions shall be made to compensate for this, e.g., rendering coat, screed.

The concrete surface to which tiles, flags, terrazzo, screed, etc. are to be placed, shall be cleaned by wet sandblasting and washed with water under pressure, so as to produce the specified surface condition.

The concrete surface shall be kept thoroughly wet for a period of 24 hours prior to the placing of tiles etc.

The screed coat of mortar shall consist of one part Portland cement and four parts sand and shall be worked to a true, level or plumb surface, finishing approximately 15 mm below finished level for floors, borders, and thresholds and approximately 10 mm back of finished face of bases and other vertical surfaces.

The subsurface of floor coverings shall be cleaned carefully prior to commencement of work.

The base for coverings to be placed without underlay shall be smoothed with filler compound. In the case of major unevenness, a suitable levelling compound shall be used.

Any filler or levelling compound shall be applied so that it will bond firmly and durably to the base, will not crack and will adequately withstand pressure.

* + - 1. Protection of flooring

All flooring work, such as PVC flooring, raised flooring, tile flooring, terrazzo tiling, stairs, etc., shall be protected from any damage. Flooring access barriers to the individual rooms shall be provided until the floorings can be walked on. Floorings shall be covered by adequate means, such as sawmill, plastic foils of min. 1 mm thickness or similar protecting materials. Before handing over, all flooring work shall be properly cleaned.

* + - 1. Floor Preparation

The floor shall be smooth, level and free from protrusions before installation of the raised floor system.

The concrete surface beneath the raised floor level (including walls and floor surface) shall be sealed with urethane, epoxy or acrylic based product to protect against surface dusting, collection of dust on concrete, reduce moisture seepage and limit water penetration. The sealant may be sprayed or roller applied. The sealant shall be clear or light in colour.

The height and placement of ceilings, windows, doors or other openings shall accommodate the installation of the raised floor system’s height.

Prior to the raised floor system installation, all permanent partitioning walls shall be installed and fastened to building floor and ceiling. Partitioning walls shall not be installed on nor secured to the raised floor system.

* + - * 1. Doors and Windows
      1. Windows

All windows for the control building shall be double glazed windows with heavy duty anodized aluminium frames. They shall be fitted with insect screens and shall be burglar proof where applicable. The windows shall have grey reflective solar control film.

The insect screen frame shall be of hollow extruded aluminium frames. Finish shall match the main frames and sash for the windows. The insect screens shall be made of fiberglass or aluminium wire secured with a vinyl spline.

All joints shall be all-weather sealed.

The size of the window openings of the control building shall be of minimum dimensions 1500mm by 1500mm. These windows shall be sliding windows. The window openings and grooves in the frame or wall shall be capable of accommodating the sliding sashes when opened. The sliding mechanism should be wheeled for smooth movement. The windows shall have at least two sashes that overlap slightly and slide horizontally within the frames. This shall apply for all windows except those in the washrooms and telecommunication room.

The size of the window openings in the washrooms shall be of minimum dimensions 600mm (width) by 800mm (height). These windows shall be awning windows that open outwards at the bottom.

The size of the window openings in the telecommunication room shall be of minimum dimensions 1000mm (width) by 600mm (height). These windows shall be fixed windows that will not open but only allow light.

Ultimately, the final window sizes and design shall be subject to approval by the Employer/Employer’s representative.

Aluminium windows

The construction features of aluminium profile windows shall be identical to those specified for doors of aluminium profiles.

Sizes as per relevant design. All movable windows shall be bottom hung. Internal insect protection screening shall be provided. All hardware shall be of concealed construction in the aluminium frames; the parapet shall be covered with an aluminium sill. Double glazing as per Specification. All fixings, screws, bolts, etc. shall be of stainless steel and of approved size and type.

Insect protection screening

Consisting of a separate aluminium frame (see window dimension) with an approved screen material to be mounted removable on to the window with clips and angle fillers.

Application: at all aluminium windows that may be opened

Position: Internally (i.e. behind glass panels) and shall not be seen at external elevations.

Louvres

Openings in exterior walls for air inlet and outlet, shall be covered with louvers and dust filters. The size shall be in accordance with the design.

Thickness of steel sheet shall be minimum 1.5 mm. The louvers shall be mounted on L profile steel frame, galvanized and of minimum thickness 50/50/ 4 mm. The opening behind the louvers shall be covered by aluminium screen for protection against insects and birds. The dust filters shall be specified according to the demands of ASHRAE.

The louvers shall be fixed to the walls. All fixing accessories such as screws, nuts, bolts, etc., shall be of stainless steel.

The joints between wall and steel frame shall be filled with mineral wool and shall be sealed with permanent elastic sealing compound approved by the Employer / Employer’s Representative.

* + - 1. Doors

The Contractor shall make provision for at least two main external entrances –excluding the battery room door – in to the control building, whose location shall be made to abide to the Fire and Safety Regulations.

The external door in the storeroom shall be double leaf. The external door in the battery room shall be leaf and half type. All the other external doors leading to main control building shall be double-leaf.

All external doors shall be made of 1.5mm minimum thickness zinc-coated steel sheet to BS 1449 and BS EN 10152 and shall incorporate welded corners. The frames shall also be made of zinc-coated steel. These doors shall be fitted with a panic lock and shall support provision for access control facilities.

All internal doors shall be single leaf and shall be made of heavy duty anodized aluminium.

The doors shall have adequately sized glass transom windows at suitable height subject to approval by the Employer/Employer’s Representative.

All doors shall fire resistant and the construction must meet the following requirements:

* All external doors shall be provided and installed such that they will open to the outside of the control building.
* All internal doors (except the protection and control panel room) shall be provided and installed such that they will open to the inside of the respective room.
* All doors shall be capable of being opened from inside the rooms without using a key.
* All doors shall be provided with a Master key system subject to the approval of the Employer/Employer’s Representatives.
* The sizing of the doors shall allow for wheeling of complete panels.
* All doors shall be triple hinged doors.
* Suitable dust covers shall be provided for all outside doors and all joints shall be all-weather sealed.

Gauges of sheet steel

Except where other gauges are indicated or specified, the gauges of sheet steel shall not be lighter than the following gauges:

* Door frames in general 16
* Frames in hinged doors, having an inside height of more than 1.8 m 16
* Architrave, auxiliary frame, etc. 16
* Door saddle, rails, stile, panel plate, flush plate 16

Steel doors criteria

All galvanized steel doors must meet the following minimum requirements under this contract as specified hereafter:

* Material: Steel sheet of at least 1.0 mm thickness
* Frames: To be made at least of 2.0 mm thickness.
* Build-up: Steel doors shall be of double skinned construction, fully filled with suitable, approved fire resistant material.
* Hinges: Each door leaf shall be fixed at least 3 hinges.
* The fixing of the doors to the walls shall be accomplished by means of flat steel anchor strips 40/4 mm and 8 to 10 mm diameter steel bolts, either cemented into walls where masonry or concrete will be met, or welded to a steel substructure. On a length of 2.50 m, a minimum of 3 anchors have to be provided. The lengths of the bolts shall be such that they will stand the stresses to be expected.
* Hardware: All doors shall receive mortice locks for steel doors, with back sets of 65 mm; the function of the locks shall be of the night latch type with one separate dead bolt.
* stainless steel lever handles. Alternatively, on one side a knob may be requested by the Employer / Employer’s Representative
* stainless steel door handle plates or roses
* cylinder lock for general master key system
* stainless steel roses for the cylinder lock, unless covered by handle plate stainless steel dust cover to locks at outside door closer.
* The clearances for hinged doors shall be 3 mm at jambs and heads, 6 mm at meeting stiles of pairs of doors and 6 mm at bottom, unless specifically indicated or specified otherwise.
* Joints formed with mechanical fastenings shall be closely fitted and made permanently watertight.
* Top and bottom edges of all metal doors shall be closed to provide a weather seal. This seal may be provided as part of the door construction or by the addition of inverted steel channels or other suitable shapes welded to the face sheets.

Criteria for fire doors

Fire rated steel doors and frames shall be labelled/listed type and shall be designed, manufactured and installed in according with NFPA 80 and shall be tested in accordance with NFPA 251 or equivalent.

Fire rating of door, frame, hardware and other accessories shall be at least 90 minutes for stability/integrity and 30 minutes for insulation.

Fire door assembly test certificate from an independent, internationally recognized laboratory confirming the above shall be submitted along with Vendor / Material submittal.

Fire door leaves shall be manufactured with double flush skins of galvanized steel sheet, edges and welded to the case. The case has to be stiffened with steel section frame. The door leaf shall be filled with suitable fire resistance material to limit the transmission of heat on the unexposed side of door.

The size of door shall be suitable for access of the largest items of the equipment to be installed and to the satisfaction of the Employer / Employer’s Representative.

All the fire door hardware, fire exit hardware, builder’s hardware, glazing material in fire doors shall be listed / labelled type.

Manufacturer’s literatures confirming the labelling and listening of door, frame, hardware, glazing material etc. shall be submitted along with Vendor / Material submittal.

All door hardware, furniture, unless specified otherwise, shall be stainless steel. Samples shall be submitted for the Employer / Employer’s Representative approval.

Weather sealing gasket around the door leaf shall be provided to prevent the ingress of dust. The sealing gasket shall be from non-combustible or limited combustible material of listed type.

Number of latches and hinges shall be according to NFPA 80 and shall be listed / labelled type.

The door assembly shall be adequately reinforced for all hardware, lock and the cut outs for lock, handle, knob etc. shall be made at the factory.

Complete, detailed drawings with sections, hardware, furniture etc. shall be submitted for approval by the Employer / Employer’s Representative before manufacturing the door.

Painting of door and frame shall be according to the relevant section of these specifications. Two shop coats protected against corrosion are required. The first coat to be applied before assembling of the door starts.

The fixing of the door frame to the walls shall be carried out by means of flat steel anchor strips either cemented into the masonry or concrete wall or to be screwed to the steel structure.

Three anchors shall be provided per 2.5 m length with a minimum of six anchors per door frame.

Mortice locks to be installed for centre latch, fire-protected by suitable material, prepared to insert a profile cylinder of the master key system, panic device, exit device, designed for trouble-free operations.

Overhead surface mounted door closer, fully adjustable to spring power and closing speed, stainless steel.

For double winged doors: door selectors and lever bolts with rod and keep shall be applied.

Door stopper for each leaf shall be fixed according to the advice of the Employer / Employer’s Representative.

All fire doors shall be arranged to remain in the normally closed position with suitable self-closing device.

Panic device

Panic devices shall be installed for all emergency exits and the switchgear hall exits, both for single and double-winged doors with overlapping astragal. Simultaneous opening of double doors shall be ensured by slight pressure on any part of the panic cross-bar.

The outside operation shall be made by lever handle with a dead locking mechanism.

Sectional doors or hinged wing doors

Generally, profiled galvanized steel doors of the overhead track type shall be installed. They shall be of the polyurethane foam-filled type or an approved equivalent.

The minimum size for the doors to be used by trucks delivery shall be 3.50 x 5.00m.

* + - 1. Insulation

Jambs, heads, sills and exterior mullions, window units and exterior door frames shall be completely insulated with fiberglass in place and of thickness as shown on the approved drawings.

* + - 1. Connectors

Exposed screws and bolts for aluminium work shall be aluminium alloy or stainless steel, lengths as required and chemically treated to match the bronze finish whenever used on duranized items. Modified truss and pan heads may be used, if approved by the Employer / Employer’s Representative, in areas where counter-sinking is not practicable due to gauge of finish material.

* + - 1. Metal finishes

Unless otherwise specified, aluminium surfaces shall conform to the following: Duranodic finish, or equivalent.

All exposed aluminium surfaces shall have a finish with standards and procedures equivalent to the Bronze Natural Colour applied to mill finish.

The coating shall be applied having a minimum thickness of 17 µm and have a minimum weight of 5 mg/cm2. Colour range samples shall be submitted to the Employer / Employer’s Representative for approval before commencing with the production.

* + - 1. Criteria for the construction of doors, windows and walls of aluminium profile

General construction features:

Table 5: Criteria for the construction of doors, windows and walls of aluminium profile

|  |  |
| --- | --- |
| Height/width | As shown on approved drawings |
| Material | Frames of extruded aluminium profiles of decorative duranodic or powder coating finish; quality of aluminium alloy to withstand the adverse local climatic conditions a 5-year guarantee has to be given on all materials |
| Sections | Approx. 55 mm (deep) x 110 mm width, thickness not less than 2 mm, and the bottom rail 125 x 55 mm |
| Glazing | Double Glazing, with glazing stops of square profile of the snap-in type, with neoprene bedding for glass panes (glazing clips) |
| Fanlights | As per relevant description |
| Hardware | Security bolt lock with profile cylinder for master key system; 1 floor mounted automatic door-closer with hold-open at 150 degrees with floor stop, door-holder and cover-plate; top off-set pivots in aluminium; aluminium cross- bars on both sides of each leaf as pull/push handle, 200/10 mm tubular section; all bolts and screws shall be concealed in the frame of the top flush type; rose type fact plates for lock and cylinder; all material stainless steel |
| Fixing | Fixing of aluminium frame to the structure shall be done as per the standard and as approved by the Employer / Employer’s Representative with anchor plates and bolts, rigidly cemented into wall. Space between door construction and concrete/masonry wall shall always be filled with rock-wool or other approved insulation. |
| Joints | Joints of doorframe to walls shall be covered with aluminium angles 25/25/2 mm on each side, and the outside shall be sealed with permanent elastic materials. |

These construction features apply to single and double winged doors, fanlights, as well as to fix side frame elements or any other exterior glass wall elements.

The components of the construction shall be sized to the stress required, but not less than mentioned as follows:

* Built-in frame 30/110/2 mm
* Mullions 50/110/2 mm

During application of grouts, the Contractor shall give special attention to manufacturer's written instructions and follow them carefully.

* Sidelights framing 50/50/2 mm
* Fanlight framing 50/50/2 mm

For door stop, rubber seal required

The hardware for the metal work shall be furnished and installed in the door by the Manufacturer, and shall include standard items as follows:

* Mortice security lock, prepared for the profile cylinder of the master key system
* Door-o-matic floor spring, with backstop, consisting of fully hydraulic closer with adjustments for spring tension plate closing and latching speed, cover-plate of stainless steel
* Top offset pivot of stainless steel
* Push bars on each side of each wing as pull handle, height 200 mm, approx. 10 mm thickness, aluminium tubular section, width same as door wing, securely fastened into spacer, mounted by screws on the door sills
* Profile cylinders
* Weather shield of extruded aluminium profile
* Double glazing, safety glass
  + - 1. Master key system

An appropriate serviceable and functional key system shall be installed. Details of the system itself shall be defined in close co-ordination with the Employer / Employer’s Representative and only after obtaining approval from the Employer / Employer’s Representative the order shall be placed.

Necessary attention shall be paid to later extensions to the Grand Master Key System, which shall be suitable for the entire plant including all final stages.

The profile cylinders shall be sea water resistive and shall suit all plant requirements and shall be of types such as half, double, asymmetrical, short cylinder, etc.

The material of the cylinders shall be of massive brass, nickel plated with six security pawl studs, Heavy security cylinder mortar lock, profile SNP cylinder, all in accordance with the key system of the existing phase.

The keys shall be made of new silver material and shall have an engraved indication of the applicable key system and the compound/group/ or door number. Keys shall be supplied in accordance with the requirement of the Employer / Employer’s Representative.

Keys shall be supplied in the following numbers:

* General master key 3
* Main keys 3 nos. per each building
* Single keys 3 nos. per each door

The following requirements shall be met:

* the general master key shall operate all locks
* the main key shall open all locks of one building
* the single key shall open the lock of a single room
  + - * 1. Painting
      1. Paints

The Contractor shall submit for approval the name of the manufacturer proposed to be used. Only paints suitable for the climatic conditions of the site shall be used.

All materials shall be delivered to site in sealed containers on which the maker's name, specification and date of manufacture are clearly displayed and shall be stored to comply with the requirements for the preservation of the paints.

Colours and undercoats as described in the KETRACO colour manual and approved by the Employer shall be used.

* + - 1. Application

Application of paint shall be by brush or roller, as a roved or directed the Employer. The treatment to be given to the different surfaces shall be specified by the Contractor and approved by the Employer / Employer’s Representative.

All paint shall be applied in accordance with the manufacturer's instructions and shall not be diluted in any way unless specifically stated or agreed by the Employer. No external paint work shall be carried out during high winds and rains or other unfavourable weather conditions.

All rubbish and debris shall be removed and floors swept and dampened before painting commences. Door, furniture, light switch covers and the like shall be removed and surrounding surfaces covered with canvas or other approved protection.

Newly painted surfaces shall be protected against contamination by dust or other causes.

* + - * 1. Cable Ducts/Trenches

Cable trenches/ducts shall only be used in the control building upon approval from the Employer/Employer’s Representative.

Cable trenches/ducts inside the control building shall be covered by hot dipped galvanized steel checkered plates. The thickness of the checkered plates shall not be less than 6 mm. They shall be designed to support floor live loads and they shall be provided with adequate non-protruding handles to allow easy opening.

When placed in position, the covers shall be good in level and matching the formed/finished surface of the floor and the appropriate galvanized angles with continuous bore stops shall be installed on the cable ducts/trenches to position the checkered plate.

All cable ducts, trenches and entries shall be fully sealed against weather and vermin. The contractor shall provide a suitable sealing solution that shall be approved by Employer/Employer’s Representative.

* + - * 1. Portable Fire Extinguishers

The extinguishers shall be designed, installed and tested in accordance with NFPA No. 10 and SASO standard of latest edition. Extinguishers shall be distributed in all staircases and corridors in a manner that traffic will not be obstructed. As a further condition, extinguishers shall be located at easily visible and accessible locations considering the event of fire.

Dry chemical extinguishers, multi-purpose cartridge type, shall be supplied. As a rule, powder units containing 12 kg shall be supplied which combine all of the extinguishing effects and are permitted for fires of class A to C in the presence of electrical voltage up to 1000 V. For class D fires involving combustible metals, dry compound extinguishers shall be introduced.

The portable fire extinguishers shall be fitted with spring headed interchangeable safety valves.

Rooms and areas where a voltage above 1000 V may be present and/or housing relays control and computer units shall be equipped with portable carbon dioxide extinguishers. In addition, suitable masks to prevent injury to personnel shall be supplied and placed within easy reach of control building personnel.

All extinguishers shall be designed to service over a period of 20 years taking the conditions at the site into account.

The supplied extinguishers shall be provided as early as possible; at the latest, on commencement of pre- commissioning preparation of control buildings and equipment.

Reference shall be made to the respective fire protection standards during the construction period.

After completion of the installation, random tests of 5% of the portable extinguishers supplied shall be performed in connection with a training program. The necessary refills shall be provided by the Contractor.

The following arrangement criteria shall be met:

* Maximum travel distance to an extinguisher: 25 m
* Maximum area to be protected per extinguisher: 500 m2

The fire protection requirements may be fulfilled by several extinguishers at ratings lower than 12 kg. This shall be subject to approval by the Employer/Employer’s Representative.

* + - * 1. Furniture

In general, furniture requirements shall be as stipulated in this Specifications and subject to the Employer/Employer’s representative approval.

The office chairs shall be of ergonomic design.

* + - * 1. Roofing
      1. General

This specification covers the roofing systems of this specification. The design and execution must be state of the art, functional and complete in all parts in accordance with this specification.

The Contractor shall furnish all plant, labour, materials and carry out all operations in connection with the installation of all rigid insulation, built-up roofing and plastic flashings as shown on drawings and as specified.

Rigid insulation and asphalt built-up roofing shall be applied to the roof surfaces indicated. Roofing operations shall be coordinated with sheet metalwork so that flashings are installed to permit continuous roof surfacing operations. The roofing or flashing shall be applied to a smooth and firm surface free from moisture, dirt, projections, and foreign materials. Vents and other items penetrating the roof shall be secured in position and properly prepared for flashing. Surfaces shall be inspected and approved immediately prior to application of roofing and flashings. Roofing materials shall be stored in an approved manner and shall be protected from contact with soil and exposure to the elements.

Rain water shall be discharged via gutters and downpipes into the storm water drain pipes.

* + - 1. Codes and Standards

Design and execution must be in accordance with all relevant standards.

* + - 1. Materials (Quality, Delivery, Storage, Handling)

Materials shall be protected from damage and from exposure to sun, weather and dampness during transit and after delivery to the Site. Damaged or damp material shall not be installed in the work.

* + - 1. Execution (Assembling, Installation)

Application of roofing

The entire roofing system, including cement tile surfacing, shall be finished in one operation up to the line of termination and of day's work. Phased construction will not be permitted. Temperature of bitumen at the time it is applied shall be in accordance with the roofing felt manufacturers recommendations. Layers of roofing shall be laid free of wrinkles or buckles at right angles to the slope of the deck. To insure a waterproof membrane, care shall be taken to preclude bare spots between plies. To prevent slippage, care shall be taken to preclude use of an excessive amount of bitumen. Bitumen shall uniformly cover all roof areas to be mapped to provide an effective bond.

Each course of roofing felts shall be lapped as specified in Table I. The surface of the felts shall be carefully broomed-in with 45 or 50 cm wide, soft-Fibre-type floor broom to obtain complete adhesion between plies and to eliminate air pockets.

Each layer of roofing felt shall be carried up abutting vertical surfaces.

Table 6: Laps for Roofing Felts

|  |  |  |
| --- | --- | --- |
| Layer of Plies | Laps in cm  91 cm width | Starting widths in cm  91 cm width |
| 1 | 10 cm | 91 cm |
| 2 | 48 cm | 45 and 91 cm |
| 3 | 63 cm | 30, 60 and 90 cm |

End laps of roofing felts shall be not less 15 cm and shall be staggered a minimum of 30 cm.

Water cut-offs

At end of day's work, and whenever precipitation is imminent, exposed insulation shall be protected with two full width strips of felt set in plastic bituminous cement. Extend half-width of strips up and over the finished roofing and extend the other half-width out and onto the bare roof deck surface. Water cut-offs shall be removed before continuing installation of roof system.

Nails and fasteners

Nails and fasteners for security roofing shall be flush-driven through flat metal disks of not less than 25 cm diameter. Metal disks may be omitted where heads of fasteners are equivalent in size to the 2.5 cm diameter disks.

Mechanical application

Mechanical application devices shall be mounted on pneumatic tired wheels, and shall be designed and maintained to operate without damaging the insulation or the roofing membrane.

Rigid roof insulation

Rigid roof insulation shall be applied in strict accordance with manufacturer's recommendations and the following:

* Preparation of deck

Roof deck shall be firm, dry, clean and properly graded to all outlets.

* First

Apply the insulation by mopping into bitumen using 1.2 kg per square meter. Asphalt shall be applied between a temperature of 175°C and 218°C.

Edges of the felt shall be turned up on, but no cemented to all vertical surfaces to height of 20 cm.

* Second

Apply the units of insulation with long joints continuous and short joints broken. Mop the full width under each unit of insulation with asphalt using 1.6 kg per square meter, or per layer of insulation, when more than one layer is used. Before application of the roofing, the projected 15 cm of felt at vertical surfaces and at all edges shall be turned over the insulation and mopped solidly with asphalt. The insulation shall not be left exposed to weather. No more insulation shall be applied than can be completely covered with the roofing felt on the same day.

Flashing

Shall be provided in the angles formed at walls and other vertical surfaces and where required to make the work watertight. Bituminous-plastic-type-flashings described below shall be used where metal flashings are indicated. Flashings shall be provided and installed immediately after the top ply of roofing is placed and shall be returned and sealed or capped and sealed to waterproof edges and ends. Flashings shall be stepped where vertical surfaces abut sloped-roof surfaces.

Base flashing

Base flashings shall consist of one layer of the roofing felt base flashing over one ply of roof felt. Masonry and concrete over which flashing is to be installed shall be primed with asphalt primer. After asphalt primer has thoroughly dried, the roofing felt and base flashing shall be evenly embedded in successive layers of bituminous cement, trowelled on at 2.5 kg per square meter. The flashing shall extend not less than 10 cm onto the roofing felts, and not less than 20 cm or more than 40 cm up the vertical surface, secured at the top on 20 cm centres with nails or fasteners. Base flashing and felt sheet shall not be greater than 3.5 m in length lapped not less than 15 cm with laps staggered in each layer. The roof edge of the base flashing shall be covered with a 10 cm wide strip of roofing felt, embedded in and coated with bituminous cement. The entire surface of asbestos base flashing shall be given a 3 mm thick trowelled coating of bituminous cement. Final coat of bituminous cement shall cover fasteners and shall extend at least 2.5 cm above top of flashing on vertical surface. Instead of bituminous cement, flashings may be applied with Type III asphalt in accordance with manufacturer's printed recommendations followed by the final coat of bituminous cement as described above.

Strip flashing

Roof flanges of lead and sheet-metal flashings, such as plumbing flashings, provided under other clauses of the specifications shall be stripped with 2 layers or roofing felt set in plastic cement. After installation of flanges or flashings over the top of roofing, the strip flashings, consisting of two layers of roofing felt 23 and 30 cm wide shall be successively plastic cement, to form a waterproof joint between roofing and flashings.

Roof cut-out samples

Samples shall be taken as directed by the Employer/Employer’s Representative when there is reason to believe that deficiencies exist in the roofing membrane. When samples indicate deficiencies in the roofing membrane, corrective action shall be taken as directed.

Surfacing

After roofing felts have been laid and flashings installed, the entire roof surface shall be uniformly covered with soft building sand, slightly damp and evenly laid as to no exceed 1.5 cm in depth and consolidated by tamping. After the sand has been laid building paper shall be laid over the sand, lapped so that the sand is completely covered. Concrete pavers shall be set in a 1 cm thick mortar bed composed of 1:3 cement mortar laid over the building paper. The joints between pavers shall be the same cement mortar of thickness.

* + - * 1. Clean and Waste Water Supply System

The water supply system required for the substations shall include:

* A main storage tank with capacity of min. 5000 litres Reinforced concrete underground tank shall be installed. The main tank shall be provided with a water inlet. Two smaller tanks of each 1500 litres shall be installed on an elevated platform near the control building and the guard house respectively. The tank has to be protected and insulated against sunshine heating effects.
* The smaller tank shall be automatically filled by a pump from the main tank. The pump motor shall be controlled by a water level controlled switch in the smaller tank.
* all pipelines, connections pump and associated works for the satisfactory operation of the water supply system.
* internal connections for the sanitary installations.
* The main pipe supplying water to control building shall be PVC lining carbon steel pipe (ø ½”). All valves shall be made of cast iron or bronze.

The fittings shall include toilet paper roll holders, soap dispensers, etc.

The following points shall be supplied with water points:

* toilet and battery room wash basins
* toilet's urinal
* water closet
* showers
* kitchen
* Solar water heating system

Water pipes within buildings will generally be of cooper or galvanized steel. Unplasticised PVC pipes may be used for cold water lines only, subject to approval of the Employer. Unplasticised PVC pipes shall conform to approved class and manufacture and shall be jointed and fixed to walls using the correct fittings and fixings as supplied or specified by the manufacturer.

* + - 1. Sanitary Installations

The Control building shall have sanitary installations comprising of WC sets, urinals, washbasins and shower units connected to a septic tank or public sewer system if available. All material to be supplied shall be standardized and shall be of selected quality approved by the Employer/Employer’s Representative.

* + - 1. Water Supply

The water supply to a solar water heating system shall be provided. Where borehole water is provided, the pumping system shall be powered by solar pump, complete with the PV panels, automated control and accessories.

A rain water harvesting solution shall also be included in the design.

The tank shall be supplied along with the necessary inlet pipe, outlet pipe, vent pipe, overflow pipe, drain pipe and necessary accessories.

PVC pipes shall be supplied and installed for cold-water distribution from the main inlet to the water tank and from the water tank to all sanitary fixtures according to the design accessories such as bends, union, etc.

The Contractor shall determine the most practical way to provide water from the existing water system. In the event that there is no existing water system, the Contractor shall provide a borehole. The Contractor shall submit the design of the water supply system for approval.

* + - 1. Lavatory basins

Lavatory basins in the sanitary and battery rooms shall be white ceramic, with mirrors, to be approved by the Employer before purchase or fixing in the works.

* + - 1. WCs and cisterns

Unless otherwise agreed or directed, water closet pans shall be of western type, white ceramic or metal. Flushing cisterns of white ceramic metal or plastic. All materials shall be approved by the Employer/Employer’s Representative before fixing in the works.

* + - 1. Urinals

The urinal shall be white ceramic.

* + - 1. Waste water system

The waste water from kitchen, sink, battery room wash basin, urinal and exterior taps shall be connected by drain pipes to septic tanks outside of the substation buildings.

* + - * 1. Roads and Surfacing
      1. General

The permanent roads within the site are to be designed on the basis of a 25-year life with 50 commercial vehicles per day. Due account is required to be taken in the road design of abnormal loads during both the construction phase and also during the operational life of the plant resulting from heavy maintenance.

The roads are required to be of such geometrical alignments (longitudinal gradient, cross-fall, radius and width) to accommodate the movement of heavy goods vehicles at the design road speed of 15mph.

Major access roads shall be 7.3m wide and shall include the necessary kerbs, drainage, road markings and signs. Main road construction shall be of a geotextile membrane, if required, with crushed rock sub-base, and road base on compacted subgrade appropriate to the ground conditions, with Macadam base and wearing course except that concrete block paving shall be

The main access road outside the substation shall be a 12m road with two lanes of 3.5m, shoulders of 1.5m and provision for the drainage facilities. Access roads within the substation shall have a carriage way of 5m wide and provision for the necessary kerbs and drainage facilities.

provided where fuel spillage may occur.

Road markings and signs shall be in accordance with the Department of Transport publication ‘Traffic Signs Manual Volumes 1 to 14’.

Footpaths shall be of 1500mm nominal width and designed for an accidental wheel load of 20kN. Footpaths shall be either precast concrete flags or bitumen macadam.

Within the plant area height limit gauges shall be provided where height clearances are limited and in particular where there is danger from overhead lines.

Safety barriers shall be provided where there are exceptional local hazards or where specific plant protection is required. These barriers will be of the Armco or substantial bollard type.

* + - 1. Codes and Standards

The actual thickness of road-courses shall be calculated based on the final results of the soil investigation, loads, intensity of traffic, design life, etc.

The design, materials and workmanship shall comply with the latest Kenyan Road Design Manual.

* + - 1. Compaction of sub-grade

The area of the Works shall be cleared of any material or obstructions which in the opinion of the Employer / Employer’s Representative might adversely affect the stability of the fill or pavement, and the top layer removed to a depth of 300 mm (or more if the design so required).

The formation shall be compacted to a dry density of at least 95% of the maximum dry density.

Where the land contours require it, fill in embankment shall be placed and compacted with minimum embankment slope of 1:4.

Compaction shall be carried out by means approved by the Employer / Employer’s Representative.

The sub-grade compaction test shall be according to an approved standard.

* + - 1. Sub-base

Sub-base material shall be crushed rock or other approved local material having suitable properties and confirming to the following grading:

BS (British Standard) Sieve (mm) Percentage by Weight Passing

75 100

37.5 85-100

10 45-100

5 25-85

0.6 8-45

0.075 0-10

The sub-base shall be compacted by approved plant to a dry density which shall not be less than 98% relative compaction until movement of the surface ceases and the surface is closed.

* + - 1. Wet mix road base

Wet Mix road base material shall consist of crushed gravel or crushed rock and shall be suitably proportioned to confirm to the following grading as approved by the Employer / Employer’s Representative.

BS (British Standard) Sieve Size (mm) Percentage by Weight Passing

50 100

37.5 90-100

20 60-80

10 40-60

5.00 25-40

2.36 15-30

0.600 8-22

0.075 0-8

Material constituents shall comply with the following maximum limits:

For material passing the 0.425 mm sieve:

liquid limit 25%

linear shrinkage 3%

plasticity index 6%

For coarse material:

stone size aggregate 50 mm

aggregate crushing value 25%

water absorption 2%

flakiness index 35%

elongation index 35%

Mg S04 soundness 15%

The base shall be compacted by approved plant to a dry density which shall be not less than 98% relative compaction and until movement of the surface ceases and the surface is closed.

The final surface shall be shaped and finished true to line and level within a tolerance of + 10 mm to the levels shown on the drawings.

* + - 1. Placing of road base

Wet mix road base material shall be crushed and mixed by approved mechanical placing plant. Water for adjusting the moisture content shall be added at the mixer. If required, the moisture content shall be adjusted to allow for evaporation road base loss during transportation.

After mixing, the material shall be removed from the mixer and transported to the placing location without delay.

The compaction procedure and plant shall be proved by trials at the commencement of the Works. The weight, type and number of passes of compaction plant shall be varied to determine the optimum compaction effort.

The road base shall achieve a minimum dry density of 98% of the maximum laboratory dry density and an in-situ CBR (California Bearing Ratio) value of not less than 80% according to BS 1377 and BS 812 or equivalent standard or modified Proctor density of 97% according to DIN 1821-2.

* + - 1. Hard shoulders

The material used for any hard shoulders shall comply with the General Technical Requirements/Particular Technical Requirements for wet-mix road base.

* + - 1. Bitumen Macadam

Aggregate shall be hard, clean, durable crushed rock or gravel, and sand all in accordance with BS EN 12591 or any other approved standards and shall be obtained from approved source which shall not include quarries containing significant proportions of weathered, decomposed or extensively fractured materials. The Contractor shall propose a suitable source, or sources, and samples shall be obtained for specified testing before arrangements for obtaining aggregate are approved. Laboratory tests shall be made at regular intervals to confirm the suitability of aggregate.

Coarse aggregate is defined as that fraction retained on a 3.5mm BS sieve. It shall have physical properties which do not exceed the following test values when tested:

Wearing Course Base Course

Aggregate crushing value 20% 25%

Flakiness index 25% 30%

Elongation index 25% 30%

Water absorption 2% 2%

Coarse aggregate may contain up to 15% of pieces with one uncrushed face in each grading size.

Wearing course shall be of 40 mm finished thickness, the aggregate grading shall be as follows:

Test Sieve (mm) Grading (20mm nominal size) % by weight passing

28 100

20 95-100

14 70-90

10 55-75

6.3 40-60

3.35 25-40

1.18 15-30

0.075 2-6

Bitumen shall be of Grade 60/70 penetration.

* + - 1. Final surfacing

The Bitumen Macadam binder course shall be kept clean and uncontaminated so long as it remains uncovered by a wearing course. Should the binder course become contaminated the Contractor shall make good by cleaning to the satisfaction of the Employer / Employer’s Representative and if this is impracticable by removing the layer and replacing it to specification.

* + - 1. Interlocking paving blocks

Roads and areas to be paved with interlocking concrete blocks shall be excavated and placed with 300 mm depth of compacted material at the exact levels and falls required for the finished work.

If parts of the base are found to be unstable the Contractor shall excavate further to a firm bed and fill with layers of fine crushed rock or aggregate, thoroughly compacted. The upper surface of the base shall reflect the exact profile, fall or contour of the final paving as irregularities shall not be compensated for by varying the depth of sand bedding.

A stable edge shall be provided to retain the paving units and sand bedding by means of precast concrete edging unit or kerbs set in-situ concrete.

The sand bedding shall be a fine, well graded sand in a dry to moist condition and laid to an uncompacted thickness of 50 mm.

The paving blocks shall be laid in accordance with the manufacturer´s instructions and shall be compacted at completion of each day's work.

The interlocking block shall be a minimum of 80 mm thick and the concrete quality must be approved by the Employer / Employer’s Representative.

* + - 1. Car Park

All materials, workmanship and testing shall be in accordance with the Department for Transport ‘Specification for Highway Works, Part 3’. All areas of roads or hard standing that could be subjected to a fuel, oil or chemical spillage shall be constructed in concrete.

A minimum capacity of 10 No vehicles shall be provided.

* + - 1. Road Drainage

Access roads shall be constructed with an elevated grade above the level of water that ponds on the surface during the rainy season. The roads shall be graded to drainage gullies which shall discharge into the main drainage system.

Culverts should be installed through the elevated roadway to allow the free movement of the water and to avoid ponding adjacent to the roadway.

Where pipes pass under the road they shall be surrounded by concrete or laid in concrete ducts and the road shall be bridged over them if necessary.

* + - 1. Kerbs

The roads shall be constrained between kerbs.

Kerbs shall conform to BS EN 1340:2003 Concrete Kerb Units – Requirements and test methods.

They shall be cast to the required radii for all curves less than 12 metres. Paving slabs will be to BS EN 1339.

Concrete bedding and backing to kerbs shall be cast in-situ to the dimensions shown on the drawings. Bedding mortar shall consist of freshly mixed moist 1:3 cement sand mortar using sand complying with BS 882 grading M. Kerbs shall be backed with concrete with a grade of not less than C15.

Flush kerbs shall be similarly laid or may be cast in-situ. The outside corner of the kerbs shall be chamfered.

Marginal strips and kerbs shall be protected against covering or splashing with bitumen or cement. Kerbs and manhole frames shall be primed before bituminous macadam is laid.

* + - * 1. Fencing and Gates

This section specifies fixed chain link fencing. This type of fencing shall be used for site boundary fencing (other than where walls are required), demarcation fencing of site areas, and for general compound fencing. The provision and installation of chain link fencing shall conform with the requirements of BS 1722 Part 10 "Specification for anti-intruder fences in chain link and welded mesh" except where varied by this Specification. The chain link fence shall be suitable for an industrial type "power plant" site.

The location of gates shall be agreed with the Employer/Employer’s representative, the general requirements being as shown on the enquiry drawing.

* + - 1. Materials

Chain link fabric

Chain link fabric shall be galvanized wire (Grade A) and PVC (plastics) coated and have a diamond mesh pattern size of 50mm in accordance with Clause 3.2 of BS 1722 Part 10. The width of the mesh roll shall be six feet. The external diameter of the mesh coated wire shall be 6.4mm conforming to Table 1 of BS 1722-10.

All wire shall conform to the relevant parts of BS EN 10223 or BS 4102.

The fabric shall be furnished on the top and bottom edges with a twisted and barbed selvage. Chain link mesh shall be joined by interweaving a spiral and restoring the knuckle or barb.

A continuous concrete sill 300mm wide x 300mm deep shall be cast in the ground over the full length between posts, with the top approximately 25mm below the bottom of the chain link mesh. Concrete shall conform to requirements specified herein for unreinforced structural concrete. Hair pin staples 4mm diameter shall be threaded over the bottom row of mesh and line wire, at 500 mm centres and set in the sill to a depth of 150mm.

Line wire

Line wire shall be galvanized wire (Grade A) and plastics coated conforming to BS 4102 and Clause 3.3 of BS 1722: Part 10. The external diameter of the wire shall be 6.4mm, conforming to Table 1 of BS 1722-10.

Chain link fence shall have a minimum of five rows of line wires. The top row of wires shall be double and secured not more than 50mm below the top of the chain link mesh, excluding the barb. The bottom row of line wire shall be close to the ground.

Stirrup wire

Stirrup wire for securing line wires to intermediate posts shall be galvanized and plastics coated conforming to BS 4102 and Clause 3.4 of BS 1722: Part 10. The external diameter of the wire shall be 3.55mm, conforming to Table 1 of BS 1722-10.

Tying wire

Tying wire for securing mesh to line wires shall be galvanized and plastics coated conforming to BS 4102 and Clause 3.5 of BS 1722-10. The external diameter of the wire shall be 2.0mm, conforming to Table 1 of BS 1722-10.

Posts

Intermediate posts for chain link fencing shall be circular hollow sections in accordance with Table 2 of BS 1722 Part 10. Material properties, protective treatments tolerances on size etc. shall conform to the recommendations of BS 1722-10 Section 5.

Straining posts for chain link fencing shall be concrete/circular hollow sections in accordance with Table 2 of BS 1722-Part 10. The post size shall be 89.2mm o.d x 4mm x 3.2m length for supporting 'heavy duty' mesh panels. Material properties, protective treatments, tolerances on size etc. shall conform to the recommendations of BS 1722-Part 10, Section 5.

Struts for chain link fencing shall comprise concrete/circular hollow sections in accordance with Table 2 of BS 1722-Part 10. The strut size shall be 48.3mm o.d x 3.2mm x 3.2m lengths for supporting 'heavy duty' mesh panels. Material properties, protective treatments, tolerances on size etc. shall conform to the recommendations of BS 1722-Part 10, Section 5.

Barbed wire

Barbed wire for use on chain link fence (as well as on all boundary walls) shall only be provided at those fence locations shown on the bid drawings as follows:

Barbed wire for chain link fence shall comprise 3 Nos straight strings, equally spaced, and shall be fixed on each supporting arm.

Barbed wire for gates shall consist of 5 rows of "straight" strings, equally spaced.

Each string of barbed wire shall consist of two strands of 2.5mm dia (12 gauge) wire with 2.0 mm dia (14 gauge) four pointed barbs spaced approximately 125 mm apart along the wire. The wire shall be galvanized in accordance with ASTM A121 to produce a minimum zinc coating of 0.244kg/m2 of surface area on 2.5mm dia (12 gauge) wire and 0.198kg/m2 of surface area on 2.0mm dia (14 gauge) wire.

Barbed wire shall conform to BS EN 10223-1.

Fittings for chain link fences

Fittings required for chain link fences, typically comprising: fixing and straining devices, eye bolt strainers and cleats, winding brackets, stretcher bars, staples, droppers for barbed wire, bolts, nuts and washers, extension arms, etc. shall conform to the requirements detailed in Section 5 of BS 1722-10.

* + - 1. Concrete sills

Where chain link fences are used in unpaved areas a concrete sill shall be constructed as specified in the “Chain link fabric” section above. The top surface of the sill shall be 50mm above grade, or as otherwise shown on the approved drawings.

Entrance gates (hinged)

Side hinged entrance gates shall be of heavy galvanized steel profiles with adjustable hinges (height and distance adjustment). All profiles shall be hot dip galvanized and coated in approved colour. Minimum dimensions shall be for:

Main double gate wings: approximately 2.0 m x 3.0 m each wing (width x height) but minimum half of the width of the road.

Pedestrian (side) gates: approximately 1.2 x 3.0 m

Side and top frame tubes: 100 x 50 x 4 mm

Bottom tubes: 100 x 50 x 4 mm

Verticals: 25 x 25 x 2.5 mm

Intermediates: 100 x 50 x 4 mm.

Alternatively, heavy duty cast aluminium gates may be proposed for approval.

* + - 1. Foundations for Fencing

Foundations shall be designed and constructed of cast-in-place concrete in accordance with this specification, comprising a pad base, adequately sized, to support the fence, and loading criteria (including wind) imposed by the works and satisfying the geotechnical parameters of the subsoil at the location of the fence.

Any damage to the fencing caused by the construction operations shall be rectified promptly by the Contractor at his own expense.

* + - * 1. Roof and Wall Sheeting

Roof and wall claddings shall normally be constructed of approved composite wall panels, comprising profiled galvanized steel sheeting in composite insulated (injected rigid foam) panel form. The foam insulation shall be at least 50 mm thick and the internal lining shall match the required appearance.

Panels must be factory manufactured units, produced on a continuous online injection facility with the bonding foam completely filling the space between the panels. Temperature control of the metal substrates, of the chemical dispensing area and of the online conveyor press is obligatory to maximize the uniformity of the foam density and the foam substrate adhesion.

The insulation foam shall be a factory injected rigid closed cell fire retardant CFC free polyisocyanurate (PIR) foam with a minimum depth of 50mm between the inner and outer sheets. It shall be resistant to moisture, not support fungal growth, nor rot or deteriorate with age, and shall also be resistant to moist oils, greases, adhesives, diluted acids and alkalis at normal temperature.

The heat transition value of the panels shall be less or equal 0.4 W/ (m2\* K).

Properties and tests for the insulation foam shall be as follows:

|  |  |  |
| --- | --- | --- |
| **Property** | **Test** | **Test Requirements** |
| Density |  | 40 kg/m3 |
| Compression Strength |  | C 10 = 1.5 kg/cm2 |
| Modulus of Compressibility |  | 37 kg/cm2 |
| Tensile Strength |  | 2.8 kg/cm2 |
| Thermal Conductivity |  | 0.4 W/ (m2\* K) |
| Flame Resistance |  | Foam only B2 rated minimum |
| Water Vapour Transmission |  | 72 g/m2 24h (at 38%-90% relative humidity |

Panels shall provide an effective cover width of 1000 mm and shall be manufactured in exact lengths to suit the structure and minimize jointing. Panels shall have encapsulated side-tapes to ensure maximum side lap joint uniformity.

External steel sheeting shall be of a hot dip galvanized steel sheet (not less than 275 g/m2) of at least 0.75 mm thickness with a trapezoidal profile. The external coating system shall be a multi-layer system consisting of:

|  |  |  |
| --- | --- | --- |
| - | Prime Coat | Epoxy primer of a nominal thickness of at least 8 µm |
| - | Base Coat | Epoxy barrier coat, nominal thickness of at least 70 µm |
| - | External Weather Coat | Urethane pigmented colour coat, nominal thickness of at least 50 µm |

The inner skin of the panel shall be of hot dip galvanized sheets of at least 0.5 mm thickness, corrosion protected with a polyester coating of white colour. The panel shall be flat with a shallow 3 mm deep profile across the panel face and a return edge detail providing a concealed butt joint side lap.

Alternatively, a similarly coated aluminium panels may be proposed as inner and outer skin of such sandwich panels.

External and internal flashings shall be manufactured from materials matching the external and internal sheeting in gauge, colour and finish.

Fixing of panels shall be done only with stainless steel self-tapping screws, complete with stainless steel (or aluminium) washers incorporating neoprene sealing washers and PVC colour caps.

Where applicable, black synthetic rubber profile filler blocks shall be used in conjunction with flashings to adequately seal ridge, eaves, gables and drip.

* + - * 1. Water Proofing
      1. General

The design and execution must be state of the art, functional and complete in all parts in accordance with this specification.

The scope of work covered by this specification comprises damp-proofing against non-pressurized water, damp-proofing against lateral and rising moisture, damp-proofing against seepage water, surface water and the like in the open air and indoors.

Furthermore, it comprises damp-proofing against pressurized water by means of bituminous damp-proofing and unbacked felts against water under hydrostatic pressure (e.g. ground water, pocketed water etc.).

* + - 1. Materials (Quality, Delivery, Storage, Handling)

The Contractor shall furnish an approved manufacturer's surety bond on all water proofing material covering a period of ten (10) years.

All bituminous materials shall conform at minimum in its quality to the relevant Standard.

Undercoating materials

Bituminous solution: Bitumen content 30 to 45% by weight; softening point of the solid not less than 115°C.

Bituminous emulsion: Bitumen content not less than 30% by weight; softening point of the solid not less than 45°C.

Top-coating materials to be worked cold

Bituminous solution without filler Bitumen content not less than 50% by weight; softening point of the solid not less than 60°C.

Bituminous solution with filler Bitumen content not less than 30% by weight; softening point of the solid not less than 60°C.

Bituminous emulsion without filler Bitumen content not less than 45% by weight; softening point of the solid not less than 45°C.

Bituminous emulsion with filler Bitumen content not less than 30% by weight; softening point of the solid not less than 50°C.

Top-coating materials to be worked hot

Bitumen without filler: Softening point of the bitumen without filler not less than 115°C.

Bitumen with filler: Bitumen content not less than 54% by weight, softening point of the bitumen with filler not less than 115°C.

Bituminous felts, factory-finished

Bitumen felts, factory-finished, shall consist of an inlay and outer layers which are applied to both sides of the inlay; the outer layers shall be sprinkled with fine sand. Softening point of the outer layers 55 to 90°C.

The inlay and the outer layers shall be closely bonded to each other. The sanding of the outer layers shall adhere well.

Impregnated inlays shall not have visibly unimpregnated places; woven glass inlays in building paper are expected.

The bituminous felts shall be waterproof. It shall lie flat on an even bed and shall not have any unevenness (e.g. bulges, depressions). It shall have a regular surface and thickness and be free from faults such as cracks, folds, etc.

Bituminous felts with an inlay of impregnated 500 g/m² crude felt, with bitumen outer layers on both sides, shall have a thickness not less than 3.5 mm. Longitudinal and transverse breaking strength (breaking load), not less than 300N. Longitudinal and transverse ductility, not less than 2%.

Bituminous felts with an inlay of impregnated 300 g/m² jute fabric, with bitumen outer layers on both sides shall have a thickness not less than 3 mm. Longitudinal and transverse breaking strength (breaking load), not less than 600 N. Longitudinal and transverse ductility, not less than 5%.

Bituminous felts with an inlay of impregnated 300 g/m² woven fibre glass shall have bitumen outer layers on both sides.

Bituminous felts with an inlay of 0.1 mm thick copper foil with bitumen outer layers on both sides shall have a thickness not less than 3 mm. Longitudinal and transverse breaking strength (breaking load), not less than 500 N. Longitudinal and transverse ductibility, not less than 5%.

* + - 1. Execution (Assembling, Installation)

General

Before commencement of carrying out the work specified under this specification, the Contractor shall verify that all conditions are suitable for a timely and effective performance of his work. In particular, the Contractor shall verify that such conditions as the following do not exist

* extensive unevenness of the bed
* too rough, too porous, too smooth surfaces
* sharp edges of boarding and ridges
* incorrect level of the surface of the bed
* unrounded corners, edges and channelling
* stress and settlement cracks, holes
* too moist surfaces
* oily surfaces, paint residue
* unsuitable type or position of penetrating structural members.

Horizontal and slightly inclined damp-proofing (with the exception of horizontal damp-proofing in walls and damp-proofing with water-repellent mortar) shall be given a protective covering at once e.g. a thick covering of concrete. Sharply inclined and vertical damp-proofing shall also be given a protective covering immediately if the damp-proofing has to be secured or there is a risk of damage.

Water-proofing of walls against moisture

Water-proofing with felt shall be carried out with two layers of 500 g/m² bituminized roofing felt. The felt layers shall not be bonded either to the bed or to one another. Each layer shall overlap by not less than 10 cm.

Water-proofing with thermoplastic sheeting shall be carried out with one layer of plastic sheeting, unless stated to the contrary in the specifications. The lengths shall overlap 5 cm at the joints. They shall be sealed together by solution welding, unless otherwise specified.

Water-proofing against moisture

Damp-proofing with bituminized coatings shall be carried out with an undercoat and top coat.

An undercoating substance which must be worked cold shall be used. The undercoat shall be applied as a single coat. It shall be completely dry throughout before carrying out further damp-proofing operations.

Three top coatings with a bituminous solution without filler to be worked cold shall be applied as cold flow top coats.

Water-proofing against seepage water and surface water

Water-proofing with felt shall be carried out with a prime coat and two courses of unbacked felt. Unbacked 500 g/m² bituminized felt shall be employed if no other quality is specified.

Not less than 1.0 kg of adhesive per square meter shall be applied for the adhesive coatings and the top coating.

Water-proofing against water with pressure effects

On completion of any layer of water-proofing, the Contractor shall carefully inspect it for defects; any defects found shall be immediately rectified. If the next layer (protective layer, concrete or brickwork) is not applied directly after the damp-proofing. The Contractor shall repeat his investigation of the water-proofing immediately before application of the next layer and shall eliminate any defects.

Connection of the water-proofing to penetrations

The connections shall be made with the use of fixed flanges (build-in steel flanges) and loose flanges.

The connecting elements (fixed flanges and loose flanges) shall be cleaned and removed of rust and dirt. The points which are in contact with the water-proofing shall have a prime coat applied to them immediately after cleaning.

Bonding shall not be carried out on top of fixed flanges, and loose flanges shall not be tightened until the undercoat has dried thoroughly and contains no more solvent. The undercoat on fixed flanges shall be free from moisture before bonding on top of it; if necessary, special precautions shall be taken to dry it immediately beforehand.

In the region of fixed flanges, the water-proofing shall be reinforced by way of applying an additional layer of unbacked felt extending at least 30 cm beyond the flanges in all directions. In the region of the fixed flanges, the individual layers shall meet with butt joints; the joints in the individual layers shall be staggered relative to each other.

The water-proofing shall be clamped between the fixed flanges and the loose flanges.

Water-proofing over construction joints

Water-proofing over structural joints shall be reinforced unless otherwise specified.

Water proofing over structural joints intended to allow for the contraction the expansion of structural members shall be reinforced by putting in the cup-flutted copper strip 0.2 mm thick. The copper strip shall be bonded.

Water-proofing over structural joints intended to allow for differential vertical movements of adjoining structural members up to a differential settlement of 1 cm shall be carried out as above. If settling differentials of more than 1 cm are to be allowed for the water-proofing shall be carried out in such a manner that the more stringent conditions involved shall be satisfied.

Water-proofing over structural joints intended to allow for movements resulting from temperature changes, vibration, torsion etc. shall be carried out in such a way that both type and extent of the expected movements will be satisfied without damaging effects to the water-proofing.

Sealing joints in the protective layers

Joints in the protective layers applied onto water-proofing of floors and slabs shall be raked out without damaging the damp-proofing and completely filled with hot-flow bitumen sealing compound.

* + - * 1. Plasterwork
      1. General

This chapter covers all internal and external plastering for all buildings and structures etc. The work shall include all necessary labour, materials, equipment and auxiliary works as required. Plaster shall be applied in accordance with the finish schedule given on the drawings or specified in the specification, or as directed by the Employer/Employer’s Representative.

* + - 1. Standards

Unless otherwise specified hereinafter the following standards shall apply to the works covered by this chapter:

|  |  |  |
| --- | --- | --- |
| BS | 1199 | Building Sands from Natural Sources |
|  | 1200 | Building Sands from Natural Sources |
|  | 1202 | Specification for Nails |
|  | 1369 | Steel Lathing for Internal Plastering and External Rendering |
|  | 5492 | Code of Practice for Internal Plastering |

* + - 1. Materials

Binding Agents

Binders of mortar shall be from factories which guarantee adequate quality control. The materials shall be stored on Site, protected from rain, and inclement weather kept off ground and away from damp surfaces, all to the satisfaction of the Employer/Employer’s Representative. The cost of covering materials shall be included in the offered prices. Damaged or deteriorated materials shall be removed from the Site.

Uniformity of the material shall be guaranteed.

Cement shall always be fresh and free of moisture. No lumps will be permitted. Single lumps shall be taken out and bags containing excessive lumps shall be permanently removed from the Site and replaced at the Contractor's expense. Cement shall comply with the requirements stated in the relevant clauses of this specification for „concrete and reinforced concrete”.

Lime shall be freshly burnt, stone lime delivered to the Site in large lumps, slaked on the Site, and then shall not be used within 15 days of slaking. Hydraulic lime may be used if stone lime is not available. Lime putty shall be kept moist and screened through the appropriate sieve before use.

Aggregates

The sand to be used shall be clean, well washed and free from injurious amounts of saline, alkaline, organic or other deleterious matters.

The sand shall be guaranteed to produce a faultless plaster and shall comply with BS 1199 and BS 1200 respectively the relevant standards as mentioned under Chapter "Concrete and Reinforced Concrete" of this specification. Both the purity to the appropriate standard and the uniformity of the fractions shall be guaranteed continuously.

The quality shall be subject to the approval of the Employer/Employer’s Representative.

Water

Water shall be clean, free from harmful amounts of deleterious matter and from any unusual proportion of dissolved salts. Water shall be potable water complying with BS 3148.

Admixtures and Colouring Agents

If admixtures, sealing coats and the like are used or special processes or materials applied, the maker's or supplier's instructions shall be strictly observed. Such instructions for application shall become part of the Contract upon approval of the Employer/Employer’s Representative.

Plaster Lathwork

Expanded metal lathing shall comply with BS 1369 and galvanised in accordance with BSEN 10143. Nails for fixing metal lathing shall be galvanised and complying with BS 1202. Angle beads, plaster stop beads shall be galvanised and shall be of type approved by the Employer/Employer’s representative.

Wire netting, expanded metal and building steel lathwork shall be of commercial quality and of a thickness suited to the purpose. They shall be of non-shrinking material and be suitable to meet all stresses being imposed on them and excluding any undesirable movements.

The nails for use in the damp rooms shall be non-rusting or rust protected. Galvanised staples of the same length may also be used instead of nails.

Wooden lathwork shall be such that its thickness, shape and spacing of the laths ensure faultless adhesion of the Plaster.

* + - 1. Execution of Work

The composition of the plaster shall be suited to the purpose of the plastering, the suction capacity, and the surface roughness of the plaster background, and, in the case of exterior plaster, to the climate.

Prior to the start of his operation under this chapter, the Contractor shall verify that all conditions are suitable for the timely and effective carrying out of his work. In particular, the Contractor shall verify that such conditions as the following do not exist:

* Extensive unevenness
* efflorescence
* Stress and settlement cracks
* Over smooth surfaces
* Over moist surfaces
* Oily surfaces (e.g. through form oil)

The Contractor shall perform touching-up work after other trades have finished their works on plastered surfaces of rooms. He shall repair cracks, marks and defects and these shall be filled with approved material. The surface shall be evenly smoothed by the spatula, irrespective of the reason, and leave all metal furring, lathing and plastering in first class conditions.

Surface Preparation

All surfaces to be plastered shall be prepared and cleaned by removing loose particles, dust adhering to mortar, grease, oil, efflorescence, foreign matters, and shall be wetted down before plaster is applied. All surfaces shall be brushed down by wire brush to remove any loose material. Joints in brickwork and blockwork shall be raked out to a depth of 10 mm minimum.

Smooth concrete surfaces to be plastered shall be roughened by hacking or brush hammering and cleaned with water under pressure.

All surfaces to be plastered shall be thoroughly sprayed with potable water and all free water shall disappear before plaster is applied.

Junction of Different Material

Junctions between different material (other than those between the main reinforced concrete member and the brick or block walls) shall be reinforced. The reinforcement shall apply to the joints between walls and stiffeners, concrete frames around steel doors and similar situations where cracks are likely to develop and as directed by the Consultant. The reinforcement shall consist of a strip of galvanised wire mesh (10 mm to 15 mm hexagonal mesh) of 150 mm width which shall be nailed with galvanised nails and washers or staples fixed to plugs or by similar approved method. Nails or staples shall be fixed at both edges of the wire mesh at intervals not exceeding 300 mm. The reinforcement shall be fixed so that it is embedded completely in the undercoat of plaster. Where the junctions are between main concrete element (beams, columns etc.) and brick wall or blockwork, definite break shall be carried out through the plaster finish by stop beads or similar approved by the Consultant.

Before receiving plaster, metal lathing shall be cleaned of oil paint, tar coats, oil patches and the like. Any rust and scale shall also be removed.

Cement Plaster

Surfaces of the walls shall be rendered prior to the floating coats. Surfaces to receive rendering shall be thoroughly cleaned and dampened immediately before applying rendering in one coat and the one being scratched to leave an adequate key for the floating coat.

The floating coat shall provide a true surface to receive the finish. The plaster shall be trowelled on and all superfluous material struck off with a long straight-edge. This straight-edge is kept pressed against the rules and is moved from side to side upwards.

The floating coat shall then preferably receive a setting coat just before plaster sets. It is polished to an even surface with the trowel.

The material for rendering and floating coat shall consist of the same elements in the same proportion as mortar. For the setting coat the proportion shall be 1:3 (cement type I: Sand). The material must be screened before mixing. Sand used shall comply with BS. 1199.

Mortar shall be mixed only in quantities for the work immediately in hand. No mortar that has stiffened by starting to set shall be used. Exposed edges shall receive galvanised edge protection strip. Where suspended ceiling is required wall plaster shall be carried out up to 10 cm above suspended ceiling.

The minimum thickness of finished plaster shall be;

* With exterior plastering 20 mm
* With interior plastering 15 mm

if nothing different is prescribed in the specifications. The mortar layer for cornices shall not be thicker than 40 mm.

If plaster is to be applied in damp rooms on lathwork which, on account of its composition, can rust, the lathwork shall be protected from rust on all sides.

If felt-floated, floated, or smoothed plaster is not prescribed in the specifications, the plaster shall be scoured. Pockets shall not remain in the plaster.

Mechanically Applied Plaster

Where plaster will be applied mechanically the first coat shall be 0.7 - 1 cm thick. Immediately after setting, a finishing coat of approximately 1 cm thickness shall be applied by hand, smoothing any irregularities and finally treated.

If wire mesh is required it shall be adequately fixed to avoid movement when the pressure mortar of the first coat is applied.

Waterproof Plaster

The binder used for water-proof plaster shall be of Portland cement. In order to ensure as smooth a surface as possible, the sand shall be carefully graded according to a sieve curve as shown in the stated standards.

External Plaster

Water-proof plaster shall be applied only by skilled and experienced personnel.

Plaster work during rain or intense sunshine may be executed only if surfaces are carefully protected and then only with the approval of the Employer/Employer’s Representative.

Plaster Limits

Corners and edges including those at doors and windows shall be made either sharp-edged, chamfered or rounded according to requirements. Plaster stops shall be provided where necessary and all exposed edges shall be protected by approved corner fillets up to 1.50 m above floor level. Expansion joints of the structure shall be continued through the plaster in accordance with the Employer/Employer’s Representative's instructions.

No working joints shall be visible in plaster surfaces; exceptions may be allowed if justified, but only upon approval by the Employer/Employer’s Representative.

Joints shall be arranged and sealed e.g. between material changes as concrete to masonry.

Openings

Plaster around pipes and other structural parts which are installed prior to application of plaster shall be neatly finished.

Installed erection parts shall be carefully protected by suitable covers.

Pipe openings, recesses, ducts and the like shall be suitably closed in order to avoid penetration by plaster mortar. Any soiled parts shall be cleaned before the mortar has set.

Coordination of Plaster Work

Plaster work shall, after consultation with the Employer/Employer’s Representative and any erection Contractors involved, be started and executed to ensure that construction and erection schedules will be met and mutual obstruction avoided. The Employer/Employer’s Representative's instructions shall be carried out at all times.

* + - 1. External Finishes

The external finish of plastering shall be as follows:

* Painting the external render by one coat of two component polyamide cured epoxy primer with dry film thickness of 100 micron
* Applying epoxy based textured coating
* Applying two coats of two component polyurethane finish based on cured acrylic resin each coat of 75 microns dry film thickness.
  + - 1. Sample Panels

Sample panels of external finish shall be executed for the demonstration of colour and surface texture to the satisfaction of the Employer.

* + - * 1. Auxiliary Works

The following works, however not limited to, are to be included in the Contract price under the chapter:

* Protection of the works from heat, wind and draught
* Any scaffolding required for the plaster work
* Supply of the operational materials
* Cleaning of the plaster background of dust and loose parts
* Pre-moistening of strongly absorbent plaster background and keeping the plaster background moist until setting
* Plastering in and plastering around openings, pipe penetrations and the like; all costs being included in the unit rates of plaster work
* Customary measures of the trade for the protection of floors, doors, windows, coverings and other structural parts and furnishing from soiling and damage through the plastering work, including supply and removal of the necessary materials
* The price of plastering or rendering concrete are to include bonding coat and work to soffits at all heights, touching up of plasterwork after other trades
  + - * 1. Oil Containment

Power transformers shall be sited in oil containment areas and drain via a flame trap to an underground facility to remove oil away from a fire in the event of an incident. The capacity of the underground containment shall be equal to the volume of oil contained within the transformer plus 50% to allow for rainwater and firefighting materials externally applied by the firefighting service.

Where there is more than one power transformer on a site, it may be economic to link the oil containment drainage areas of these to a single underground tank with capacity for the largest transformer alone. Connecting pipe work shall be designed to ensure rapid discharge of oil to the underground facility that, together with the pipe work, shall be resistant to transformer oil at a temperature of up to 80°C. Underground oil containment facilities shall be provided with a means of inspection and allow for pumping out of accumulated rainwater or oil.

The area within the transformer enclosure shall be designed as a water retaining structure to BS 8007 and coated with 2 coats of bituminous paint and be surfaced with a 100 mm thick layer of gravel on steel grating. It shall be tested in accordance with Part 19 of Section 5 of QCS.

The road immediately adjacent to transformers used by oil handling equipment for maintenance will also drain to the containment facility to prevent ground pollution in the event of accidental spillage.

* + - * 1. Generator House and External Fuel Tank
      1. Generator House

Foundations and Support

The foundations together with any steelwork, foundation bolts, tubes or other equipment necessary shall be supplied in accordance with the relevant requirements specified elsewhere in this document.

The generator sets shall be mounted on fabricated steel channel sub-frames of the skid type through anti-vibration mountings of a type to be approved by the Employer.

All supports for intake air filtration equipment and exhaust silencers; daily service oil tanks and any other equipment shall be supplied. Silencer and exhaust pipe support shall be of the anti-vibration type. Equipment such as the control panels and any other item likely to be affected shall be protected from vibrations transmitted through the floor.

Outdoor Weather Protective Sound Attenuating Enclosure

The generator set shall be provided with a sound attenuated housing which allows the generator set to operate at full rated load in the ambient conditions. The enclosure shall reduce the sound level of the generator set while operating at full rated load to below 95 dBA at 1 meter from the generator set. Housing configuration and materials used may be of any suitable design which meets application needs, except that acoustic materials used shall be oil and water resistant. No foam materials shall be used. The enclosure shall include hinged doors for access to both sides of the engine and alternator, and the control equipment. A panel viewing window shall be provided. Key locking door latches shall be provided for all doors. Door hinges shall be stainless steel. The enclosure shall be provided with an exhaust silencer, which is mounted outside of the enclosure, and allows the generator set package to meet specified sound level requirements. Silencer and exhaust shall include a rain cap and rain shield.

Fire detection

Diesel generators housing shall have fire detection system suitable for use in an area containing diesel fuel. The fire detection system shall cut off the fuel line. Refer to fire fighting facilities chapter

* + - 1. External Fuel Tank

General

External fuel tanks of a capacity adequate for 10 hours operation of the generator set shall be provided. Provide pre-engineered aboveground atmospheric tank system complete with tank, piping, secondary containment, gauges, and other accessories specified herein as a complete assembled system.

Tank Construction

The tank shall be manufactured from carbon steel with thickness as U.L. Standard 142. The tank shall be externally coated with 2 layers of coatings. The prime layer using Red Oxide paint and the top layer using water proof plastic layer. Tank shall comply with the normal and emergency venting requirements NFPA 30. Tank shall carry a ten (10) years warranty including materials and workmanship. Fuel tank to have, lowest point drain facility for water and sludge, fuel level gauge direct mounted or remote electric, filler pipe and locking cap.

Accessories

The tank shall be manufactured to support the following accessory equipment and shall be provided with suitably located lifting lugs:

* Direct Level Indicator: A steel pipe of suitable size shall protect the level indicating, the level indicator shall be made of plastic pipe connected through suitable valves and approved by the supervising engineer.
* Inspection Port Adapter Cap: Tank shall be equipped with a not less than 300 mm adapter and lockable cap for inspection and manual gauging of fuel level. Gauge port shall be accessible from steps or ladder.
* Tank Fill Opening: The tank shall be provided with a suitable sized filling opening that will minimize the oil spilling during tank filling operation.
* Vent Opening: The tank shall be provided with a suitable sized venting pipe to prevent the increase of gas pressure inside the tank. The vent opening should be covered with a wire mesh to prevent anything from entering and blocking the vent.
* Supply Pipe Connection: The tank shall be provided with a suitable sized ASME B36.10, Schedule 40 Black steel supply pipe connection with a stainless steel two – piece body, stainless steel ball, Teflon seats and stuffing box ring, lever handle and balancing stops, threaded ends with union Ball Valve.
* Drain Pipe Connection: The tank shall be provided with a suitable sized ASME B36.10, Schedule 40 Black Steel Drain pipe connection with a Carbon Steel, Stainless ball, with Viton seals Spill Sump Drain Valve.
* Access Steps and Ladders: The Tank shall be equipped with access steps or ladder. Steps and ladder shall be of welded steel construction with prime and finish paint of industrial enamel, and shall be designed to conform to OSHA requirements. and finish paint of industrial enamel, and shall be designed to conform to OSHA requirements.

Fuel Distribution Pipe and Pipe Fittings

The design criteria shall conform to the following minimum requirements:

* Steel Pipe: ASME B36.10, Schedule 40 Black Steel
* Fittings: ASTM B16.3, 300 lb. Threaded malleable iron, or ASTM A234, forged steel welding type.
* Finish: Prime and finish paint with industrial enamel.

Drawings

The contractor should submit design (shop) drawings for the tank and fuel pipe distribution, location of fittings and accessories with specific dimensions, for approval by Employer prior to product fabrication.

Test

The tank shall withstand an internal air pressure test of 3-5 psi.

Welding

Welding shall be carried out in accordance with an approved standard or code of practice. The welding plants and processes used shall be suitable to the materials, configurations and purposes of the welded parts. Only qualified welders, certified for the type of welding required, shall be employed. The Contractor shall exercise strict control over the welding conditions and parameters and shall continuously monitor the standard of welding achieved in supply from the tank in the event of a fire. The fire detection system shall operate an alarm system. The system shall meet the requirements of Kenyan fire regulations.

* + - * 1. Guard House with Telecom collocation room

The guard house shall be a concrete masonry unit of sufficient size to accommodate the security requirements. It shall be constructed using a reinforced concrete frame with in-fill, insulated block work walls and a reinforced concrete roof slab. An outdoor lean-to sunshade with profiled steel sheet roof shall be provided for the water dowser.

The contractor shall also implement a separate telecoms room next to the guard house to be known as the “Telecom Collocation Room” for the purpose of hosting other service providers who will be using KETRACO infrastructure such as OPGW fibres.

The general scope of works shall entail:

1. Construction of a 5.2m\*6.9m\*3m (L\*W\*H) telecom collocation room
2. Construction of cable tranches and covers from the main control building’s telecom room to the Customer Equipment rooms
3. Access road in concrete paving blocks finish
4. General drainage works and rehabilitation
5. Making good all disturbed areas

The Collocation room shall contain the following rooms (with the respective minimum dimensions in mm (Length\*Width\*Height)):

* Customer Equipment Room (5,200\*2,500\*3,000) – One single double leaf door into the main Equipment Room (large enough to wheel in and out control cabinets), one external window (facing the inside the substation) (1200mm\*1500mm), one row of minimum 4 equipment cabinets each with overhead and underground cable trenches linking to the main control building telecom room and control and protection rooms.
* Open office Area (5200\*2500\*3000) – One single leaf door (1000mm wide) into the main Equipment Room, one window into the main Equipment Room and one external window (1200mm\*1500mm).
* Ladies and Gents Washrooms (each 1325\*1400\*3000) – Fully fitted with a fully functioning sink installed external between the washrooms. The access of these facilities shall be away from public and secured (preferably facing the direction of the substation and away from the road)
* Battery/Storage Room (2000\*1400\*3000) – One large door (minimum 900mm wide large enough to wheel in and out equipment). The placing of this room shall also be away from public access and preferably facing the direction of the substation.

NOTES:

1. All windows to be fitted with burglar proof steel grills
2. All windows shall be air tight double glazed to minimize energy loss
3. Doors shall be air tight and fire resistant
4. The design of the overhead and underground cable trench routes and dimensions shall be submitted in detail for the Employers approval. All cable paths including building control, air conditioning and power cable shall be made in their own independent embedded route paths. Their design shall also be submitted to the Employer for approval as part of the building designs.
5. The Customer Equipment Rooms and the Office are shall be fitted with air conditioning systems appropriately sized. The calculations and design of the air conditioning system shall be submitted to the Employer for approval
6. All slabs at ground level to be poured over 1000-gauge polyethene sheeting on 50mm thick stone dust on hardcore
7. All soil under slab and all-round external foundations to be poisoned for termite control
8. All soil on cut embankments to be stabilized. The slope shall not exceed the natural angle of repose
9. All black cotton soil to be removed from below all buildings and paved surfaces. Buildings to be clear of black cotton soil for a distance of 3m outside the perimeter
10. Depth of foundations to be determined on site to structural engineers and employer’s approval
11. All walls less than 200mm thick shall be reinforced with hoop irons at every alternate course
12. All adjacent R.C works and masonry walls to be tied with strap irons at every course
13. All plumbing and drainage to comply with city council’s specifications
14. Drains passing beneath buildings and driveways to be encased in 150mm thick concrete surround
15. All inspection chambers cover and framing shall be cast iron to comply with BS497 table 2 Grade A
16. The storm water drain pipe shall comply with BS556
17. Minimum slope in the drain pipes to be 1%
18. All conduits must be laid before plastering.