

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specifications – Architectural

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PARTICULAR SPECIFICATIONS FOR ARCHITECTURAL WORKS

Clause numbers herein corresponds with the numbers of related articles, if any, in the Standard Specifications – Specifications for Building Works – Volume I (ICTAD Publication No

SCA/4/1 3rd Edition (Revised) July 2004. The numbering of new clauses is continuous with related clauses in the Standard Specifications. In the Event of any discrepancy between Particular

Specifications and General Specifications, content/description of Particular Specification shall take precedence.

1.0 EXISTING SERVICES

(Add the following sub clause)

All the existing services connected to the construction site should be identified, marked and submitted to the Engineer prior to demolition & diversion. Contractor shall divert all services of functioning floors in working order. Any damages made to the functioning services shall be repaired at his own cost to the approval of Engineer.

2.0 PAINTING NEW/EXISTING WALL SURFACES

(Recommend Brands - CIC or Approved Equivalent/higher)

Material

Emulsion paints shall be in compliance with SLS 533 and 557 or equivalent ASTM standards.

Use the following products or equivalent approved.

Apply one coat of wall primer applicable for both interior and exterior walls

Apply two coats of emulsion paint for interior walls and two coats of weather shield paint for external walls, CIC, Dulux “power flex” or equivalent as per the manufacturer’s recommendation and specifications.

Application

All external walls prior applying painting system should be pressure washed and rub down and make to the acceptable quality where repairs required approved to Engineer.

All primers shall be applied by brush. Subsequent coats may be applied by brush, spray or roller unless otherwise directed. No priming coats shall be applied until the surfaces have been inspected and the preparatory work has been approved by Engineer. Engineer reserves the right to inspect and approve undercoats and finishing coats between stages.

Apply approved type two coats of wall putty, coat of primer and two coats of weather proof paint or equivalent for the internal surface of the vanity walls depending on the manufacturer’s specification to the satisfaction of the engineer.

Warranty

The Contractor submits minimum 07 years warranty certificates to cover the manufacturing defects from the paint manufacturer. In addition, latest test certificates, technical information, manufacture's specifications to be submitted for approvals, laboratory tests shall be in compliance with applicable ASTM standards.

3.0 ALUMINIUM APPLICATIONS

(Recommended Brands - Alumex or Approved Equivalent/higher)

General

Aluminium profiles shall be powder coated to a minimum coating thickness of 60-80 microns and conforming to latest BS, SLS, and ASTM standards.

Manufacturer's detail, technical information, latest test certificates to be submitted for approvals.

Aluminium extrusion shall be in compliance with the under mentioned or equivalent standards,

Alloy EN AW-6063 / BS EN 515:1993

Part 01 to 04 of BS EN 573/ Part 01 to 09 of BS EN 755 and Part 01 to 02 of EN 12020

Temper

T1, T4, T5, T6

Physical Properties

Tensile Strength of 160 Mpa,

0.2% Proof Stress of 110 Mpa,

Elongation of 7% (minimum)

Surface Treating - Powder Coating

Powder Coating shall be accordance with BS 6496:1984.

Polyester Powder coatings colour to be chosen by the Engineer and the film thickness (EN ISO 2360:2003) to be 60 – 80 microns.

The treated surface should not show defects (scratch, swelling, straining, waving, and other imperfections) visible at naked eye from distance not less than 5mts for external application and 3mts for internal application. The surface treatments of the aluminium frames should not corrode or alter its outer aspect and it should last for the life of the product. Consequently, the surface of the product should be protected by eventual contact with metallic components or other material which can cause corrosion phenomenon.

Glazing

Glass shall have thickness suitable for the dimensions and the location of the doors, windows and the curtain wall on the façade of the building. Calculation of the glass thicknesses should be shown taking into consideration the wind pressure of 1.0 kPa (max). Glass shall be installed using setting blocks of suitable hardness depending on their supporting or spacing functions. Blocks lengths shall be suited for the weight they must support.

Insect mesh fixed to the aluminium louver panels

Insect mesh to be fixed to the aluminium louver panels where specified with Gauge - 1.2 mm (18 gauge) with necessary powder coated aluminium frame firmly fixed to the wall. All screws, used in aluminium doors, windows shall be made out of stainless steel.

All joints between glass and frames and joints between profiles should be fully weather tight. Suitable approved type acrylic beading and sealant to be used. The drainage points shall be provided as required.

The gaskets should be made in elastomeric ethylene-propylene (EPDM) with the necessary vulcanized corner joints to guarantee the perfect continuity of the perimeters where installed. Gaskets and weather beadings shall be supplied from the proprietary system supplier.

Aluminium profiles and friction stay in side-hung, top-hung, and centre-pivoted sashes, if any, should be strong enough to withstand high wind pressure.

The samples, trader literature and test certificates for aluminium profiles and ironmongery should be forwarded to the Consultants for approval prior to the commencement of work.

Shop drawings for all types of doors and windows including fixing details of aluminium profiles, full size sections of aluminium profiles, beading etc., methods of assembly, methods of glazing, layout (Sectional plan and elevation) of complete assembly, provisions for vertical and horizontal expansion, junctions and trim to adjoining surfaces, fittings and accessories to be submitted to the Engineer for approval prior to the commencement of work.

The manufactures specifications and design calculations, in support of profiles to cater for wind pressure of 1,000 Pascal should be submitted along with the tender. All aluminium profiles should be strong enough to withstand high wind pressure.

Particulars of Projects and Client's references should also be submitted.

Aluminium Louvers - Fixed louvers shall be of the weatherproof type, suitable for overcoming water carry-over by wind up to a velocity of 161kph. The fixed louvers shall have free areas of not less than 50% and shall have a pressure drop of not more than 40 of 150m/min for airflow direction normal to the louver blades. The Contractor is required to submit air flow characteristics of the weatherproof louvers with his tender.

The Contractor shall provide a guarantee in respect of the weatherproof properties of the fixed louvers.

Louver panels shall be of substantial and solid construction. Unit widths shall be based on a module width and height all as shown on the Architect's drawings. All extrusion coatings

shall match the windows. Panels shall be so constructed as to be completely weather proof at junctions with adjoining structures as specified for windows.

Air and Water Infiltration - Fabrication and installation of aluminium units shall be thoroughly watertight and the rate shall be included for necessary testing for water infiltration after installation is completed.

The degree of resistance to air leakage shall be Grade A (Superior resistance) recommended for air-conditioned buildings.

The Contractor shall be responsible for ensuring that the installation is entirely water tight and the rate quoted shall be deemed to include all bedding and fixing material including all necessary flashing weather stripping insulation etc.

The installation shall be designed in accordance with BS 4315 for air infiltration.

Hardware and Accessories

Accessories should be made by materials resistant to the weather condition and should give the necessary mechanical resistance, stability and functionality.

The gaskets should be made in elastomeric ethylene-propylene (EPDM) with the necessary vulcanized corner joints to guarantee the perfect continuity of the perimeters where installed. Gaskets and weather beadings shall be supplied from the proprietary system supplier.

Samples

Samples, systematic catalogue and specification for all kinds of aluminium extrusions, hardware items, glass, gasket, sealant, door closers to be submitted for prior approval by the Engineer.

Guarantee

The Contractor submit warranty certificates from aluminium manufacturer and/or an approval testing laboratory which attest that the coating thickness offered is as specified. The Contractor shall submit Test Certificates from the manufacturer of aluminium extrusions guaranteeing that the products comply with standards applicable to the country of origin of these materials.

Workmanship

The fabrication and installation of all aluminium work must be carried out by specialist tradesmen.

All dimensions shown on the drawings and the shop drawings must be verified by actual site measurement before fabrication and installation. Any cutting to enlarge the size of openings and any cement mortar filleting behind frames required after installation shall be executed by the Contractor at his own expense.

All aluminium members shall be factory fabricated to the best standard of workmanship under experienced factory supervision and control.

Materials, method of fabrication, assembly, installation, fastenings, supports, braces, operating parts and the like shall be in accordance with the approved shop drawings.

Operating parts and hardware shall be fabricated and installed so as to facilitate smooth, free and noiseless operation without excessive friction. In addition, they shall be adequate for the purpose for which they are intended.

All joints in frames at corners, junctions and intersections shall be mechanically jointed and be such that when assembled they are as strong as rigid adjoining sections. Due care must be taken to ensure that all joints are watertight and leak –proof. Joint lines should not be visible on the finished surfaces.

Provisions must be made for expansion and contraction in horizontal and vertical members, which are exposed, to the weather or elements. Any distortion of members or any glass cracked or broken as a result of inadequate provisions must be rectified by the Contractor at his own expenses.

All works shall be securely installed and anchored in position, set plumb, square and level in accurate alignment with other work, all in accordance with the approved shopdrawings to the Architect's satisfaction.

The allowable tolerance in terms of specified dimensions shall be plus/minus 1.5mm.

Gypsum Board Glazed with Aluminium Partition Sections

(Insert this new sub section)

(Recommended Brands - ELEPHANT/BORAL or Equivalent/higher)

9 mm thick regular gypsum wall partition- Framework Hot dipped GI C studs 40x100mm & GI Runner 25x101.5mm all 0.6mm in thickness, installed vertically at 600mm centres with top & bottom GI runners. Horizontal cross GI stud of same specification fixed at 3meter height level for stability.

For Powder coated Aluminium partition section, refer item 9.7 in this document.

Aluminium composites

General Requirements for materials

Aluminum coil (sheet) :

Shall be alloy products with higher corrosion resistance and mechanical property (such as 3000 series, or 5000 series) with a minimum thickness of 0.5 mm. The Aluminum coil shall be treated with cleaning and chemical pretreatment to remove oil stain.

Coating materials

For panel should be fluorocarbon resin with favorable weather resistance, or other coating materials with equivalent or outstanding performance.

Note 1: fluorocarbon resin Polyvinylidene Fluoride (PVDF) is widely use at present, but pure PVDF resin should not be coated on the aluminum and it should be combined with other materials to change the coating performance, so it is called as 70% fluorocarbon resin.

Core Material

- Composed of low density polyethylene with at least 75% of mineral material (classified B).
- Composed of at least 90% of mineral material with low density polyethylene (classified A2).
- Corrugated aluminum sheets with minimum thickness of 0.2 mm (classified A2).

The core materials of ACP shall meet any of the following requirements for fire performance:

- Class B,A2, as per EN 13501-1

Composite binding film used between core material and aluminum product shall be fire retardant.

Dimensions and tolerance

Commonly used specifications and sizes of panel are as following:

- Length: 2000, 2440, 3000, 3200 mm.
- Width: 1220, 1250, 1500 mm.
- Minimum Thickness: 4 mm.

Note: Length and width of panel shall be decided between relevant parties.

The tolerances for length, width, straightness and squareness of edges shall Comply with the requirements listed in Table 1

Table 1: Tolerances for length, width, straightness and squareness of edges

| Item | Tolerances |
|-------------------------------|------------|
| Length/mm | ±3 |
| Width/mm | ±2 |
| Thickness/mm | ±0.2 |
| Diagonal Line Differential/mm | ≤5 |
| Side Straightness/(mm/m) | ≤1 |
| Warp Degree/(mm/m) | ≤5 |

Aluminum skin physical properties

The below mentioned physical properties shall comply with the values specified in table 2

Table 2: Aluminum skin thickness and Coating Thickness values

| Physical Properties | Test Method | Requirements |
|--|-------------|--------------|
| Thickness - Aluminum skin (top and bottom) | Caliper | ≥ 0.50 mm |
| Tensile strength | ASTM E 08 | ≥170 MPA |
| Elongation % | ASTM E 08 | ≥ 7 |

ASTM B209- Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate

Performance requirements

The performance of ACP shall meet the requirements in Table 3

Table 3: **Performance requirements**

| S/NO. | Property | Test method | Requirement |
|-------|---|----------------------------|---|
| 1 | Thickness of panels | Calibrated Caliper | ±0.2 mm |
| 2 | Weight of panels | Calibrated weighing device | ± 5% from Declared value |
| 3 | Coating thickness | ASTM D 1400 | ≥25 µm |
| 4 | Abrasion resistance | ASTM D 968 (Method A) | ≥ 50 L/mil |
| 5 | Pencil hardness | ASTM D 3363 | ≥ H |
| 6 | Coating Film adhesion | AAMA 2605 (Clause 7.4) | No loss of adhesion (0% failure) |
| 7 | Impact resistance | AAMA 2605 (Clause 7.5) | No removal of film from substrate |
| 8 | Shear strength | ASTM C 273 | ≥ 3.2 MPa |
| 9 | Gloss at 60° | ASTM D 523 | ± 5% from Declared value |
| 10 | Bend test | ASTM D 522 | 2T (No Cracks) |
| 11 | Peel off test | Peel off test (ASTM D903) | > 08 kg /25 mm for B > 11 kg /25 mm for A2 |
| 12 | Panel tensile strength | ASTM E 08 | ≥50 MPa |
| 13 | Punch shear test | ASTM D 732 | ≥20 MPa |
| 14 | Corrosion resistance: 1. Humidity resistance for 4000 hrs at 38°C and 100%RH in accordance with ASTM D 2247 or ASTM D 4585. 2. Salt spray resistance ASTM B 117 | AAMA 2605 | 1. Humidity resistance: No formation of blisters to extent greater than "Few" blisters size #* as shown in Fig. 4 of ASTM D 714. 2. Salt spray resistance: Minimum rating of 7 on scribe or cut edges, and a minimum blister rating of 8 within the test specimen field in accordance with Table 1 & 2 of AAMA 2605 an |

| | | | |
|----|--------------------------------------|----------------------|---|
| 15 | Weathering resistance | ASTM C 481 (Cycle A) | <ul style="list-style-type: none"> • shear strength no effects when test as per ASTM C 273 • film adhesion no effects when test as per AAMA 2605 (Clause 7.4) • Impact resistance no effects when test as per AAMA 2605 (Clause 7.5) |
| 16 | Temperature for thermal deformation | ASTM D 648 | ≥100 ° C |
| 17 | Thermal conductivity | ASTM C 518 | Declare value |
| 18 | Linear thermal expansion coefficient | ASTM D696 | ≥ 2.4 mm/m/c ⁰ |
| 19 | Reaction to fire classification | UAE fire safety code | Approval from DCD as per fire code |

4.0 IRONMONGERY

British or European standard or Approved Equivalent/higher)

All locks latches etc., shall be of an approved imported quality, or equivalent/higher to Engineer's approval.

Ironmongery shall be made by materials resistant to the weather condition and should Give the necessary mechanical resistance, stability and functionality.

They shall be of Aluminium die cast alloy & stainless steel compatible with Aluminium. The Engineer shall duly approve all items of ironmongery before fixing in position.

The samples, trader literature and test certificates for accessories / ironmongery should be forwarded to the Consultants for approval prior to the commencement of work.

All Aluminium Door & Windows to Be As Listed Below

Powder Coating Thickness for Aluminium Sections to be 60-80 Microns"Y" Louvers to be incorporated to all External Doors & Windows Louver Spacing to be used appropriately at moderate level to avoid drizzling when louvers are exposed to exterior.

☐ The Contractor/Supplier Shall Provide Shop Drawings for all the Doors, Windows And gates, Etc. Prior to Manufacture / Supply the Items

☐ The Contractor/Supplier Shall include all Necessary Accessories, Washers, Beading, Sealants, Etc. For Each Item as Per Relevant Weight and Sizes.

☐ All Double Doors Shall Have Twin Door Handles

☐ The Contractor/Manufacture/Supplier shall include all the necessary Accessories (other than mentioned here) required completing all the Doors and windows.

☐ Approvals shall be obtained for the Al profiles & Accessories with Technical details, Warranties and other relevant Test Reports.

☐ **All Ironmongeries for Fire Doors to Be 2 Hour Fire Rated**

☐ All Fire Doors to Be 2 Hour Fire Rated Steel Door as Per Manufacturers Specifications

☐ All Steel Gates / Doors Finish To Be (Unless Otherwise Specified)

☐ 2 Coats of Anti-Corrosive Marine Paint

☐ 2 Coats of mat finish Enamel Paint

☐ All Galvanized Iron Gates / Doors Finish To Be (Unless Otherwise Specified)

☐ 1 Coat of Etching Primer

☐ 2 Coats of Anti-Corrosive marine Paint

☐ 2 Coats of mat finish Enamel Paint

Hardware & Accessories

☐ Refer the Schedule of Ironmongery for all the Accessory Requirements of Doors and Windows.

☐ Ironmongery used shall satisfactorily perform the function for which it is intended.

☐ The Engineer shall duly approve all items of Ironmongery before fixing in position.

☐ All Door Handles, Locks, Hinges, Door closer & Accessories to be British/European standard or Approved Equivalent/Higher Brand.

☐ All Stainless Steel (S/S) Accessories, Etc. To Be Grade 304, Hairline Finished.

☐ For all Timber / Aluminium Doors Approved Type / Size / Weight Door Closer, Hinges to be introduced where specified.

☐ Sliding tracks, Sliding Wheels Door guard with chain, etc. to be Heavy Duty and compatible with the Door/Window weight, etc.

☐ Accessories for all Aluminium Windows to be Powder Coated Cast Aluminium finished.

☐ All Hinges / thickness, No & Sizes of the Hinges to be strong enough to suit the door weight without any distortions.

☐ All Handle widths to be min. 25 mm wide.

☐ All Handles & Locks to be square type.

☐ For Fire Doors – all Handles, Door closers & Locks to be Fire Rated

□ Accessories For Galvanized Iron (GI) / Steel Doors / Gates to be as per the detailed drawing including similar finishes assigned above & colour to be matched with doors / gates. Steel hinges shall confirm to BS 1227 part1A and CS 30.

Main Doors (frameless Tempered Glass)

Handle : 300 / 450 / 600 mm Vertical Push/Pull Handle
Lock : Both Side Key Lock
Material : Stainless Steel (S/S)
Finish : Hairline Finish
Duty Level : Heavy Duty
Fire Rating : None

Other Aluminium / (Unless Otherwise Specified)

Handle : Lever Handle
Lock : Both Side Key Lock
Material : Stainless Steel (S/S)
Finish : Hairline Finish
Duty Level : Heavy Duty
Fire Rating : None

Main Toilet Door

Handle : Lever Handle with Lock
Material : Nickle plated
Finish : Matt Finish
Duty Level : Heavy Duty
Fire Rating : None

Disable Toilet Door – Swing

Handle : 300mm Pull Handle Fixed Externally
600mm Push Handle Fixed Internally
Lock : 100mm Barrel Bolt Internally
Material : Nickel
Finish : Matte Finish
Duty Level : Heavy Duty
Fire Rating : None

Duct / Service Door

Handle : Lever Handle With Lock
Lock : Single Side Key Lock
Material : Powder Coated Cast Aluminium
Finish : Matte Finish
Duty Level : Heavy Duty
Fire Rating : None

Fire Door

Ball bearing butt hinge 4" x 3" x3 mm in SSS
Mortise sash lock 50mm BS, 20mm sq for end strip, SSS 1"
6 pin EP cyl. L=70mm both side keys in SNP (1 each)
Tubular lever handle with roses and esc. SSS (1 each)
Door closer spring size 3 with standard arm, CE marked
Concealed flush bolt body with rod, Length - 265mm , Vision panel of
6mm thick borosilicate Fire Rated clear glass of size 200mm (W) x
300mm (H), self-adhesive side roll (Ceramic Tape) as required.

05. STAINLESS STEEL

SS Rectangular Hollow Section Specification

Specifications: ASTM A554 / ASME SA554
Sizes: 70x50x2.5mm 4.39kg/m
Available Steel Grades: 304, 316
Finish: Mat or unpolished

SS Flat Section Specification

Specifications: ASTM A276M
Sizes: 50x5mm 2.04kg/m
Available Steel Grades: 304, 316
Finish: Mat or unpolished

SS solid bar Specification

Specifications: ASTM A276M
Sizes: 10mm 0.62kg/m
Available Steel Grades: 304, 316
Finish: Mat or unpolished

6.0 PLASTERING

Products shall be Febmix plus, Sika or approved equivalent complying to BS-EN 934, 2009.

The product preparation shall be as per the Manufacture specified ratios.

7.0 CEILING FINISHES

15 mm Tk. Mineral Fibre Ceiling Panels With 600x600 P/C Aluminium Ceiling Frame Work

(Recommended Brand - "DAIKEN" or Approved Equivalent/higher)

Lay-in ceiling type System C (Exposed Grid Ceiling).

- a. Dimensions- 600 x 600 x 19 mm thick
- b. Edge Detail - Tegular Edge (VT 24)
- c. Colour - White Similar to RAL 9010
- d. Weight - 4.7 Kg/m²

Properties:

- a. Light Reflectance - up to 88%
- b. Humidity Resistance - 100% RH
- c. Surface Burning Characteristics - Class1, BS 476:Part 7:1987
- d. Fire - REI30 – REI120 as per EN 13501-2
- e. Thermal Conductivity - $\lambda=0.040$ W/mK as per EN 12667 - $\alpha_w= 0.90$ as per EN ISO 11654
- f. Sound Absorption /reflection - NRC = 0.90 as per ASTM C 423
- g. Performance Recycled content - >25%
- h. Specification: 600x600x19 Lay-in ceiling type Exposed grid system mineral fibre AFM Thermatex Aquatec or equivalent suspended ceiling.
- i. 600x600x19 Lay-in ceiling type Exposed grid system mineral fibre AMF Thermatex Thermofon suspended ceiling.
- j. Rod/wire with adjustable Butterfly Clips of 4mm dia. securely affixed to structural ceiling using 6mm dia. hook type Anchor fastener.
Ceiling Suspension System to be fixed at interval (Main Runner) of 1200mm spacing's. Proprietary supplied ceiling suspension system to consist of Main Runners @ 1200mm and joined by long cross tee @ 600mm and capped prefinished in high -gloss polyester enamel with two coat system on cold rolled steel.

SUPPLY & INSTALLATION OF PERFORATED CLIP-IN ALUMINIUM PANEL CEILING

(Recommended Brand - COMPTON or Approved Equivalent/higher)

| | |
|--------------------|---|
| Material | 0.7mm thk. high quality aluminium |
| Surface | Finishes Electrostatic Polyester Powder coating or Pre-painted Steel |
| Production Process | Mould forming |
| Perforation Finish | As per approval of the Engineer |
| Colour | As per approval of the Engineer |
| Acoustic Felt | Yes/fire rated |
| Fire | GB 8624 A2 Grade / BS476 Part 6 Part 7 |
| Sound | NRC = 0.65 – 0.8 (ISO 354) |
| Grid Size | 600mm x 600mm |
| Suspension System | Suspended on concealed grid with hot dipped GI frame work |
| Concealed | aluminium clip in ceiling panel system mounted on a proprietary suspension system consisting of main triangular runners fixed on to carrier channel and suspended on 4.0 mm thick hanger rods with adjustable spring clips. |

4.5mm thk. Non- Asbestos Ceiling

(Insert this new sub section)

(Recommended Brand - Superflex or Equivalent/Higher Standard)

☐ Basic composition- Portland cement, refined sand and cellulose fiber.

☐ Specifications/Physical Properties

UCO Superflex is certified to MS 1296:1992 "Fiber Cement Flat Sheets"

☐ Fire Resistant

a) BS 476: PART 6 :1989 (Fire Propagation), Index Performance (1)=0.0 TO 1.8

Sub-Index (i1)=0.0 to 1.1

b) BS 476 : PART 7:1997 (Surface Spread of Flame) No Surface Flame Spread- Class 1 (The best class)

☐ Density At Oven Dry- 1.33 to 1.42 g/cm³

☐ Water Absorption (by weight)- 22.0 % (** EMC to Saturated),

☐ Moisture content at EMC (By weight) 8.0%

☐ Flexural Strength (Modules of Rupture)

| | Average | Across fiber | Along fiber |
|-----------|---------|--------------|-------------|
| Over Dry | 20 | 22 | 17 |
| EMC | 18 | 21 | 15 |
| Saturated | 13 | 15 | 11 |

☐ Thermal Conductivity

Estimated at 20 C 0.30 W/m.K

☐ Moisture Movement

0.06 % to 0.08% (Saturated to EMC)

| Normal Thickness | Nominal weight of board (KG) for standard size in (mm) | | | | |
|------------------|--|-------------|--------------|-------------|-------------|
| | 2440 x 1220mm | 1220 x 1220 | 1220 x 610mm | 603 x 603mm | 595 x 595mm |
| 4.5 | 19.6 | 9.8 | 4.9 - | - | - |

☐ Standard Sizes and Dimensions

☐ Suspended Ceiling Installation

The Framing members for suspended ceiling should be, Main runners are fixed at 1220 mm centers securely fastened to the structural soffit using an appropriate suspension at 1220mm centers. Cross tees of 1220 mm length to be fixed between the main runners at 610mm centers and another cross tee fixed at mid span between 610mm to form a grid structure of 610mm x610mm.

☐ Warranty to be submitted to the product minimum 01 Year.

8.0 FLOOR FINISHES

Material

PORCELAIN FLOOR & SKIRTING TILES

(Recommended Brand - ROCELL or Approved Equivalent/Higher Standard)

Thorough full body rectified rough, Matt, non-slip, semi glazed Homogeneous v porcelain floor with vitrified edges laid flush & level on cleaned, levelled floor with approved type levelling screed & suitable type tile adhesive (recommended by the tile manufacturer.) The specified spacing between tiles to be neatly filled asper the recommended type & colour grout by the Consultant/Engineer.

Thorough (full) body porcelain tiles shall conform to group B1a as per standard EN14411. The tiles shall consist of single, compact, impervious mass that resist chemical attacks, achieved through dry-pressing of high-quality bodies made up of natural raw materials (kaolin minerals, feldspars and inert materials), atomized, and mixed in the press. The tiles shall be made mechanically resistant through a sintering process at very high temperatures.

Colours shall be selected from the manufacturer's standard colour range for earth colour tones.

For all tiles no thickness variations allowed, all corners to be 90 degree, edges not to have any chipping, spacing should be maximum 2-3mm using special spacers (plastic) and colours or textures shall be selected as per the requirements of Consultant/Engineer.

A sample shall be selected all be selected from the manufacturer's standard colour range for earth colour tones.

A sample colour board of intended colours and textures of tiles will be available for the examination of the bidders prior to submission of their bids.

Codes and Standards

All materials, workmanship testing shall be in accordance with the following documents, in their latest revisions. This is not exhaustive and bidder shall verify the listing and supplement with the latest applicable document or documents. Comply with the requirements of the reference standards noted herein, except where more stringent requirements are listed herein or otherwise required by the Contract Documents.

The following standards and codes shall apply where not in conflict with this Specification:

Construction

Products supplied shall conform to the following construction requirements

| | |
|--------------|---|
| BS 5385-1 | Code of practice for the design and installation of internal ceramic and natural stone wall tiling and mosaics in normal condition |
| BS 5385-3 | Code of practice for the design and installation of ceramic floor tiles and mosaics |
| BS 7976-1 | Pendulum Tester Specification |
| BS 7976-2 | Pendulum Tester Method of operation |
| BS 7976-3 | Pendulum Tester Method of calibration |
| BS 8000-11 | Workmanship on building sites. Internal and external wall and floor tiling. Ceramic and agglomerated stone tiles, natural stone and terrazzo tiles and slab, and mosaics. Code of practice. |
| BS 8204-1 | Screeds, bases and in-situ floorings. Concrete bases and cement sand levelling screeds to receive floorings, Code of practice |
| BS EN 1365-2 | Metal lath and beads. Definitions, requirements and test methods. External rendering. |

Performance Requirements

| | |
|--|------------------------|
| Length & Width | +/- 0.6% max |
| Thickness | +/- 5.0% max |
| Rectangular squareness | +/- 0.3% max |
| Straightness of sides | +/- 0.5% max |
| Surface flatness | +/- 0.5% max |
| Water absorption / porosity | ≤ 0.5% |
| Modules of rupture | ≥ 35 N/mm ² |
| Flexural Breaking Strength | ≥ 1300N |
| Impact resistance in terms of Coefficient of Restitution | = 0.55 |
| Abrasion resistance | ≤ 175/mm ² |
| Degree of surface hardness | ≥ 6 |

| | |
|--|--|
| Polished & Pre-Polished / matt floor tiles (Moh's coefficient) | |
| Linear thermal expansion | $\leq 9 \times 10^{-6}/^{\circ}\text{C}-1$ |
| Resistance to thermal shock | No visible defects |
| Front resistance | No visible damage |
| Chemical resistance | No visible effect/Manufacture to state class / (class \geq UB) |
| Stain resistance | Manufacture to state class (class ≥ 3) |
| Colour difference | Conform |
| Safety: slip resistance | Report value and test method adopted |
| Surface roughness | Pendulum skid resistance & ramp test |
| Veranda | ≥ 60 or $\geq R 11$ |
| Colour resistance to UV light | - Conform |

Manufacture & Supplier

Manufacture to be accredited and registered under ISO 9001 or SLS 1181:2013. Tiles shall conform to group B1a as per standard EN14411. Supplier shall be an authorized agent of the manufacturer. Supplier shall provide commercial registration to confirm that the organization has been in operation in Sri Lanka for at least five (5) years & confirmation from the manufacturer that the organization is an authorized agent or a reseller of the product.

Adhesive

High performance, flexible, water resistant cementations adhesive with extended open time and reduced slip for ceramic tiles and stones as per the manufacturer's instructions.

Fields of Application

Interior and exterior floor and wall bonding of all types and sizes of porcelain tiles, ceramic tiles, natural stone, marble, granite, porcelain ceramic, clinker on cementitious renders, cementitious screeds and concrete.

Bonding of porcelain tiles ceramic tiles or granite on existing granite, porcelain, ceramic, marble.

Properties

- Perfect adherence.
- Highly deformable, resistant to temperature changes.
- Waterproofing.
- Extended open time.
- Can be applied on vertical surfaces even for bonding of heavy tiles without sagging.
- Easily trowelable.

Grout

High performance (high resistance to abrasion and reduced water absorption), cementitious, silicone enhanced, fungi and yeast resistant grout for 2 to 20 mm joints shall be in compliance with (American National Standards Institute) ANSI – A118.

Fields of Application

Grouting interior and exterior floor and wall in all types and sizes of ceramic tiles, granite, clinker, glass mosaics, marble, natural stone for 2-20mm joints.

Properties

- ☐ Less prone to dirtiness, easy to clean.
- ☐ Low water absorption with water repellence.
- ☐ Resistant to fungi & yeast growth.
- ☐ Approved to be used in contact with water intended for human consumption.
- ☐ Low shrinkage, therefore absence of cracks and fissures.
- ☐ Very good abrasion resistance.
- ☐ Good compressive and flexural strength and good resistance to freeze/thaw cycles.
- ☐ Fast curing.
- ☐ A smooth final surface.
- ☐ Low water absorption.
- ☐ Ultra-violet and atmosphere resistant 32 different colours.

Colours, Textures and Patterns

Where manufacture's standard products are indicated for tile, and other products requiring selections of colours, surface textures, patterns and other appearance characteristics, provide specific products or materials complying with the following requirements:

Factory Blending: For tile exhibiting colour variations within ranges selected during Sample submittals, blend tile in factory and package so tile units taken from one package show same range in colours as those taken from other packages and match approved Samples.

Grooves & Step Nosing for Staircases and Ramps

The Granite of the stairways shall have a nosing and min. 2nos of 10 – 12 mm wide grooves engraved to the tiles as per the approval of the Engineer.

The Granite used for the ramp areas shall have evenly spaced 10 – 12 mm wide grooves engraved to the tiles as per the approval of the Engineer.

Workmanship

The surface fall tiled floors shall be perfectly in level and shall be executed by experienced workers in the field of tile laying. The Contractor shall appoint an experienced supervisor during the process to prevent errors while laying & setting out tiles.

The tiles shall be cleaned at all times to prevent damage on the surface while cleaning of the stubborn stains at a later stage. A sample panel of laid tiles of each type shall be approved by the Engineer before commencement of tile laying.

Chipped or damaged tiles installed by the Contractor shall be rejected and shall have to be replaced by the Contractor at his own cost and risk.

Warranties

Warranties shall be backed by an insurance guarantee for performance requirements of materials. Warranties shall be for the value of materials & manufacturing defects for a period of Ten (10) years from the date of Employer's Formal taking of the delivery which is to be transferred to the name of end user.

NATURAL STONE SLABS

(Delete the sub section entirely and substitute the following)

Granite Slabs (flamed granite)

18mm – 20mm thk. Polished Granite slabs shall be installed on to Steps, lift floor & countertop of the Pantry counters where specified and as per the detail.

Material characteristics, physical requirements, and sampling shall be appropriate to the selection of granite for particular application. Uniform textured finish produced by the application of a high temperature flame to the stone surface with all panels processed horizontally (parallel) shall be to the grade as requested.

Material physical properties

- Density, min., kg/m³ - 2560
- Absorption by weight, maximum % - 0.40
- Compressive strength, min. MPa - 131
- Modulus of rupture, min, MPa - 10.34
- Abrasion resistance, min, hardness - 25
- Flexural strength, min, MPa - 8.27
- A smooth final surface.
- Low water absorption.
- Ultra-violet and atmosphere resistant 32 different colours.

Colours, Textures and Patterns

Where manufacture's standard products are indicated for tile, and other products requiring selections of colors, surface textures, patterns and other appearance characteristics, provide specific products or materials complying with the following requirements:

Factory Blending: For tile exhibiting color variations within ranges selected during Sample submittals, blend tile in factory and package so tile units taken from one package show same range in colors as those taken from other packages and match approved Samples.

Grooves & Step Nosing for Staircases and Ramps

The tiles of the stairways shall have a nosing and min. 2nos of 10 – 12 mm Wide grooves engraved to the tiles as per the approval of the Engineer.

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GREY CEMENT RENDERED FLOOR

Clean the floor surface from dust, dirt oil and nail & other loose materials before start works. Concrete surface are sufficiently roughen to receive plaster & surface is dampened before application.

1:3 cement: Sand Mortar with adequate walkability to be used for rendering

complete with 12 mm thickness with masonry trowel and level with straight edge finish semi rough and apply cement slurry as above and trowel to get smooth surface. Levels to be finish as per Architects' Drawings. Slops to be finalized for Required areas.

EXTERNAL INTERLOCKING PAVING TILES

(SMS or Equivalent/Higher standard)

SLS Standard 1425 Part 01

- For Path Ways - 15 N - Strength
- For Light Vehicles - 30 N - Strength
- For Heavy Vehicles - 40N & BS Standard

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Types of paving

- a. Heavy Duty interlocking Pavers COBBLE (SMS)
- b. 100x100 Arena/ELIANA (SMS) Equivalent/Higher standard

9.0 ZINC-ALUMINIUM COATED PROFILED STEEL SHEET ROOFING

- BlueScope or Equivalent/Higher standard)

Zinc-Aluminium Coated Profiled Steel Sheet

Supply of color coated trapezoidal profile sheet of 1015mm effective cover width and nominal 28.5 mm deep ribs .The end rib shall be designed for anti-capillary action. The feed material is manufactured out of nominal 0.42 mm Base Metal Thickness (BMT), Hi-Tensile steel with min. 550 MPa yield strength, metallic hot dip coated with Aluminium-Zinc alloy (55% Aluminium, 43.5% Zinc) as per Standard, AS 1397 - Zinalume AZ200 (Min. 200 gms/sq.mt total on both sides). The color coated sheet shall be oven baked Super Durable Polyester COLORBOND steel with thematic solar reflectance technology quality paint system as per AS/NZS 2728 Class 4. The paint shall have a total coating thickness of nominal 40 µm, comprising of nominal 20 µm exterior coat on top surface and nominal 10 µm reverse coat on back surface over nominal 5 µm primer coat on both surfaces of approved color shade by concern authority.

Standards to be international standards for coated products.

ASTM A792/A792M – standard specification for steel sheet 55% Aluminium Zinc Alloy coated by the Hot-dip process.

ASTM A755/ A755M – standard specification for steel sheet metallic coated by Hot-dip process and pre-painted by coil coating process for exterior exposed building products.

Preferred roofing sheet type: Step tilted profile from Supper-met or equivalent
Colour –As specified by Architect

Anti-corrosive paint shall be applied on to all cut edges, nailed/anchored joints, etc. while installation.

Painting New Surfaces with Plastic Emulsion Paint

Material

Emulsion paints shall be in compliance with SLS 533 and 557.

Use following products or equivalent approved to

Wall painting-Wall putty Glidden or Approved equivalent

Wall paints internal - CIC or Approved equivalent 01 coat of Exterior/Interior

Primer

Wall paints external - 02 coats of CIC Dulux weather shield "power flex" or

Equivalent

Application

Painting system for interior walls

Approved type two (2) coats of wall putty to required smoothness, one (1) coat of primer and two coats of approved type emulsion paint or equivalent for the internal surface of the walls shall be applied. However Contractor shall apply number of coats as specified by the manufacture to the satisfaction of Engineer.

Painting system for exterior walls

One (1) coat of acrylic based penetrative sealer, two coats of acrylic based primer with flexible elastomeric property and two coats of acrylic based external weather proof paint for external wall area. (Approximate dry film thickness 160microns) on semi rough plastered and neat cement floated walls, columns, beams. However Contractor shall apply number of coats as specified by the manufacture to the satisfaction of Engineer.

10. DRY WALL PARTITION

98 mm thick metal framed, non-load bearing partitions with two layers of Hilux Calcium Silicate boards on either side of G.I. frame and 50mm thick ceramic wool placed in the cavity can achieve Two Hours fire resistance.

Performance

| | |
|------------------|-----------|
| System Thickness | 98 mm |
| Fire Resistance | Two Hours |
| Sound Insulation | 48 dB |
| Maximum Height | 4200 mm |

Installation:

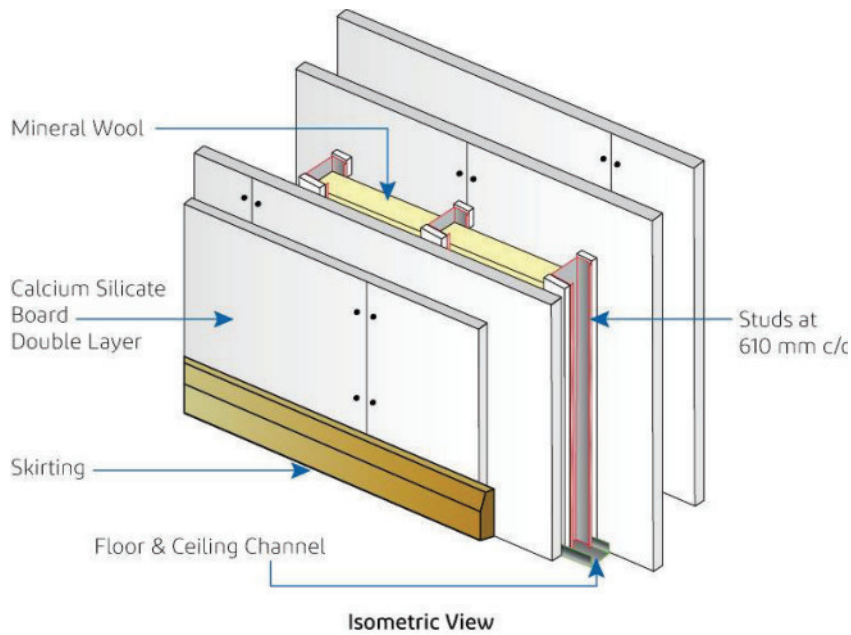
Frame work and board fixing is done as described in double layer partition chapter.

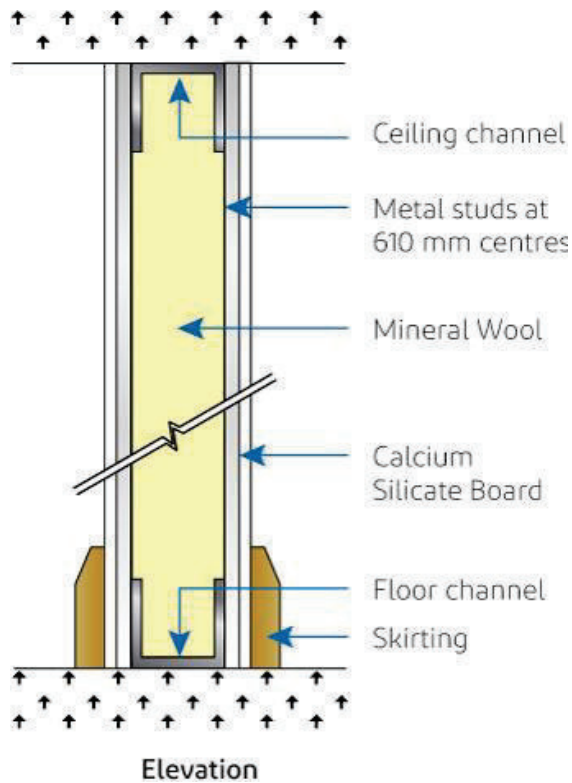
Jointing and Finishing:

Hilux board joints of outer layer are filled and finished with specially formulated jointing compound and 48mm wide Self-adhesive fiber mesh tape to get seamless finish.

Insulation:

Rockwool 50mm thick and 64kg/m³ density is placed in the cavity after completing board fixing on one side of the partition.





Installation:

| | | |
|-----------------------------------|---|--|
| Hilux Board | 2440 x 1220 mm 8/10/12 mm Thick | Two boards on each side of Studs |
| Hilux Floor / Ceiling Channel | (50 x 32 x 32) mm | Top and bottom perimeter of the partition |
| Hilux Stud | (48 x 34 x 36) mm | Vertically at 610 mm c/c |
| Hilux Bracing member / Flat Strap | 45 x 15 x 15 x 0.9 mm / 75 x 0.9 mm | At horizontal board joint |
| Hilux Screws (Phillips head) | 25 and 35 mm long, self-drilling with under head cutter | 12 mm from the edge and 40 mm from the corner of the board at 200 mm c/c |
| Insulation | Rock Wool - 50 mm x 64 kg/m ³ | Placed in the cavity |

11.0 THERMAL INSULATION:

(Recommended Brands - Mcfoil or Approved Equivalent/Higher standard)
Minimum specification requirements:

Specifications for Foil

Tensile strength : 1,500N/25mm x D.60N25mm (ASTM D828)
Surface Reflectivity : 0.95 (ASTM D1263)

Water vapor transmission rate: 5.75 ng/N.s (ASTM E96)
Reflectivity : 95%
Emissivity : 5%

Specifications for Glass wool

Temperature Range : -4 0C to 121 0C (ASTM C411)
Moisture Absorption : 3% < at 49 0C and 90% relative humidity
(ASTM C1104)
Fire Rating Class : 0 (BS 476)
: No support or promote mold or fungus growth
(ASTM C665)

Specifications for Galvanized Mesh: Strong and durable support for Insulation

Tensile Strength : 38.8 N/mm² (3 x3 mesh or equivalent, BWG 17(1.37mm), Zinc 45g/m²)
Wire diameter tolerance : +0.01 mm
Standards of conformation : Manufactured with iron, coated with Zinc
(Galvanized before weld) in compliance with
ASTM F2919

12.0 SIGNAGE

External Signage- Building Name Board

3mm Thk. Stainless Steel, Grade- 304, Hairline finished dimensional letters with back Lit on specified (LED Strip to be introduced) Letter height to be finalised as per the drawing.

Location Map

Weather Proof mat finish 3 mm THk. Printable Aluminium composite panel (ALUCOBOND or equivalent/ higher standard)

Toilet Door Signage

Size : min. 150mm x 150mm (as per approval of the Engineer)
Material : Stainless Steel Plate with durable black engraving
Finish : Hairline Finish
Fire Rating : None

13.0 ROLLER DOOR

(Recommended Brands – Three Sinha, Elcardo or Approved Equivalent/Higher standard)

Roller Door mechanism : Manual

Roller Door Material : Powder coated

Min. 0.6mm thk. Zinc. Aluminium Plates

Design : as per the engineer's approval

Colour : as per the engineer's approval

Roller door pulley to be concealed with powder coated Zinc/Aluminium cladding with necessary frame work. The colour to be matched with the roller door. (Refer below diagrams)




14. SANITARY FITTINGS AND ACCESSORIES



- ☐ Refer Annex 01 for Sanitary Fittings
- ☐ Refer Annex 02 for Schedule of Bathroom Accessories


Bathroom Mirror

5 - 8mm thk. Frameless Mirror polished plate glass with polished pencil edge. Fixed with Stainless steel studs/knobs Standards to meet ASTM C 1036-91 Shall have a warrantee against silver spoilage for fifteen (15) years.

Mirror shall have plating and sealer coatings as per the accepted standards to withstand 15 year warranty. Mirrors shall be supplied as one piece per details up to 28 sq. ft. (2.6 m2) and less than 84" (2134mm) in either H or W dimensions and shall have polished pencil edges. Mirrors larger than 28 sq. ft. (2.6 m2) or with either linear H or W dimensions larger than 84" (2134mm) shall be supplied as multiple pieces per Detail.

| | Item | Code Number/ Name | Brand Name | Location |
|----|---|---------------------------------|------------------------------|--|
| 01 |  | Water Closets Riveiar | European / American standard | All toilets Ground floor Except ward toilet & common toilets |
| 02 |  | Water Closets Intense | European / American standard | Ground floor ward toilets |
| 03 |  | Water Closets Aqua + | European / American standard | All Accessible toilets Common toilets ground floor All First Floor toilets |

| | | | | |
|----|---|--|------------------------------|--|
| 04 |  | Wash basins Dew Point Half Pedestal | European / American standard | All ward / common wash rooms Including Accessible Toilet |
| 05 |  | Wash basins Evok | European / American standard | All Staff wash rooms |

| | Item | Code Number/ Name | Brand Name | Location |
|----|--|--|-----------------------------|-------------------|
| 01 |  | SD90943L Single Lever Cold Water Tap Brass Chromium Plated | European or Higher standard | All wash Basins |
| 02 | Angle Valve 1/2" | A280 | European / Higher standard | All Toilets |
| 03 | Soap Holder | P090100 | European / Higher standard | All Toilets |
| 04 | Robe Hook/Dress Hook | IDC-A021 | European / Higher standard | All Toilets |
| 05 | Drop Down Grab Bar | BG0801CS | European / Higher standard | Accessible toilet |
| 06 | Grab Bar | BR0600CS | European / Higher standard | Accessible toilet |
| 07 | Bidet Spray | RB.TGN.0FA200.AB.PA- | European / Higher standard | All Toilets |
| 08 | Gully Grating | 2361 | European / Higher standard | All Toilets |
| 09 | Paper Holder | IDC-A219 | European / Higher standard | All Toilets |
| 10 | Kitchen Sink | ARTISAN RSX 611-91 3 1/2" WWK REV | European / Higher standard | Pantry at Dining |

15.0 LANDSCAPE WORKS

PARTICULAR SPECIFICATIONS FOR LANDSCAPE WORKS

Clause numbers herein corresponds with the numbers of related articles, if any, in the Standard Specifications – Specifications for Landscape Works– Volume I (ICTAD Publication No SCA/7. The numbering of new clauses is continuous with related clauses in the Standard Specifications.

GENERAL

1.0.0

(Insert this new sub section)

The works covered by this Sub-section includes type of materials to be used in landscaping of the Site, as shown on the Drawings or as instructed by the Engineer. Under this sub-section, planting of trees, shrubs, etc. shall be carried out in accordance with the plans approved by the Engineer.

TOPSOIL AND GROUND WORKS

(Insert this new sub section)

Topsoil shall be removed according to excavation plans proposed by the Contractor and approved by the Engineer and stored in somewhere in the Site for the use of landscaping works as specified in Earthwork, Top soil shall be piled free of roots, stones, and other undesirable materials and it shall be protected from erosion. The Contractor shall take measures and precautions to prevent contamination of the topsoil by cement, lime, etc.

Following the completion of building and related infrastructure works, such as trenches, traffic and pedestrian roads, parking areas etc., the Contractor shall start grading work in the site according to the shop drawings approved by the Engineer. If and where required, necessary filling shall be performed and embankments shall be constructed and fills shall be compacted within the lots for landscaping purposes upon the instruction of the Engineer.

Filling material shall be free from roots and other organic matter, trash, debris and stones larger than 7.5 cm. No payment shall be made separately for filling, embankment and compaction works for landscaping purposes, since it is deemed to be included in the excavation and backfilling items. Topsoil shall be spread evenly and graded after the completion of final grading under the top soil. Graded areas shall be protected from erosion, any settlement or washing away that may occur for any reason prior to the acceptance shall be repaired and re-established at no cost to the Employer. All landscape work (such as planting works) shall be carried out at an appropriate season and under appropriate weather conditions and completed in a timely manner.

PLANTS AND PLANTING

General Specifications for Supply and Planting

A Planting Trees, Shrubs, etc. and Transplanting Trees

(Insert this new sub section)

Plants shall be adequately and carefully packed and protected during the transportation to Site. After delivery, if planting is not to be carried out immediately, they shall also be protected according to the relevant requirements. All plants shall be free from disease, insects, defects and physical damage.

The species of the trees and shrubs shall be as indicated in the Bill of Quantities and minimum height of stem shall be 150 cm. Plantings shall be carried out in accordance with the plans provided to the Contractor or as instructed by the Engineer. Excavation of tree pits shall be taken from the finished levels of graded areas. Tree pits shall be excavated in suitable diameter and depth appropriate for the pieces of trees to be planted- Excavation of tree pits, planting of trees shall be carried out so as to meet the requirements of relevant standards and specifications under the supervision of the Engineer. All planted material shall be well watered at the time of planting and afterward, required maintenance of planting trees shall be carried out by the Contractor to keep the trees in good condition until the project is completed. Trees shall be fixed to the ground with ropes or wires to prevent damage from wind.

Trees which are in the excavation area and suitable for transplanting shall be transplanted to the green areas within the Site or the park area as within the Urban Housing. Area as instructed by the Engineer. Suitable equipment has to be used for transplanting. The Contractors have to propose a procedure and specification for transplanting and receive the Engineer's approval before starting transplanting works. The Contractors are responsible to keep the transplanted trees in good condition up to completion of the project.

B Ground Covering Plants

Slopes exceeding 40 degrees around the buildings shall be planted by ground covering plants in order to prevent sliding of the soil. Minimum 16 units of ground covering plant shall be planted per square meter. Fertilizer shall be incorporated on all planted slopes and the maintenance shall be carried out by the Contractor in a proper way.

C The Wall Protection

Depending on the ground condition instead of retaining walls prefabricated interlocking concrete blocks shall be constructed at the locations found appropriate by the Engineer. The interlocking concrete blocks shall comply with precast concrete specification. All expenses relevant to complete Toe wall protection to the Engineer's satisfaction are deemed to be included in the unit price given by the Contractor.

D Workmanship

All grading works, backfilling / compaction / embankment (if necessary) spreading of top soil, grassing, planting, transplanting, maintenance of planting material, and assembling and disassembling equipment and related works shall meet the requirements of relevant standards, technical specifications, and the manufacturer's instructions.

Every stage of the works shall be subject to the Engineers' approval. The items referred to in this sub-section shall include but not limited to, supply, transport. Storage and proper use of top soil, filling material, fertilizers planting materials including trees, shrubs, ground

covering plants etc. and clearance of grounds to be landscaped, spreading, levelling and rolling of topsoil. Excavation and filling of tree pits and planting of trees, shrubs, ground covering plants etc., transplanting, maintenance of all completed landscape works and transplanted trees and reinstatement of losses and defaults, transport of labor, materials, construction plant, etc., necessary for the execution of the relevant work. Storage, keeping the Works in a dean and sanitary condition, cleaning after completion and all incidentals necessary to complete the Works according to the Contract documents. All works shall be carried out to the satisfaction of the Engineer, The items concerning landscape shall include, but not by way of limitation, the supply, transport, storage, deliver, assembly, erection, fixing, construction of all necessary foundations, maintenance of all completed, works ditto.

E Measurement

Planting of trees and ground covering plants shall be measured in actual number planted and maintained. Transplanted trees shall be measured in actual number transplanted and maintained.

G Paving Blocks and Grass Pavers

(SMS or Equivalent/Higher standard)

1. Cobble Paving Blocks

Size : 200 x 100mm thickness 80mm
Compressive Strength: 40 N/mm²

2. Eliana Paving Blocks

Size : 100 x 100mm thickness 80mm
Compressive Strength: 40 N/mm²

3. Grass Paver Paving Blocks

Size : 110 x 220 mm thickness 80mm
Compressive Strength: 40 N/mm²

DESIGN SERVICES FOR EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI IN MALDIVES

Specifications- Structural

23553-01-TN-ST-SP-9800

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| 1.0 | URO | Initial Issue | 25.09.2023 |
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CHAPTER 1

INTRODUCTION

1.0 Materials

Material used shall be the best of its kind. It shall conform to the relevant British Standard, and where such a Standard is not available shall conform to the Local approved standards.

1.1 Water

All water used for mixing concrete, mortar or grout shall conform to BS and be obtained from a source approved by the officer-in charge. The water shall be fresh, clean and free from acid, alkali, oil, organic impurities, lime in solution or other matter which is deleterious to concrete or steel. In general potable water shall be used.

As a guide, the following concentrations may be taken to represent the maximum permissible limits of deleterious materials in water.

- (a) Suspended matter - 2,000 mg/litre
- (b) Dissolved matter (max concentration)
 - 1. Sodium & Potassium Bicarbonate 1,000 mg/litre
 - 2. Sodium Chloride 20,000 mg/litre
 - 3. Sodium Sulphate 10,000 mg/litre
 - 4. Ca +Mg Bicarbonate as HCO_3 400 mg/litre
 - 5. Calcium Chloride 20,000 mg/litre
 - 6. Iron Salts - 40,000 mg/litre
 - 7. Sodium Iodate, Phosphate, Arsonate & Borate 500 mg/litre
 - 8. HCL + H_2SO_4 - 10,000 mg/litre
 - 9. NaOH - 5,000 mg/litre
- (c) pH value of water shall generally be not less than 6.

Sea water shall not be permitted for mixing or curing of concrete.

Water found satisfactory for mixing is also suitable for curing concrete; however, water used for curing shall not produce any objectionable stain or unsightly deposit on the concrete surface. The presence of tannic acid or Iron compounds is objectionable.

The Contractor shall make arrangements for and provide all the water necessary for concrete, mortar, curing or any other purpose on the work.

1.2 Cement

General

Cement shall be from an approved source and shall one of the following types of cement as specified.

Type

Ordinary Portland cement

Rapid hardening Portland cement

White Portland Cement

Colored Portland cement

Portland Blast furnace cement

Low heat Portland cement

Sulphate resisting Portland cement

Low heat Portland blast (furnace cement)

Super Sulphated cement

Ultra high early strength

Portland cement

Water Repellent Portland
cement

Hydro-phobic Portland
cement

Masonry cement

The initial setting time shall not be less than 45 minutes and the final setting time not more than 10 hours for ordinary Portland cement.

1.2.1 Supply

The cement shall be packed in bags (multiply paper, or cloth) Alternatively it may be supplied at site in silos installed for the purpose.

1.2.2 Transport, Storage and Handling

The cement needed for concrete mortar and grout shall be purchased by the Contractor to suit the construction schedule. He shall make all necessary arrangements and be responsible for transporting, storing and handling it.

Cement shall be stored on the site in such manner as to facilitate identification or inspection of each consignment. The storage sheds shall be of weather proof construction and the floors shall be free from all possibilities of flooding. Chipping up or re-using of partially set cement shall not be allowed. The bags shall be stacked at least 100 to 200 mm clear above floor level over wooden planks and joints. A spacing of 600 mm should be kept between the exterior walls and the stacks. Cement bags shall be placed close together in the stack to reduce circulation of air to the minimum. To avoid lumping under pressure, cement bags shall not be stacked more than 10 bags high. Extra precaution shall be taken during monsoons or when cement is to be stored for unusually long periods; the stack shall be enclosed completely in thick polythene sheet, canvas sheets or any other suitable water proof sheeting, with the flap closing on the top of the stack. Care shall be taken to see that the water proof sheeting, with the flap closing on the top of the stack. Care shall be taken to see that the water proof covering is not damaged at any time during use. When removing cement bags for use the 'first in, first out' rule shall be applied.

In the case of large works, the storage capacity shall be adequate to ensure uninterrupted work in accordance with construction schedule.

Storage of cement at the site of work shall be at the contractor's expense and risk.

1.2.3 Testing of Cement

The officer-in charge may extract samples of consignments of cement as and when he desires for the purpose of testing. Testing shall conform to BS 12 for Portland cement and to the relevant British standards for other cements. If the sample fails the test, the particular consignment shall be rejected and shall be removed from the site within 24 hours of notice in writing to the contractor to do so. Any consignment of cement stored at site for more than 3 months shall be re-tested if so required by the officer-in charge.

If the contractor provides the cement, he shall arrange for the cement to be delivered at the site in sufficient time for standard tests to be made before the cement is required for use, or provide certificates of tests from the supplier that will be acceptable to the Officer - in charge.

1.3 Lime

Lime shall be obtained from an approved source; it shall be one of the following types, as per BS depending on the raw material from which it was manufactured,

Type 1 Dolomitic Lime

Type 2 Coral lime* and sea shells

Type 3 Burnt Miocene lime stone

Lime which has perished, or which has been damaged by damp, rain, or intermixture of dirt, or which has become partially air slaked shall on no account be used on the works and shall be removed from the site within 24 hours of notice to remove. Lime which gives a residue of more than 10 percent by weight when tested with hydrochloric acid shall be rejected.

The lime stored at the work site shall be protected from weather action, by being kept in a weather proof shed with impervious floor and sides.

1.3.1 Quick Lime

This shall be freshly burnt from good hard coral*, sea shells or limestone broken to a uniform size not exceeding 40mm and carefully freed from earth and other impurities.

The lime shall be delivered at the site of the mortar mill quite fresh, i.e. within 15 days of the date on which it was drawn fresh from the kiln. In cases where compliance herewith is not possible due to seasonal closure of kilns, written permission of the officer - in charge is necessary before stored slaked lime can be used.

Note : *Government is contemplating the banning of coral lime.*

1.3.2 Hydrated/Slaked Lime

All impurities, ashes or pieces improperly or carelessly burnt shall be screened or picked out before slaking. Quick lime shall be slaked with sufficient water; slaking shall be done neither earlier than three weeks nor later than one week before being put into the mill.

The lime after slaking shall be screened through a sieve of such size as the Officer-in charge may direct and all stuff that does not pass through the sieve shall be rejected. For plastering second and third coat or for any fine work, unless otherwise specified, the lime shall pass through a 1.18 mm BS Test sieve: for all other work, unless otherwise specified the lime shall pass a 2.36 mm BS Test sieve wire screen.

1.3.3 Lime Putty

Lime putty shall be obtained by treating either quicklime or hydrated lime with sufficient water so as to produce a plastic, sound product.

It shall be sieved to be entirely free from coarse particles and shall be thoroughly matured for not less than 16 hours before use.

1.4 Fine Aggregate for Concrete

This shall be conforming to BS 882: See chapter 4.

1.5 Coarse Aggregate

Coarse aggregate for granolithic floor finishes shall be as specified in Chapter 4.

1.6 Building Sands from Natural Sources

The sand may be naturally occurring like river sand, pit sand or crushed stone sand. It shall generally conform to BS 1198, BS 1199 and BS 1200. It shall be hard, durable, clean and free from adherent coatings such as clay. It shall not contain harmful materials like pyrites, salts, coal or other organic impurities mica, shale or similar laminated materials, or flaky or elongated particles in such a form or in sufficient quantity to affect adversely the hardening, strength or durability of the mortar. In addition to the above, the sand when used for reinforced brick work shall not contain any material which may attack the reinforcement.

The quantity of clay, silt and dust shall not exceed the following unless there is satisfactory evidence to the contrary.

| | | |
|---|---|--|
| In natural sand | - | 3 % by mass when determined by the decantation method given in BS 812. |
| In crushed stone sand sedimentation method | - | 15% by mass when determined by the given in BS 812. |

1.6.1 Grading

Sand for brickwork/stone work/block work and external plastering shall pass completely through a sieve of 2.36 mm. Sand for second and third coats of plastering, pointing and fine work shall completely pass through a 1.18 mm test sieve.

1.7 Methods of Stacking

Materials normally measured in stacks are rough stone of all kinds broken stone and broken brick, gravel, sand, and lime. However for purpose of mixing of mortar, concrete etc. materials like sand, broken stone etc. shall be measured in properly constructed measuring boxes (or by weight as instructed by the Officer- in -charge) to suit the specified proportions of those materials.

Piles shall be formed of regular shape and uniform cross section.

Materials shall not be stacked on uneven ground or in any manner which does not permit correct and ready measurement from external inspection of the piles.

Rough stone which is to be measured in the stack shall be packed so closely as to give the minimum quantity of voids possible, without actual dressing of the stones to fit the interstices.

1.8 Other Materials

Materials not dealt with in this chapter will be specified in the relevant chapters.

CHAPTER 2

SITE PREPARATION, EXCAVATION & EARTH WORK

2.1 Site Work

General

The area described or shown on the relevant site plan or bill of quantities shall be cleared of all obstructions, roots and growth, vegetation of every description, trees and saplings. Unless otherwise specified, 150 mm top soil shall be removed from that part of the site to be occupied by the proposed buildings and for a distance of 3 meters around it and the area leveled. The top soil shall be preserved in stock piles if so directed by the officer -in charge.

2.1.1 Existing Services

Particulars of over/under ground services shall be obtained from the Employer before commencing any work which may affect such services.

These services shall be maintained/diverted/plugged dismantled as specified or directed. In case the drain ends are required to be sealed off, contaminated earth shall be removed and disinfected as specified.

2.1.2 Demolition of Existing Structures

Where buildings are to be demolished this shall be down to ground level, or the bottom of posts, stanchions, etc. as specified. Special care shall be taken to cause the minimum damage to the materials in the process of dismantling. The value of the materials which in the opinion of the Officer-in -charge have been broken or damaged through carelessness on the part of the contractor will be recovered from the contractor. All serviceable materials shall be removed and stacked or disposed of as specified, and all debris shall be carted away by the contractor.

Refer also Chapter 16 - Dismantling & Demolition.

2.1.3 Felling and Removal of Trees

The trees shall be cut only after written permission of the Officer-in charge is obtained.

The roots of trees shall be removed completely and the hollows filled up with suitable earth in layers of 150 mm leveled and rammed so that the surface at these points conforms to the surrounding area.

Wood, branches of trees and other useful materials shall be handed over to the Officer-In-Charge. The felled trees shall be cut to such lengths as directed by the Officer-In-Charge, trunks and branches cleared of limbs and tops and stacked neatly, well away from the site of work. Other serviceable materials shall be stacked as directed and handed over to the Officer-In-Charge.

2.1.4 Disposal of Waste Materials

At the conclusion of the site work, the contractor shall tidy up and leave the site of the work in a clean and sanitary condition. All unserviceable material shall be removed from the area and disposed of as directed. Care shall be taken to see that the unsuitable waste materials are disposed of in such a manner that there is likelihood of these getting mixed up with materials meant for construction.

2.1.5 Waterways

All field drains and other water ways encountered during the excavation shall be temporarily diverted and reinstated, or otherwise taken care of, as directed by the Officer-In - Charge.

Filling of the location from which water courses have been diverted shall be commenced after clearing away all vegetable growths and soft deposits.

2.2 Excavations

Note: *The contractor shall visit the site, inspect the trial holes or bores where available, and decide for himself the nature of the ground, subsoil to be excavated and the ground water levels. The furnishing of particulars of trial holes or bores for the information of the contractor does not absolve the contractor from his responsibilities nor does it guarantee that similar conditions apply on other parts of the site.*

2.2.1 Establishment of Levels

2.2.1.1 Bench Marks

A masonry pillar of a suitable design shall be erected at a prominent place in the site to serve as a bench mark for the execution of the work. This bench mark shall be so located that it remains undisturbed till all the works are completed. This shall be connected to a Standard Bench Mark if so directed by the Officer-in -Charge.

2.2.1.2 Levels

Before any excavation is commenced, the levels of the surface after removal of top soil shall be agreed by the Officer-In-Charge and the Contractor. Such agreement shall be recorded on a drawing showing levels at predetermined intervals, and shall be signed by the contractor and the Officer-In-Charge. The contractor shall provide all labour and instruments to obtain and record these levels.

2.2.2 Classification of Soils

Excavation in various types of material shall be classified under the following categories (refer Standard Methods of Measurement) No distinction shall be made whether the material is dry or wet. The decision of the Officer-In-Charge with regard to the classification shall be final.

(a) Soft/Loose Soil

Generally and soil which yields to the ordinary application of pick and shovel, rake or other ordinary digging implements; for example vegetable or organic soils, turf, gravel, sand, silt, loam, clay, peat etc.

(b) Hard/Dense Soil

Generally any soil which requires the close application of picks jumpers or scarifiers to loosen same; for example, stiff clay, gravel and cobble stone.

Note : *Cobble stone is the rock fragment usually rounded or semi rounded having maximum diameter in any direction between 80 mm and 300 mm.*

(c) Mud - A mixture of soil and water in a fluid or weak state.

(d) Soft disintegrated rock (not requiring blasting)

This shall include rock or boulders, which can be excavated by barring, wedging and splitting manually or using pneumatic tools. It shall also include embedded boulders measuring not more than one meter in any one direction.

Note : *The mere fact that the contractor resorts to blasting to loosen the material shall not mean that it will be classified as hard rock.*

(e) Hard rock (requiring blasting)

This shall include all rock occurring in large masses which cannot be removed except by blasting. Hard varieties of rock such as granite with or without veins and secondary minerals which in the opinion of the Officer-In-Charge requires blasting shall be considered as hard rock. Boulders of hard rock larger than one meter in any one direction lying in the overburden and requiring to be blasted for easy and efficient removal shall also be classified as hard rock. Refer clause 2.2.3.

(f) Hard rock (blasting prohibited)

For hard rock requiring blasting as described in (e) but where blasting is prohibited, the excavation has to be carried out by chiseling, wedging or any other agreed method. Refer clause 2.2.3.

(g) Common Excavation

This shall refer to excavation in all soils except rock requiring blasting with the use of excavating and earth moving machinery.

2.2.3 Blasting

Should rock be met with, in the course of excavation, it must be removed with wedges and levers. Blasting shall not be allowed without the written permission of the Officer-In-Charge, who must be fully informed by the contractor as to the steps taken by him to safeguard the surrounding property: the contractor shall take all responsibility for any damage or annoyance caused by way of blasting. Blasting operations shall be carried out as per the specifications set out under rock blasting in Section XIV of BSCP 2003.

In soft rock, if the contractor wishes to resort to blasting, he can do so only with the permission of the Officer-In-Charge, but at no extra cost.

2.2.4 Antiquities and Useful Materials

Any finds such as relics of antiquity, coins, fossils or other articles of value which may be discovered during the excavation work shall be the property of the Employer and shall be delivered to the Officer-In-Charge.

2.2.5 Protection

Trenches and foundation pits shall be provided with proper caution-signals and marked with red lights at night to avoid accidents.

The contractor shall take adequate protective measures to see that the excavation operations do not affect or damage adjoining structures, services etc.

2.2.6 Reinstatement of Damages during Excavations

All materials, structures, foundations, surfaces etc. affected or damaged during excavation shall be made good by the contractor at no extra cost to the Employer.

2.2.7 Anti-Termite Treatment

The treatment may be pre-constructional or post constructional. Where specified, the work shall be carried out according to standard techniques and practices using chemicals of approved make and concentrations, and as directed by the Officer-In-Charge.

2.2.8 Stability of Excavation

The methods of excavation shall in every case, be subject to the approval of the Officer-In-Charge and the contractor shall ensure the stability and safety of the excavation, adjacent structures, services and the works.

The sides of the excavation shall be timbered and shored by a proper method previously approved by the Officer-In-Charge.

The contractor shall have full responsibility for the stability of the excavations and safety of workmen. If any slip occurs, the contractor shall remove all the slipped material from the excavated pit without payment. If any damage to a built up structure occurs because of the slip the contractor shall make good without any payment.

2.2.9. Excavations for Foundations

Excavation for foundations shall be taken to the natural firm ground and to the depths indicated in the drawings. Specific instructions shall be obtained from the Officer-In-Charge if:

- (1) The natural bearing stratum occurs at a depth less/more than that indicated.
- (2) The nature of the bearing stratum vastly differs in its bearing characteristics.

In the case of sloping site, all work including foundation excavation, construction and backfilling shall be completed at the lower locations before the excavation at the higher location is commenced.

The bed of the excavation shall generally be made horizontal, and stepped in the case of sloping ground or when the bearing stratum requires such stepping.

Excavation for foundation in steeply sloping sites or sites on rock shall conform to drawings specially prepared for the purpose or approved by the Officer-In-Charge.

(Some guidance notes are given in Appendix 2.A)

Excavations shall be made to the correct profiles and levels shown on the drawings, trimmed to exact shape: and all disturbed material and other debris removed. Excavated material shall not be placed closer than one meter from the outer edge of the excavation.

The bed of the excavation shall be consolidated by watering and ramming. Soft/defective spots shall be dug out and filled with lean concrete or other material as directed by the Officer-In-Charge. In case any excavation has been made below the level shown or required the contractor shall, at his own expense, fill up the excavation to proper level with lean concrete or other material as directed by the Officer-In-Charge.

Excavations are to be inspected by the Officer-In-Charge and the work approved before any further work or concrete or backfill is laid on them. Concrete or back fill shall be laid as soon as possible after inspection to prevent deterioration due to water or weather. The contractor shall take sufficient precautions against deterioration of excavated surfaces. If surfaces become unsuitable due to water or other causes, deteriorated surfaces shall be removed and replaced with concrete as directed by the

Officer-In-Charge. The above shall be at the contractor's expense if it is caused by negligence or for want of precautions on the part of the contractor.

2.2.10 Disposal of Surplus Materials

All surplus material shall be carried away from the site and dumped at dumping sites selected by the Officer-In-Charge. The Officer-In-Charge may instruct the contractor to dump the excavated materials in regular heaps, bunds, blankets, ripraps with regular slopes as directed and leveled so as to provide natural drainage. As a rule, all softer material shall be laid along the center of heaps, the harder and more weather resisting materials forming the casing on the sides and top.

2.2.11 Dewatering

The contractor shall provide, maintain and operate sufficient pumping equipment of the required capacity to keep the area of construction free of water from rain, drains, floods springs etc. During the construction period at no extra cost to the Employer.

Method of Dewatering

The contractor shall obtain the written permission of the Officer-In-Charge for the method he would use to keep the excavations free from water, the procedure adopted shall not result in the withdrawal of water/or soil from underneath the foundation of adjacent sites.

2.2.12 Planking and Strutting

Excavation with vertical sides shall be kept supported by planking and strutting which shall be 'close' or 'open' depending on the nature of the soil and the depth of the trench. The support required shall generally conform to section 10 of BS CP 2003.

Guideline to the type and extent of support required is given in Appendix 2B.

Support for trench excavation along a public road shall be of adequate design and to the satisfaction of the Highway Authority.

2.2.12.1 Close Planking and Strutting

Close planking and strutting shall completely cover the sides of the trench, generally with short, upright members called 'poling boards'. These shall be 250 mm x 38 mm

in section or as directed by the Officer-In- Charge. The board shall generally be placed in position vertically in pairs, one board on each side of the cutting.

These shall be kept apart by horizontal walings of strong wood at a minimum spacing of 1200 mm cross struted as approved by the Officer-In-Charge. The length and girth of the struts shall depend upon the width of the trench.

Where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical 'walings' which shall be struted to similar timber pieces on the opposite face of the trench.

The lowest boards supporting the sides, shall be taken into the ground for a minimum depth of 75 mm. No portion of the vertical side of the trench shall remain exposed.

The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end proceeded with systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim from the contractor shall be entertained, for any timber which timber has been left permanently in position at the request of the Officer-In-Charge.

2.2.12.2 Open Planking and Strutting

In case of open planking and strutting, the entire side surface of the trench is not required to be covered. The vertical boards of 250 mm x 38 mm shall be spaced sufficiently apart to leave unsupported strips of about 500 mm average width. The detailed arrangement, sizes of the timber and the spacing shall be subject to the approval of the Officer-In-Charge. In all other respects, open planking and strutting shall comply with the clause 2.2.12.1 for close planking and strutting.

2.3 Filling around Foundations in Pits, Trenches, and Plinths Etc.

No filling in shall be done until the concrete foundations, brick footings etc. have been inspected and approved by the Officer-In-Charge.

All clods of earth shall be broken or removed. Material for backfilling shall generally be obtained from the spoil of excavations but the Officer-In-Charge shall have the option in case of shortage of good selected earth obtainable from excavation, to direct the contractor to get suitable filling materials from other sources.

As soon as the work in foundations has been accepted and measured, the spaces around the foundation structures in pits and trenches shall be cleared of all debris, brick bats, mortar droppings etc. it shall then be filled with earth in layers not exceeding 150 mm in thickness, each layer being watered, rammed and properly consolidated before the succeeding one is laid. The final surface shall be trimmed and leveled to proper profile.

When the area around the building is to be filled to a height more than 600 mm above the existing ground level the filling inside and outside the building shall be carried out simultaneously in order to relieve the earth pressure on foundation walls. The contractor shall be responsible for making good at his own expense any damage occurring to any part of the building, which in the opinion of the Officer-In-Charge is due to the neglect of this precaution.

On no account will sea sand be allowed for any filling.

2.4 Excavation and Banking (or Filling)

2.4.1 Cutting

The work shall be executed true to levels, slope shape and pattern indicated in the plan or as directed by the Officer-In-Charge. During excavation the natural drainage of the area shall be maintained by the contractor.

Cutting shall be done from top to bottom. Under no circumstances shall undermining be allowed.

All cutting shall be done to the required levels. In case it is taken deeper by the contractor, it shall be brought to the required levels by filling with earth duly consolidated and at contractor's cost. However, in the case of hard work, where blasting operations have been resorted to cutting shall be measured to the actual levels, provided the Officer-In-Charge is satisfied that the contractor has not gone any deeper than was unavoidable.

2.4.2 Filling/Banking

The earth from cutting shall, after approval by the Officer-In-Charge, be directly used for filling without claim for double handling. Filling shall be done in regular horizontal layers not exceeding 150 mm in depth. The surface of ground which is to receive filling, and having a gradient greater than 1 in 5 shall have horizontal benches cut to match the depths of compacted layers of filling. The earth shall be free from all roots, grass and rubbish and

all lumps and clods exceeding 80 mm in any direction shall be broken. Each layer shall be consolidated after breaking all lumps and clods and by ramming. Watering shall be done as directed by the Officer-In-Charge. Where specified, the top surface of the finally finished area shall be neatly dressed to lines and levels.

The finished formation levels of filling shall be kept higher than the required levels by making an allowance for future settlement; this may be 10% of the depth of filling in the case of ordinary consolidated fills, and 5% where the consolidation is done by heavy machinery. No allowance need be made when the consolidation is done by heavy machinery under optimum moisture conditions.

2.5 Excavation in Trenches for Pipes, Cables Etc. and Refilling

2.5.1 Cutting

Unless otherwise indicated on the drawings, trench excavation shall be by open cut. Bottom of trenches for laying of pipes, cables, etc shall be accurately graded so that the pipe or cable is uniformly supported along its length.

The excavation for underground services shall not cause instability to the foundations of the buildings. If the excavations encroach in to the stress dispersion zone bounded by the line drawn at an angle α^* to the horizontal from the nearest lower edge of the building foundations, specific approval of the Officer-In-Charge shall be obtained before commencing work.

* Note : Generally $\alpha = \alpha^*$ $\alpha^* = 45^\circ$ for stable soils
 $\alpha^* = 30^\circ$ for wet clays

2.5.2 Refilling Trenches for Pipes, Cables Etc

Normally the excavated earth shall be used for refilling unless such earth contains deleterious salts. All clods of earth shall be broken or removed. Where the excavated material is mostly rock, the boulders shall be broken into pieces not larger than 150mm in any direction, mixed with fine material consisting of decomposed rock, lateritic soil or earth as available so as to fill up the voids as much as possible, and then the mixtures used for filling.

Filling in trenches for pipes and drains shall be commenced as soon as the joints of pipes and drains have been tested and passed. Where the trenches are excavated in soil, the

filling shall be done with earth on the sides and top of pipes, in layers not exceeding 150 mm watered, rammed, and consolidated, taking care that no damage is caused to the pipe below. In case of excavation of trenches in rock, the filling up to a depth of 300 mm above the crown of pipe or barrel shall be done with fine material such as earth, lateritic soil or pulverized decomposed rock according to the availability at site. The remaining filling shall be done with boulders or rubble of size not exceeding 150 mm mixed with fine material as available to fill up the voids, watered, rammed and consolidated in layers not exceeding 300 mm. In the event of any of the excavated material being deemed unsuitable for filling by the Officer-in-Charge, the contractor shall provide approved filling material at his own cost.

2.6 Filling under Floors

2.6.1 Earth Filling

The plinth shall be filled with earth placed in layers not exceeding 150 mm each layer watered and consolidated to the satisfaction of the Officer-In-Charge. The filling shall be to a height at least 75 mm above the final level; after through consolidation it shall be trimmed to the required levels and falls. Flooring work shall not be started until the filling has been inspected and approved by the Officer-In-Charge.

2.6.2 Sand Filling

The sand shall be clean and free from dust, organic and foreign matter.

Sand filling shall be done in a manner similar to earth filling below floors. Consolidation shall be done by flooding the filling with water. The level of the consolidated sand shall be dressed to the required level or slope. Flooring work shall not be started until the filling work has been inspected and approved by the Officer-In-Charge.

Appendix 2A

1.0 (a) Isolated footings at different levels

When adjacent isolated footings are to be placed at different levels the distance between the edges shall be such as to prevent undesirable overlapping of stresses and instability to the soil supporting the footing at higher levels.

The clear distance between adjacent footings shall generally be not less than the level difference between the two footings nor half the width of the larger footing.

(b) Foundations on slopes

In the case of sloping ground the edge of the footing shall generally not be placed at a horizontal distance from the slope less than twice the width of the footing, nor shall, the stress dispersion line intersect the slope.

(c) Stepped foundations

In the case of a continuous stepped footing on sloping ground, the height of the step and the overlap shall generally be as follows:

Height of the step – Less than the foundation thickness

Overlap – Greater than 2 times the height of the step or foundation thickness whichever is greater.

2.0 Foundations on Bed Rock

In areas where hard sound rock is available over the whole site at or near ground level, it shall be chipped and the foundation keyed to it to the satisfaction of the Officer-In-Charge.

In case the rock surface is sloping, dowel rods shall be provided. Generally 16 mm diameter rods dowelled to a depth of 225 in the rock and adequately anchored into the based concrete shall be provided at a spacing of one meter or as directed by the Officer-In-Charge.

Support Required For Excavations with Vertical Sides

In Uniform Ground

- A indicates that no support is required
- B indicates that open sheeting should be employed
- C indicates that close sheeting or sheet piling should be employed

| Type of Soil | Up to 5 ft. (Shallow) | Depth of excavation 5 to 15ft (medium) | Over 15 ft. (deep) |
|--------------|--------------------------|---|-----------------------|
| Soft peat | C | C | C |
| Firm peat | A | C | C |

| | | | |
|---|----|----|---|
| Soft clays and silts | C | C | C |
| Firm and stiff clays | A* | A* | C |
| Loose gravels and sands | C | C | C |
| Slightly cemented gravels and sands | A | B | C |
| Compact gravels and sands with or without clay binder | A | B | C |
| All gravels and sands below water table | C | C | C |
| Fissured or heavily jointed rocks (shale's, etc) | A* | A* | B |
| Sound rock | A | A | A |

* Open or close sheeting or sheet piling may be required if site conditions are unfavorable.

Note : This table does not apply to complex ground conditions for which reference should be made to the text of BSCB 2003 : 1959

Note : Ref : Table 5 of BSCP 2003 : 1959

CHAPTER 3

MORTAR

3.1 Lime Mortar

The mortar shall consist of slaked lime and sand, each complying with the respective standards and mixed in the proportions specified.

Lime and sand shall be mixed dry three times on an approved platform of masonry, stone, or wood, then sprinkled with the necessary quantity of water and ground in a mortar mill. The sand and lime shall be mixed only in sufficient quantities for a day's requirements. The mortar shall be raked up continuously during the grinding process, particularly in the angles of the mill. Water may be added as required during grinding, care being taken not to add more water than will bring the mixed materials to the consistency of a stiff paste. The sides of the mill shall be maintained in good order. A satisfactory method of counting the revolutions shall be followed.

All mortar shall be used as soon as possible after grinding. As a rule it shall be used on the day on which it is made, but in no case shall mortar made 72 hours previously be permitted to be used or remain at the site of the work except mortar which is to be ground a second time for plastering work-see below. If hydrated lime is used, the ground mortar shall not be kept unused for more than 25 hours after grinding. In all cases, the mortar shall be kept damp and on no account be allowed to dry. It shall always be protected from the sun and rain. All mortar more than 72 hours old or mortar hardened or set before being used shall be removed from the work site within 24 hours of order to do so, and no second mixing will be permitted.

Mortar for plastering shall be ground a second time after storing in a damp condition for an interval of two days in the case of stone lime, and one week in the case of fat lime so as to ensure thorough slaking. The mortar shall then be used at once.

3.2 Cement Mortar

The mortar shall consist of Portland cement and sand, each complying with the respective standard and mixed in the proportions specified.

| Item of work | Cement | Sand |
|-----------------------|--------|---|
| Mortar for masonry | 1 | 5 up to 8 as may be specified |
| Mortar for plastering | 1 | 3 upto 4 as may be specified (3 for plastering of concrete surfaces) |
| Mortar for pointing | 1 | 3 |

The Portland cement shall be measured by weight, a bag weighing 50 Kg. being taken as 0.035 m³ and the sand in suitable measuring boxes. Where gauge boxes are used for measurement of cement by volume the gauge box shall be 400mm x 350 mm 290 mm height while the gauge box for sand shall be 400 mm x 350 mm x 250 mm high. The sand shall be measured on the basis of its dry volume. In the case of damp sand, its quantity shall be increased suitable to allow for bulkage to be determined by the method given in appendix 4C.

The mixing of mortar shall be done in mechanical mixers unless the Officer-In-Charge permits hand mixing taking into account the nature, magnitude and location of the work.

3.2.1 Machine Mixing

The cement and sand shall be fed into the mixer in the specified proportions and shall be mixed dry. Water shall then be added gradually and wet mixing continued for at least one minute. Care shall be taken not to add more water than will bring the mortar to the consistency of a wet paste. Mixing shall be restricted to such quantities as could be utilized on the work within 30 minutes of mixing.

3.2.2 Hand Mixing

In the case of hand mixing, the measured quantity of sand shall be spread level on a clean dry platform and the cement spread over it. The cement and sand shall be mixed dry three times over. Water shall be added to the mixture only when the mortar is required for use and then only in sufficient quantity to bring the mortar to the consistency of a stiff past.

Cement mortar shall be used up on the works within two hours after mixing. Mortar remaining unused for more than two hours shall be rejected and removed from the work site.

3.3 Lime –Cement -Sand Mortara (i.e. Composite Mortar)

3.3.1 Proportioning

Cement lime putty/dry hydrated lime and sand shall be taken in the proportions specified. Commonly used proportions for internal plastering are 1 cement: 1 lime: 5 sand. In general lime should not be used in external plastering where weather proofing qualities are desired.

3.3.2 Mixing

Lime putty and sand shall be mixed and ground in the manner described in 3.1. In case where factory made dry hydrated lime powder is used prior grinding of lime and sand is not necessary, and mixing may be done in one operation in a mechanical mixer. Only a quantity of this mixture which could be used within two hours of its mixing with cement shall be taken out and mixed thorough with the specified quantity of cement in a mechanical mixer.

3.3.2.1 Hand Mixing

Hand mixing shall be permitted by the Officer-In-Charge after taking into account the nature, magnitude and location of the work, practicability of the use of mortar mill, mechanical mixer etc. or where items involving small quantities are to be done. Cement and sand shall be mixed dry on clean water tight masonry or wooden platforms or in troughs. Lime putty shall be mixed with water to the consistency of milk of lime, which shall be added to the mixture of cement and sand, and the mixture shall be kneaded back and forth for about 10 minutes with addition of milk of lime to obtain mortar of workable consistency.

3.3.3 Precautions

Mortar shall be used within 2 hours after mixing. Mortar unused for more than 2 hours shall be rejected and removed from the work site.

CHAPTER 4

CONCRETE

The concrete shall possess the strength, durability; impermeability and resistance to abrasion required for the proposed structure. It shall be free of such defects as cracking, honey-combing, spalling of the surface, undue shrinkage etc. The concrete shall be good quality and shall be produced with careful control over the batching of materials, water cement ratio etc. Necessary care and attention shall be given to the design and preparation of formwork.

Concrete shall be produced as specified and shall meet the following requirements of each class;

(i) Non structural concrete may be a Volume Batched Mix, satisfying the following:

- (i) Proportion of the Constituents by volume
- (ii) Maximum size of aggregate

for ex. 1:3:6 (50 mm)

Structural Concrete may be specified as one of the types

(a) Volume Batched Mix satisfying the following:

- (i) Proportion of the Constituents by Volume
- (ii) Nominal Maximum size of aggregate
- (iii) Grade required

for e.g. 1:2:4 (20 mm) of Grade 20.

Testing and acceptance shall be as per clause 5.4.9.2

(b) Prescribed Mix satisfying the following:

- (i) The mix required from BS5328, Part 2, Table 5.
- (ii) Grade required
- (iii) Nominal Maximum size of aggregate

The composition of the mix shall conform to BS5328 Part 2, Table 5(See Annexure 4 D) with the required field modifications.

Testing and acceptance shall be as per clause 5.4.9.2

(c) Designed Mix satisfying the following

- (i) Grade specified
 - (ii) Maximum size of aggregate
 - (iii) Minimum cement content in Kg of cement per cubic meter and other requirements
- if any to ensure durability.

Testing and acceptance shall be as per BS 5328 Part 3, Clause 3.4.2 or Part 4, Clause 3.16 where the contractor intends to use ready mixes concrete all relevant particulars detailed in BS shall be furnished for the approval of the Officer-In-Charge.

4.1 Materials

4.1.1 Water

Water shall conform to the specifications in Chapter 1.

4.1.2 Cement

All cement shall be from an approved source and shall comply with the latest revision of the standards noted below;

| Type | In accordance with |
|---|---|
| Ordinary Portland cement | BS 12 |
| Rapid hardening Portland Cement | BS 12 |
| White Portland cement | |
| colored Portland cement | |
| Portland Blast furnace cement | BS 146 |
| Low heat Portland cement | BS 1370 |
| Sulphate resisting Portland cement | BS 4027 |
| Low heat Portland Blast furnace cement | BS 4246 |
| Super Sulphated cement | BS 4248 |
| Ultra high early strength Portland cement |] The requirements for physical properties for ordinary Portland or BS 12 |
| Hydro-phobic Portland cement | |

- Note: (i) Where cements other than those complying with requirements of BS 12 are used, account shall be taken of their properties and any particular conditions of use.
- (ii) Where Portland Blast furnace cement complying with BS 146 is used, the slower rate of hardening shall be given due consideration and adequate curing shall be ensured.
- (iii) Super sulphated cements shall not be mixed with any other type of cement.

For storage and other details see Clause 1.2

4.1.3 Aggregates

Aggregates shall be hard and not contain materials such as coal, pyrites, lumps of clay etc. that are likely to decompose or change in volume when exposed to the weather, or affect the reinforcement (where provided). Aggregates with low absorption value shall be used for all concrete that is exposed to the weather or in contact with liquids.

The aggregates shall be free from soft, friable, thin elongated or laminated pieces, coatings of dust, and from clay, alkali, organic or any foreign matter. The contractor shall wash thoroughly all aggregate or any portion of it delivered to the works if so directed by the Officer-In-Charge.

4.1.3.1 Dense Aggregate

These shall consist of one of the following:

Coarse & Fine Aggregates from Natural Sources (Complying with the requirements of BS 882 Part 2)

Coarse Aggregate

The coarse aggregate shall be crushed stone that is mainly retained on a 5 mm BS 410 test sieve or equivalent, and containing only so much finer material as is permitted. The stone shall be from an approved quarry and shall be clean, sharp, undecomposed gneiss or other approved metamorphic or igneous rock having clean, hard dense and durable fragments.

Note : As the quality of limestone available is variable harder types may be used only if they conform to the tests prescribed in clause 4.1.3.4

Fine Aggregate

Fine aggregate i.e. that mainly passing a 5 mm BS 410 test sieve (or equivalent) and containing only so much coarse material as is permitted shall be :

- (a) Natural sand - obtained from the natural disintegration of rock, i.e. it shall be clean, sharp, river or pit sand free of earth, silt, clay loam carbon, alkali, mica, organic matter and other deleterious substances.
- (b) Crushed stone sand - the use of this shall be permitted only for designed mixes. Crushed stone sand shall be manufactured from hard tough durable uncoated rock.

4.1.3.2 Special Aggregates

Broken Brick Or Tile

Mass concrete with brick or tile aggregates may be specified when a high resistance to fire is required but not a high degree of impermeability not resistance to abrasion. Where specifically allowed in the plans, the brick or tile aggregate shall be of good quality and approved by the Officer-In-Charge. The brick shall be free from adhering mortar, plaster of dust and shall not contain soluble sulphates in excess of 1/2 %.

Heavy Aggregate

Steel shots, magnetite and barytes shall be used as specified in high density concrete required for screening radioactive sources where space is limited or for providing high sound insulation between rooms.

Light Weight Aggregate

Where light weight aggregate concrete is specified, natural aggregate such as pumice or artificial lightweight aggregate such as furnace clinker expanded clay. foamed slag. etc. of a quality approved by the Officer-In-Charge and complying with the requirements of BS 3797 shall be used.

4.1.3.3 Storing of Aggregates

All aggregates shall be stored in scrupulously clean conditions as the presence of soil, clay or organic material can seriously impair the strength concrete or inhibit setting. Aggregate

storage piles shall be built on hard paved self-draining surfaces in suitable hoppers or bins so as to avoid the inclusion of any foreign matter, soil, clay etc. The aggregates of different sizes shall be kept separate from each other. It is essential that the storage floors be sloped to facilitate drainage. Coarse aggregates shall be delivered to the mixers with the least amount of free moisture and the least amount of variation in free moisture as practicable.

Before commencing any run of concreting, it is essential that an adequate supply of aggregates is stored at the site. Reliance shall not be placed on promised delivery during mixing.

4.1.3.4 Testing of Aggregates

Where necessary the suitability of the aggregate relevant to a particular structure shall be established well in advance by obtaining samples from sources and carrying out tests for determination of one or more of the following properties;

- (a) Particle size and shape
- (b) Clay, silt and fine dust
- (c) Specific gravity
- (d) Water absorption
- (e) Bulk density, voids & bulking
- (f) Moisture content
- (g) Organic impurities
- (h) Aggregate impact value (Note: this test is an alternative to test (j))
- (i) Aggregate Crushing value
- (j) 10% fines value
- (k) Crushing strength
- (l) Aggregate abrasion value

The tests shall conform to the relevant clauses of BS 812.

The quantity of material passing the 75 μm sieve, when determined in accordance with Clause 7.2.1 and BS 812: section 10.3.1: 1985 shall not exceed the following limits

| | |
|----------------------------|--------------|
| in crushed rock aggregates | 4% by weight |
| in Natural sand | 4% “ |
| in Crushed rock sand | 16% “ |

The aggregate impact value shall be as follows: for,

- (i) Normal structures shall be not more than 45%
- (ii) Wearing surfaces shall be not more than 30%
- (iii) Heavy duty concrete floor finishes shall not be more than 25%

The 10% fines value shall exceed the following limits:

- (i) For normal structures shall be not less than 50 KN
- (ii) For wearing surfaces shall be not less than 100 KN
- (iii) For heavy duty concrete floor finishes shall not be less than 150 KN.

4.1.3.5 Grading and Sizes

Coarse Aggregate

The maximum size of the aggregate to be adopted shall be as specified and will depend on the dimensions of the member being cast and the spacing of the reinforcement. As a general guide the largest particle of aggregate shall not be larger than a quarter of the least dimension of the member in which it is used, and be at least 5 mm. smaller than the least clear spacing between single bars. Generally it is an advantage to have the maximum size as larger as possible.

The continuous grading limits for coarse aggregate shown in percentage by weight are given below:

Grading Limits for Coarse Aggregates

Vide BS 882 1992, Table 3

Table 4.1

| Sieve Size (BS410) | PERCENTAGE BY WEIGHT PASSING BS SIEVES | | | | | | | |
|------------------------|--|--------------|-------------|---------------------------------------|------|------|--------|--------|
| | Nominal size of graded aggregate | | | Nominal size of single size aggregate | | | | |
| | 40mm to 5 mm | 20 mm to 4mm | 14mm to 5mm | 40mm | 20mm | 14mm | 10mm | * 5 mm |
| 50.0 | 100 | - | - | 100 | - | - | - | |
| 37.5 | 95-100 | 100 | - | 85- | 100 | - | - | |
| 20.0 | 35-70 | 90- 100 | 100 | 100 | 85- | 100 | - | |
| 14.0 | 25-55 | 40-80 | 90-100 | 0-25 | 100 | 85- | 100 | |
| 10.0 | 10-40 | 30-60 | 50-85 | - | 0-70 | 100 | 85-100 | 100 |
| 5.0 | 0-5 | 0-10 | 0-10 | 0-5 | 0-25 | 0-50 | 0-25 | 45-100 |
| 2.36 | - | - | - | - | 0-5 | 0-10 | 0-5 | 0-30 |
| | | | | - | - | - | | |

* Used mainly for precast products.

Fine Aggregate

The grading of fine aggregate, when determined by a test according to BS 812 shall be within the several limits given in Table 4.2.

Additionally not more than one in ten consecutive samples shall have a grading outside the limits for any one of the grading C, M or F given in Table 4.2. For heavy duty concrete floor finishes, the fine aggregate shall comply with C or M given in Table 4.2.

The fine aggregate shall be described as fine aggregate of the grading zone into which it falls- e.g. BS 882, Grading Zone C.

Note : *It is intended that individual zones should not be specified in contract documents relating to concrete ; the concrete mixes should be modified to make the best use of the materials readily available.*

Where fine aggregate does not fall within Table 4.2 limits, an agreed grading envelope may be used, provided the materials can produce the concrete of required quality.

TABLE 4.2 Fine Aggregate (Ref Table 4 of BS 882 : 1992)

| Sieve Size (BS 410) | Percentage By Weight Passing Bs Sieve | | | |
|------------------------|---------------------------------------|-------------------|-------------------|-------------------|
| | Overall limits | Grading Zone C | Grading Zone M | Grading Zone F |
| mm | | | | |
| 10.0 | 100 | - | - | - |
| 5.0 | 89-100 | - | - | - |
| 2.36 | 60-100 | 60-100 | 65-100 | 80-100 |
| 1.18 | 30-100 | 30-90 | 45-100 | 70-100 |
| (Micron) μm | | | | |
| 600 | 15-100 | 15-54 | 25-80 | 55-100 |
| 300 | 5-70 | 5-40 | 5-48 | 5-70 |
| 150 | 0-15* | - | - | - |

* For crushed stone sands, the permissible limit is increased to 20%, except for heavy duty floors.

4.1.3.6 Mixing of Single Sizes to obtain Graded Materials

When coarse aggregate brought to site is single sized (ungraded) it shall be mixed with single size aggregate of different size, in the proportion indicated in Table 4.3 to make it graded.

TABLE 4.3

| S/No | Cement Concrete Mixture | Nominal size of graded aggregate required (mm) | Part of single size aggregate of sizes mm | | | | |
|------|-------------------------------|--|---|-------|-------|------|-------|
| | | | 50 | 40 | 20 | 12.5 | 10 |
| 1 | 1:6:12 | 40 | - | 9 | 3 | - | - |
| 2 | 1:5:10 | 40 | - | 7 1/2 | 2 1/2 | - | - |
| 3 | 1:4:8 | 40 | - | 6 | 2 | - | - |
| 4 | 1:3:6 | 40 | - | 4 1/2 | 1 1/2 | - | - |
| 5 | 1:3:6 | 20 | - | - | 4 1/2 | - | 1 1/2 |
| 6 | 1:2:4 | 40 | - | 3 | 1 | - | - |
| 7 | 1:2:4 | 20 | - | - | 3 | - | 1 |
| 8 | 1:2:4 | 12.5 | - | - | - | 3 | 1 |
| 9 | 1:1 1/2: 3 | 20 | - | - | 2 | - | 1 |

The proportions indicated are by volume. These may be varied marginally by the Officer-In-Charge when considered necessary after making a sieve analysis of the aggregates brought to the site. No adjustment in rates shall be allowed for any variations in the proportions so ordered by the Officer-In-Charge.

4.1.4 Admixtures

Additives, plasticizers or other workability agents shall not be used without the written approval of the Officer-In-Charge.

4.2 Lime Concrete

Lime concrete shall be prepared by mixing graded stone or brick aggregate of nominal size as specified, with wet ground lime mortar. Mortar for lime concrete generally consists of lime and sand in the proportion of 1:2 by volume.

4.2.1 Proportioning

The proportioning of wet mortar and aggregate shall be by volume. Generally the internal size of gauge boxes for measuring the materials shall be 400 x 350 x 250 mm (viz. 0.035 m³ approx.) While measuring the aggregate, shaking, ramming or heaping shall not be done.

4.2.2 Mixing

The mixing shall be done by hand or in a mechanical mixer as specified. Brick aggregate shall be well soaked with water for a minimum period of 2 hours.

4.2.2.1 Machine Mixing

The mixing drum shall be free of hardened mortar adhering to its inner surface. Before commencing the mixing, the drum shall be flushed clean with water. A measured quantity of aggregate and wet ground mortar for one batch shall be poured in to the drum of the mixer, while it is revolving. The quantity of materials loaded in the drum shall not exceed the rated capacity of the mixer. The required quantity of water shall be added slowly and the wet mixing of a batch shall be continued for at least two minutes in the drum till a uniform mix of required consistency is obtained. The consistency of the concrete shall be such that the mortar does not tend to separate from the coarse aggregate. The entire concrete of a batch shall be discharged before the materials for the new batch are poured into the drum.

4.2.2.2 Hand Mixing

Hand mixing when allowed shall be done on a clean and water tight platform (of masonry, wood, or G.I Sheets) of sufficient size to provide sample mixing space. The specified wet lime mortar shall be laid on the top of the aggregate. The whole shall then be turned over and over, with addition of the necessary quantity of water by means of a sprinkler till a uniform mix of required consistency is obtained. The consistency of the concrete shall be such that the mortar shall not tend to separate from the coarse aggregate.

4.2.3 Laying

Lime concrete shall be laid (and not thrown) in layers while it is quite fresh. Each layer shall be thoroughly rammed and consolidated before the succeeding layer is placed. Consolidated thickness of each layer shall not exceed 150mm. Joints where necessary shall be staggered in different layers unless otherwise specified. Ramming shall be done by heavy iron rammers of 4.5 to 5.5 kg. The area of the rammer shall not be more than 0.03 m² each. Ramming shall be continued till a skin of mortar covers the surface completely. Compaction shall be done immediately on laying. Green work shall be protected from rain by suitable coverings.

4.2.4 Curing

After the concrete has begun to harden - i.e. about 24 hours after its laying, the curing shall be done by keeping the concrete damp with moist gunny bags, wet straw, sand or any method except water under pressure, approved by the Officer-In-Charge. Curing shall be done for a minimum of 7 days, after which period masonry and flooring work over the lime-concrete foundation or base concrete may be started.

4.3 Cement Concrete

This shall be prepared by mixing graded stone of specified nominal size with fine aggregate and cement in specified proportions and the required quantity of water to give the consistency needed for proper placement and compaction.

The grading and quality of the aggregates will be as given in clause 4.1.3.5.

Sampling testing and acceptance criteria shall be as set forth in clause 5.4.9.

4.3.1 Proportioning

4.3.1.1 Proportioning By Volume

Fine & Coarse Aggregates may be measured by volume unless otherwise specified. Boxes of suitable size shall be used for measuring the sand and aggregate. The internal dimensions of the boxes recommended are 400 x 350 x 250 mm (which is 0.035m³ and corresponds to the volume of 1 bag of cement weighing 50 kg). While measuring the aggregate, shaking, ramming or heaping shall not be done. The proportioning of sand shall be on the basis of its dry volume and in case of damp sand, allowance for bulkage shall be made as given in Appendix 4C.

Cement shall be gauged by weight. The unit of measurement for cement shall be a bag of 50 kg. and this shall be taken as 0.035 m³ ; but in case the volume of cement is permitted to be gauged in a measuring box the internal dimensions of the box for cement only shall be 400 mm x 350 mm x 290 mm to account for bulking.

The composition shall be as follows:-

Table 4.4.

| Specified mix | Equivalent Grade where specified | Quantities per 50 Kg. bag of cement | | | Approx. Water content in litres |
|---------------|----------------------------------|-------------------------------------|----------------------------------|--|---------------------------------|
| | | Fine Aggregate | Coarse Aggregate | | |
| 1:1:2 | 30 | 0.035 m ³ 1 box | 0.07 m ³ 2 boxes | | 20 |
| 1: 1 1/2 : 3 | 25 | 0.053 m ³ 1 1/2 boxes | 0.105 m ³ 3 boxes | | 22.5 |
| 1: 2: 4 | 20 | 0. 07 m ³ 2 boxes | 0.14 m ³ 4 boxes | | 25 |
| 1: 3: 6 | 10 | 0.105 m ³ 3 boxes | 0. 210 m ³ 6 boxes | | 35 |
| 1: 4 : 8 | | 0.14 m ³ 4 boxes | 0.28 m ³ 8 boxes | | 40 |

Note : 1. The internal dimension of boxes for measuring aggregate shall be 400 mm x 350 mm x 250 mm height.

If gauging boxes are allowed to be used for cement the corresponding box shall be 400 mm x 350 mm x 290 mm internal dimensions to account for bulking.

Note: 2. Quantities required per cubic meter of concrete are given in Appendix 4A.

4.3.1.2 Proportioning By Weight

Prescribed Mix

The Officer-In-Charge shall be informed of the nature and source of each material to be used and subsequently notified whenever a change is made. No admixtures shall be used unless specified.

The cement contents for these prescribed mixes are given in BS 5328, Part 2, Table 5 with the total weights of dry aggregate to produce approximately one cubic meter of concrete, Depending upon the specific gravity of the aggregate s slight adjustments may be required to the quantity of aggregates to produce this volume of concrete having the required workability, strength and cement content. BS 5328, Part 2, Table 5 also gives the approximate proportions of fine aggregate to be used although small adjustments may be required on the site depending on the properties of the local materials. For grades 7, 10 and

15 a range of fine aggregate proportions is given, the lower percentage being applicable to finer material such as zone 3 sand and the higher percentage being applicable to coarser material such as zone 1 sand. Where single sized coarse aggregates are used, the proportions shall be chosen to produce a combined grading within the limits of BS 882 for graded coarse aggregate of the appropriate size.

Where weigh - batches are not available and if the necessary site control can be ensured, aggregates can be measured by volume after conducting the necessary field density tests. Cement shall be batched by weight (or in whole bags).

Designed Mix

This shall be permitted if specifically allowed in the Bill of Quantities, when the necessary weigh batches are available and the required quality control assured.

The procedure indicated in BS 5328 shall be followed.

4.3.2 Mixing

It shall be done in a mechanical mixer. Hand-mixing shall be done only with the prior permission of the Officer-In-Charge.

4.3.2.1 Machine Mixing

The mixer drum shall be free of hardened mortar adhering to its inner surface. Before mixing commence the drum shall be primed by washing with rich cement grout. A measured quantity of dry coarse aggregate shall be first placed in the hopper. This shall be followed with the measured quantity of fine aggregate and then cement. The skip shall be raised and the dry materials slipped into the drum. The dry materials shall be mixed for at least four turns of the drum after which the correct quantity of water shall be added gradually while the drum is in motion, to ensure even distribution of the materials. The total quantity of water for mixing shall be introduced before 25% of the mixing time has elapsed and shall be regulated to achieve the specified water cement ratio. The complete contents of the mixer shall be emptied before recharging.

When the mixer is closed down for the day or for any period, exceeding 20 minutes, the drum shall be flushed clean.

Mixing Time

The materials shall be mixed for a period of not less than 2 minutes and until a uniform color and consistency are obtained. The time shall be counted from the moment all the materials have been put into the drum.

4.3.2.2 Hand Mixing

When permitted for Volume Batched mixes, this shall be done on a smooth, clean and water- tight platform of suitable size and in the following manner.

- (a) The measured quantity of sand shall be spread evenly
- (b) The cement shall be dumped on the sand and then distributed evenly.
- (c) The sand and cement shall be mixed intimately with shovels, turning the mixture over and over again, until it is of even color throughout and free from streaks
- (d) The measured quantity of coarse aggregate shall be spread out and the sand cement mixture shall be on top.
- (e) This shall be mixed at least three times dry, by shoveling and turning over from centre to side then back to the centre and again to the sides.
- (f) A depression shall be made in the middle of the mixed pile to receive the water
- (g) Three quarters of the total quantity of water required shall be added while the material is turned in towards the centre with shovels. The remaining water shall be added by a water-can fitted with a rose -head, while slowly turning the whole mixture over and over again at least three times until a uniform color and consistency is obtained throughout the pile.
- (h) The mixing platform shall be washed at the end of the day.

4.3.3 Consistency

The concrete shall be of such consistency as will suit the method of placement and compaction. The quantity of water shall be regulated by carrying out regular slump tests as prescribed in Appendix 4.B, for each mix using one bag of 50 Kg cement it shall not exceed that indicated in Table 4.4.

In the case of vibrated concrete, the water content may be suitably reduce to avoid segregation.

The following slumps shall be adopted for different kinds of works.

Table 4.5

| Work | Slump in mm | |
|--|-------------------|---|
| | Vibrators used | Vibrators not used |
| Mass concrete in foundation, footings, retaining walls and pavement. | 10 - 25 | 50 - 75 |
| Thin sections of flooring less than 75 mm thickness | 25 - 40 | 75 - 100 |
| Reinforced cement concrete work | Refer chapter 5 | Refer chapter 5 |
| Under water concreting | - | 100 - 180 (Actual slump to be decided by Officer In Charge) |

Concrete of the higher slumps range of 75 mm and above shall be produced by using additional cement slurry and not merely water, so that the water cement ratio and compressive strength are kept reasonably constant. Generally about 10% more of cement will become necessary.

4.3.4 Laying

Sufficient notice of not less than 24 hours shall be given to the Officer-in -charge prior to commencing concreting so as to enable inspection of forms, reinforcement etc. The position of all construction joints and programme of concreting shall be decided in advance. Necessary stop-boards shall be provided at construction joints.

4.3.4.1 Compaction

The entire concrete used in the work shall be laid gently (not thrown) in layers not exceeding 150 mm. It should be deposited nearly as practicable in its final position and without segregation in one continuous operation upto the movement or construction joints.

It shall be adequately compacted by means of vibrators till air bubbles cease to appear on the upper surface and a dense concrete is obtained. The vibrator will be operated in a near vertical position, and the duration of vibration limited to that necessary to produce satisfactory consolidation without causing objectionable segregation.

The Officer-in-Charge may however at his discretion, permit hand compaction for certain items depending upon the thickness of the members and feasibility for vibrating the same. Hand compaction shall be done with the help of tamping rods so that the concrete is thoroughly compacted and completely worked into the corners of the formwork.

The layers of concrete shall be so placed that the bottom layer does not finally set before the top layer is placed. Compaction shall be completed before the initial setting starts i.e. within 30 minutes of addition of water to the dry mixture. Re-tempering of concrete shall not be permitted.

4.3.4.2 Temperature

During cold weather, concreting shall not be done when the temperature falls below 4.5°C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and the work redone. During hot weather, precautions shall be taken to see that the temperature of wet concrete does not exceed 38°C.

4.3.4.3 Underwater Concreting

Concrete shall not be deposited under water if it is practicable to de-water the area and place concrete in the regular manner. Where founds necessary to deposit any concrete under water, the method, equipment, materials and mix shall first be approved by the Officer-In-charge.

The concrete shall be deposited under water by one of the approved methods such as Trenia Method, Drop Bottom bucket, bags etc.

If it is necessary to raise the water after placing the concrete, the level shall be brought up slowly without creating any waves or commotion tending to wash away cement or to disturb the fresh concrete in anyway. Detailed procedures recommended in BS 8004 may be followed.

4.3.4.4 Continuation of Work

When the placing of concrete is suspended, necessary removal of laitance and roughening the surface for jointing future work shall be done before the concrete sets. When the work is resumed the previous work must be thoroughly cleaned, roughened, watered and a group of neat cement slurry of the proportion 1 Kg of cement per 2 litres of water applied uniformly; The grout should not be allowed to dry prior to the placement of the fresh concrete.

4.3.5 Curing and Protection

Green work shall be protected from rain by suitable covering. The work should also be suitably protected from damage during construction.

After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected with moist gunny bags, or any other material approved by the Officer-In-Charge against quick drying. After 24 hours of laying of concrete, the surface shall be cured by flooding with water of minimum 25 mm depth, or by covering with wet absorbent materials. The curing shall be done for a minimum period of 7 days. In special cases, curing may have to be prolonged as required by the Officer-in-charge.

Over the foundation concrete, the masonry work may be started after 48 hours of its laying, but the curing of cement concrete shall be continued along with the masonry work for a minimum period of 7 days.

Where cement concrete is used as sub- grade for flooring, the flooring may be commenced before the curing period of sub-grade is over but the curing of sub-grade shall be continued along with the top layer of flooring for a minimum period of 7 days.

The water used for curing shall not produce any objectionable stains or unsightly deposit on the concrete surface. In special circumstances and locations, curing by other means such

as sealing material, insulating blankets etc. may be adopted with the specific prior approval of the Officer-in -charge.

4.3.6 Form Work

If centering and shuttering are required to be done for this work, it shall be done in accordance with the specifications for formwork under Reinforced Cement Concrete work.

4.3.7 Test and Acceptance

See paragraph 5.4.0

4.4. No Fines Concrete

Note: - No fines concrete consists of cement and coarse aggregate only. The absence of fine material results in a mass having uniformly distributed voids in it. The material is almost invariably cast in-situ and can be used for partitions and load bearing internal walls; if used for load bearing external walls it shall be rendered externally to prevent wind pressure forcing water through the voids.

The aggregate shall be crushed rock or approved light weight aggregate. Mix proportions may be in the range of 1:5 to 1:10 or as specified. The water content shall be such as to produce a continuous film of cement grout of paste consistency over the aggregate.

Unless otherwise specified, the following proportions of water, cement and aggregates shall be adopted.

For hard dense aggregates - 0.45 : 1:10 (10 mm to 20 mm)

For light weight aggregates - 0.60 : 1:6 (10 mm to 20 mm)

The material shall be poured as soon as possible after mixing and shall not be rammed or mechanically vibrated, though it can be lightly rodded. Pouring shall be as continuous as possible to an even height since diagonal joints are a source of weakness.

4.5 Plum Concrete

'Plum Concrete' shall be of hard dense rock of approved sizes used with concrete of specified mix.

A layer of concrete not less than 50 mm thick shall be placed, the first layer of plums placed upon this and the plums allowed to sink under their own weight. The concrete shall be of such consistency that the plums do not disappear completely from sight.

The thickness of each succeeding layer of concrete shall not be less than twice the maximum dimensions of plums permitted. The distance between any two plums and the face shall not be less than the maximum dimension of the plums not less than 150 mm.

APPENDIX 4A. Quantities of Ingredients per cubic meter of concrete for Volume-Batched mixes.

| Nominal Mix | Equivalent Grade | Cement (Kg) | Fine Aggregate (dry sand m ³) | Coarse Aggregate (m ³) | Appropriate water cement ratio |
|--------------|------------------|-------------|---|------------------------------------|--------------------------------|
| 1: 1: 2 | 30 | 552 | 0.38 | 0.76 | 0.40 |
| 1: 1 1/2 : 3 | 25 | 405 | 0.41 | 0.82 | 0.45 |
| 1: 2: 4 | 20 | 320 | 0.44 | 0.88 | 0.50 |
| 1: 3 : 6 | - | 227 | 0.46 | 0.92 | 0.70 |
| 1: 4 : 8 | - | 173 | 0.48 | 0.96 | 0.80 |

APPENDIX 4B - Slump Test for Concrete

Apparatus: The mould shall consist of metal frustum of cone having the following internal dimensions:-

Bottom diameter 20 cm

Top diameter 10 cm

Height 30 cm

The mould shall be of a metal other than brass and aluminum of at least 1.6 mm (or 16 BG) thickness. The top and bottom shall be open and at right angles to the axis of the cone. The mould shall have a smooth internal surface. It shall be provided with suitable foot pieces and handles to facilitate lifting it from the moulded concrete test specimen in a vertical direction as required by the test. A mould provided with a suitable guide attachment may be used.

The tamping rod shall be of steel or other suitable material, 16 mm in diameter, 600 mm long and rounded at one end.

Procedure: The internal surface of the mould shall be thoroughly cleaned and free from superfluous moisture and any set concrete before commencing the test. The mould shall be placed on a smooth, horizontal, rigid and non absorbent surface, such as a leveled metal plate. The operator shall hold the mould firmly in place while it is being filled with the test specimen of concrete. The mould shall be filled in four layers, each approximately one quarter of the height of the mould. Each layer shall be tamped with twenty five strokes of the rounded end of the tamping rod. The strokes shall be distributed in a uniform manner over the cross section of the mould and for the second and subsequent layers shall penetrate into the under lying layer. The bottom layer shall be tamped throughout its depth. After the top layer has been rodded the concrete shall be struck off level with trowel or the tamping rod, so that the mould is exactly filled. Any mortar which shall leak out between the mould shall be removed from the concrete immediately after filling or raising it slowly and carefully in a vertical direction. The moulded concrete shall then be allowed to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of specimen.

The above operations shall be carried out at a place free from vibration or shock, and within a period of two minutes after sampling.

Result : The slump shall be recorded in terms of millimeters of subsidence of the specimen during the test. Any slump specimen which collapses or shears off laterally, gives incorrect result. If this occurs, the test shall be repeated with another sample.

The slump test shall not be used for very dry mixes as the results obtained are not accurate.

APPENDIX 4. C

Bulking of Fine Aggregate/Sand (Field Methods)

Two methods are suggested for determining the bulking of sand/fine aggregate. The procedure may be suitably varied, if necessary. Both depend on the fact that the volume of inundated sand/fine aggregate is the same if the sand/fine aggregate were dry. Method 1: Put sufficient quantity of sand loosely into a container until it is about two third full. Level off the top of the sand and pushing a steel rule vertically down through the sand at the middle to the bottom, measure the height. Suppose this is 'X' cm.

Empty the sand out of the container into another container without loss. Half fill the first container with water. Put back about half the sand and rod it with a steel rod, about 6 mm in diameter, so that its volume is reduced to a minimum. Then add the remainder and level the top surface of the inundated sand. Measure its depth at the middle with the steel rule. Suppose this is "Y" cm.

The percentage of bulking of the sand due to moisture shall be calculated from the formula.

$$\text{Percentage bulking} = \left[\frac{X}{Y} - 1 \right] \times 100$$

Method 2: In a 250 ml measuring cylinder, pour the damp sand (consolidated by shaking) until it reaches the 200 ml mark.

Then fill the cylinder with water and stir the sand well (the water shall be sufficient to submerge the sand completely) It will be seen that the sand surface is now below its original level. Suppose the surface is at the mark of 'Y' m the percentage of bulking of sand due to moisture shall be calculated from the formula.

$$\text{Percentage bulking} = \left[\frac{200}{Y} - 1 \right] \times 100$$

Appendix 4 D - Extracted from Table 5, BS 5328 : Part 2 : 1991

| Mix proportions for standard mixes | | | | | |
|------------------------------------|--|-----------------------------------|--------------|----------------------------------|--------------|
| Standard mix and grade | Constituent | Nominal maximum size of aggregate | | | |
| | | 40 mm | | 20 mm | |
| | | slump 75 mm | slump 125 mm | slump 75 mm | slump 125 mm |
| ST1 (7.5) | Cement (Kg) | 180 | 200 | 210 | 230 |
| | Total aggregate (Kg) | 1950 | 1850 | 1900 | 1800 |
| ST2 (10) | Cement (Kg) | 210 | 230 | 240 | 260 |
| | Total aggregate (kg) | 1900 | 1850 | 1850 | 1800 |
| ST3 (15) | Cement (Kg) | 250 | 270 | 280 | 310 |
| | Total aggregate (kg) | 1850 | 1800 | 1800 | 1750 |
| ST4 (20) | Cement (Kg) | 300 | 320 | 320 | 350 |
| | Total aggregate (kg) | 1850 | 1750 | 1800 | 1750 |
| ST5 (25) | Cement (Kg) | 340 | 360 | 360 | 390 |
| | Total aggregate (kg) | 1800 | 1750 | 1750 | 1700 |
| ST1 ST2 ST3 | Fine aggregate (percentage by mass of total aggregate) | 30 to 45 | 30 to 45 | 35 to 50 | 35 to 50 |
| ST4 ST5 | Fine aggregate (percentage by mass of total aggregate) Grading limits C Grading limits M Grading limits F | 30 to 40 25 to 35 25 to 30 | | 35 to 45 30 to 40 25 to 35 | |

Note 1. The cement contents together with the total masses of saturated surface dry aggregates and added water will produce approximately one cubic meter of concrete. The values given are based on typical values of the relative densities of cement and aggregates. For some aggregates having higher or lower relative densities adjustments may be required to the quantity of aggregates to produce this volume of concrete having the required workability and cement content.

Note 2. The values given for aggregate content, may be adjusted to allow also for the characteristics of the aggregates.

Note 3. The aggregates for mixes ST1, ST2 and ST3 may be batched by volume.

Note 4. When standard mixes are specified with workability less than 75 mm slump, the mix proportions are to be taken from the appropriate 75 mm slump column.

CHAPTER 05

REINFORCED CEMENT CONCRETE

5.0 Reinforced Cement Concrete

Reinforced cement concrete work may be cast-in-situ or precast, and shall comprise the following which may be paid separately or collectively as per description of the item of work

- (a) Form work
- (b) Reinforcement
- (c) Concreting

5.1 Materials

This shall be structural concrete conforming to the requirements of chapter 4.

5.1.2 Steel Reinforcement

The reinforcement shall be:

- | | | | |
|-------|--|---|---------|
| (i) | Hot rolled mild steel round bars for concrete reinforcement | - | BS 4449 |
| (ii) | Hot rolled high yield steel bars for concrete reinforcement | - | BS 4449 |
| (iii) | Cold worked deformed steel bars for reinforcement of concrete | - | BS 4482 |
| (iv) | Hard drawn mild steel wire for the reinforcement of concrete | - | BS 4482 |
| (v) | Steel fabric for reinforcement of concrete | - | BS 4449 |

Contractor shall produce a certificate of origin and compliance with the requirements of related BS shall be produced. Steel shall be tested in an approved laboratory and results produced to the satisfaction of the Officer-in-charge.

The cost of testing etc. shall be borne by the Contractor.

Ribbed and/or Deformed steel bars shall not be assumed to be high yield steel without testing.

5.1.2.1 Properties of Reinforcing Steel

The chemical and other properties of reinforcing steel shall be complying with relevant British Standards as given in section 5.1.2.

All reinforcement when placed shall be free from dirt, oil, mud, and grease, rust, loose mill scale on any other foreign matter which can adversely affect the concrete or reinforcement chemically or reduce the bond.

5.1.2.2 Stacking and Storage

steel reinforcement shall be stored clear of the ground in a way as to prevent distortion and corrosion. Bars of different classifications shall be clearly marked/ tagged and those of different sizes and lengths shall be stored separately to facilitate issues in such sizes and lengths as to minimize wastage in cutting from standard lengths.

5.2 Formwork

Formwork shall include all temporary or permanent forms/moulds required for casting the concrete in-situ and all the temporary construction required for support.

The formwork shall be designed and constructed with adequate waling struts, braces, ties and clamps so as to produce finished concrete work to the required shape and dimensions within the limits of specified tolerances if any and with the specified surface finishes vide clause 5.4.8. The formwork shall be sufficiently rigid and tight to prevent loss of grout or mortar from the concrete and shall take due account of the method of placing and compacting.

The formwork shall withstand the worst combination of the following loads.

- (i) Total weight of formwork, reinforcement and concrete
- (ii) Construction loads including dynamic effects of placing, compacting and construction traffic
- (iii) Wind loads

Formwork shall be so constructed as to be easily dismantled and removed in sections in the desired sequence from the cast concrete, without shock, disturbance or damage. Where necessary the formwork shall be so arranged that the soffit form properly supported on props only, can be retained in position for such period as may be required by the maturing conditions or specification. Screw jacks or hard board wedges shall be provided where required to make up for any settlement in the formwork either before or during the placing of concrete.

Care shall be taken to see that no piece is keyed into the concrete.

Details of formwork shall be properly worked out, and approval obtained from the Officer-in-charge well in time for important works. The completed formwork shall be inspected and passed by the officer -in-charge before the reinforcement is placed in position, but the responsibility for the adequacy of the formwork remains with the contractor.

Propping and centering shall be sufficiently rigid and stable. The permissible stresses in bending, the buckling load of props, the permissible deflection of shuttering etc. Should not be exceeded. Suitable horizontal as well as diagonal braces shall be provided to resist the lateral forces due to dumping of concrete movement of construction equipment and action of the wind and to provide lateral stability.

5.2.1 Materials for Formwork

Temporary formwork shall be of timber, plywood, steel or any other material as specified.

Permanent formwork shall consist of filler blocks like clay/concrete hollow blocks, coffer units trough units etc. as specified.

5.2.1.1 Timber

The timber used for formwork shall be light weight and easily workable with nails without splitting. It shall be stiff and strong enough to avoid undue deflection when loaded; be stable and not liable to warp when exposed to sun and rain, or wetted during concreting. It shall not be so soft as to get damaged easily on the contact faces under normal condition of erecting forms, fixing steel and pouring concrete. The timber shall be free from loose knots, projecting nails, splits or other defects that may mar... the surface of the concrete. It shall not be so dry as to absorb water from concrete and swell and bulge, nor so green or wet as to shrink after erection. Species of timber which are not appreciably affected by contact with water shall be used. The sizes of timber generally used for formwork are given below:

The following timber sizes shall be used in general:

| Use | Size |
|---|--|
| Floor boarding | 25 mm or 32 mm thick |
| Wall boarding and sides of Beams and columns | 25 mm to 50 mm thick |
| Beam soffits | 38 mm to 50 mm thick |
| Joists, ledges | 100 x 50 to 250 x 75 mm Generally 100 x 50 mm |
| Raw jungle poles | Not less than 100 mm diameter at mid-length and 80 mm at thin end. |
| Posts | 75 x 100 to 100 x 100 mm |
| Column yokes | 50 x 50 to 75 x 75 mm |
| Diagonal braces | 150 x 32 to 150 x 50 mm |

5.2.1.2 Plywood

Phendic - resin bounded plywood shall be used as it is completely water proof and does not laminate as does ordinary plywood. Plywood panels shall be formed with 100 x 25 mm dressed timber and nailed with short, thin nails at 150 to 225 mm centers.

6 or 10 mm thick plywood shall be given a solid backing nailed at 100 to 150 mm spacing along the four edges and with at least one nail every 0.1 square meter throughout the surface. The edges of sheets shall be tacked to the same backing board to ensure the production of a smooth joint.

10 and 16 mm thick plywood shall be nailed to a skeleton backing of dressed timber before fixing to the studding. 19 mm thick plywood shall be nailed direct to studs at a maximum recommended spacing of 450 mm. For spacing greater than 450 mm skeleton backing of appropriate design shall be used.

5.2.1.3 Steel

The contractor shall use with the approval of the Officer-in-charge any proprietary systems of steel formwork generally consisting of panels made up of steel sheet on light steel angle framing in sizes that can be easily handled. Special panels shall be used where curved formwork is necessary.

Special telescopic units which can be easily removed shall be provided as a simple type of joist for suspended slab formwork. Other proprietary fittings such as beam and column clamps and adjustable props designed to facilitate erection may also be used subject to the approval of the Officer-in-charge in regard to their suitability for the particular work.

5.2.2. Formwork Ties

Wire ties shall generally not be recommended for fixing wall formwork as they are likely to cause rust stains or patches at the point where they are cut back. Such stains may be avoided by using bolts which should be either fitted with sleeves or well-greased to enable them to be withdrawn easily from the concrete when formwork is removed. Any proprietary devices when used for supporting formwork shall have the approval of the Officer-in-charge.

No metal part of any device for securing forms shall remain within the specified concrete cover.

All ties anchored against timber shall pass through a plate washer at least 50 mm x 50 mm and of sufficient thickness to transfer the load without visible deflection or penetration into the timber.

5.2.3 Top Forms

Formwork shall be provided to the top surface of concrete where the slope or nature of the work requires it.

5.2.4 Propping and Centering

Props used for centering shall be of steel, timber post round poles or any other material approved by Officer-in charge. Bamboo props or supports shall be permitted for heights or lengths not exceeding 3 meters provided they are adequately braced. In no case shall round poles be of diameter less than 100 mm measured at mid length and 80 mm at thin end. Maximum permissible spacing shall be 1.2 meters centre to centre. Poles shall rest squarely on wooden sole plates of 40 mm thickness and a minimum bearing area of 0.1 sq. meter laid on the ground. Double wedges shall be provided between the sole plates and the wooden props so as to facilitate tightening and easing of shutting without jarring the concrete.

The details of propping and centering stated above shall be applicable for spans of 4.50 meters and height upto 3.50 meters. In case any of these limits is exceeded the formwork shall be properly designed. In case the height of centering exceeds 3.50 meters, the props shall be provided in multistage and stabilized with suitable diagonals and rakes.

Proprietary systems of props shall be erected as per manufacturer's details.

5.2.4.1 Multistoried Structures

In the case of structures with two or more floors, the normal props as per 5.2.4 shall be provided for supporting the floor to be cast on the topmost floor already cast. If necessary supports below this floor shall be provided preferably to come in line with the props of the upper floor. Planks shall be provided at the top ends of these props so as to give an even distribution of load. Formwork and concreting of the upper floor slab shall not generally be done until the concrete of the lower floor has set for at least 14 days.

In case of balconies and cantilever beams coming one above the other, the members being cast shall be supported by props on two floors below the floor where initial supporting has

been done. Poles shall rest squarely on wooden sole plates of 40 mm thickness and with minimum bearing area of 0.1 square meters.

5.2.4.2 Precautions

Before the concreting is started, all the props and wedges shall be checked to see that they are intact and suitable action taken in case they are loose. While the concreting is in progress, at least one carpenter/fitter shall be readily available at the site. The carpenter shall keep a constant watch on the props and take immediate remedial measures, if any of these get loosened. Care shall be taken that props and wedges do not get loose for this minimum period specified in table 5.2.

5.2.5 Shuttering

The shuttering shall have a smooth and even surface and be appropriate to the concrete finish required. See also clause 5.4.8. For exposed concrete faces, timber for shuttering shall be coated on all faces in contact with concrete. Wooden formwork with metal sheet, plywood or other approved lining or steel plates stiffened by steel angles shall also be permitted. Undressed timber may be used for formwork for hidden faces and external faces below ground level.

When metal forms are used, all bolts and nuts shall be countersunk and well ground to provide a smooth plane surface.

The chamfers, bevelled edges and mouldings shall be made in the formwork itself.

Provision for fan clamps and other fittings connected with services shall be made in the shuttering as directed by the Officer-in-charge.

As far as practicable, clamps shall be used to hold the forms together. Where the use of nails is unavoidable the minimum possible number of nails shall be used and these shall be left projecting so that they can be easily withdrawn. Use of double headed nails shall be preferred.

Holes or openings shall be provided at suitable locations for cleaning up before placing concrete.

5.2.5.1 Surface Treatment for Shuttering

The surfaces of timber shuttering that would come in contact with concrete shall be thoroughly wetted and coated with raw linseed oil, mould oil of approved manufacture or any other approved material (such as polythene- polyethylene sheets), to prevent adhesion of concrete to formwork. Inside surfaces of forms shall be thoroughly cleaned before application of any of the materials mentioned above. Approved released agents shall be applied strictly in accordance with the manufacturer's instructions and shall not be allowed to come in contact with any reinforcement.

Re-use of the shuttering shall be permitted only after the surface has been thoroughly cleaned, and repaired if necessary.

5.2.6 Camber

Suitable camber shall be provided for the horizontal members of structures especially those of long spans, to counteract the effect of deflection. The formwork shall be so assembled as to provide for such camber. The camber for beams and slabs shall generally be 0.1% and 0.2% of the span depending upon the span and stiffness of the member in question. Cambers are not normally applied to short or very stiff cantilevers.

5.2.7 Special Formwork

Formwork locations like tall structures etc. use of special types of formwork like moving or sliding forms shall be permitted. The details of such formwork along with the sequence of working shall be approved by Officer-in-charge before erection.

5.2.8 Approval of Formwork

The contractor shall give the Officer-in-charge due notice before placing any concrete in the forms to permit him to inspect and accept the formwork as to its strength, alignment and general fitness; however, such inspection shall not relieve the contractor of his responsibility for safety of men, machinery, materials and the results obtained.

5.2.9 Removal of Formwork

The formwork shall be so removed as not to cause any damage to concrete due to shock or vibration.

Formwork shall normally be stripped in the following order:

- (i) Shutters to vertical faces e.g. side of columns, beams and walls
- (ii) Shutters forming soffits to roof and floor slabs, horizontal and inclined canopies etc.
- (iii) Shutters forming soffits of beams and girders.

The removal of the formwork for larger structures shall be planned and a definite scheme of operation worked out to the satisfaction of the Officer-in-charge.

Re-propping of beams shall not be permitted except with the approval of the Officer-in-charge.

5.2.9.1 Time of Removal

In no circumstances shall forms be struck until the concrete reaches strength of at least twice the stress to which the concrete may be subjected at the time of strike. Where possible, the formwork shall be left for as long as possible, as it would assist curing. Forms shall be eased out carefully in order to prevent the load being transferred suddenly to the partly hardened concrete. The period that shall elapse after the concrete has been laid, before easing and removal of centring and shuttering is undertaken shall be as given in Table 5.2. The Officer-in-charge may however extend the periods noted where necessary by giving written instructions to the contractor.

Table 5.2

The minimum period for removing formwork

| Part of Structure | Period for Ordinary Portland Cement without admixtures |
|--|--|
| Sides of foundations, columns, beams and walls | 24 hours |
| Under sides of slabs of upto 4.5 meter span | 7 days |
| Under sides of slabs of above 4.5 meters span and under sides of beams and arches upto 6 meters span | 14 days |
| Under sides of beams and arches over 6 meters span and upto 9 meters span | 21 days |
| Cantilever slabs and beams | 21 days |
| Domes, shells and other structures of special nature. | As per written instructions of Officer-in-charge. |

5.3 Steel Reinforcement

The reinforcement shall be :

- (i) Hot rolled mild steel round bars for concrete reinforcement - BS 4449
- (ii) Hot rolled high yield steel bars for concrete reinforcement - BS 4449
- (iii) Cold worked deformed steel bars for reinforcement of concrete - BS 4482
- (iv) Hard drawn mild steel wire for the reinforcement of concrete - BS 4482

- (v) Steel fabric for reinforcement of concrete - BS 4482

Contractor shall submit a certificate of origin and compliance with the requirements of related BSS shall be produced. Steel shall be tested in an approved Laboratory and results produced to the satisfaction of the Officer-in-charge.

The cost of testing etc. shall be borne by the Contractor.

5.3.1 Bending Lapping and Welding

5.3.1.1 Cutting and Bending

Reinforcement shall be cut and/or bend in accordance with BS 4466. Bars shall be bend cold, correctly and accurately on an approved type of bending apparatus, to the size and shape shown on the detailed drawings or as directed by the Officer-in-charge.

Where hot bending in the opinion of the Officer-in charge is necessary, only hot rolled high yield or mild steel shall be allowed to be bent at a cherry red heat and allowed to cool gradually. In the case of cold worked bars, prolonged or excessive heating may reduce its properties and hot bending shall therefore be avoided.

5.3.1.2 Laps

Preferably, bars of full length shall be used. Lapping of bars where necessary, shall be done as directed by the Officer-in -charge. The lapping bars shall not touch each other and shall be kept apart by 25 mm or 1 1/4 times the maximum size of the coarse aggregate whichever is greater, (but not exceeding 4 x diameter of bar). But where this cannot be done, the lapping bars shall be bound together at intervals not exceeding twice the diameter of such bars, with two strands of annealed steel wire of 0.90 mm to 1.6 mm thickness twisted tight. The laps shall be staggered for different bars and located at points along the span where neither shear nor bending moment is a maximum. Laps in secondary reinforcement shall be 30 times the diameter of the bar unless otherwise shown. Length of laps shall be as given in Appendix 5.A unless otherwise specified.

5.3.1.3 Welding

Welding may be used for (i) fixing in position between crossing or lapping reinforcement (ii) transfer of load between reinforcement. Welding on site shall be avoided if possible but where suitable safeguards and techniques are employed and provided that the types of steel (including high yield steels to B S 4449) have the required welding properties, it may be

undertakes with the approval of the Officer-in-charge. Welding of reinforcement shall conform to standard codes of practices and to the approval of the Officer-in-charge.

Generally however all welding shall be carried out under controlled conditions in the factory or work-shop.

5.3.1.4 Re-Bending

Where it is necessary to bend reinforcement projecting from already cast concrete, care shall be taken to ensure that the radius of bend is not less than that specified in BS 4446. Where it is necessary to re-shape steel previously bent, this should only be done with the Officer-in-charge's approval and each bar should be inspected for signs of fracture.

5.3.2 Fixing in Position

5.3.2.1 Tying of Bars

Reinforcement bars shall be placed in position as shown in the drawings. The bars crossing one another shall be tied together at every intersection with two strands of annealed steel wire 0.90 to 1.6 mm thickness twisted tight to make the skeleton of the steel work rigid so that the reinforcement does not get displaced during the deposition of concrete. The ends of the binding wire shall be bent back, clear of forms and into the body of the concrete.

Note : *If spacing of bars is less than 300 mm in each direction, alternate intersection may be tied. Crossing bars should not be tack welded for assembly of reinforcement unless permitted by the Officer-in-charge.*

5.3.2.2 Spacers and cover Blocks

The bars shall be kept in position by using spacers, chairs etc. Spacers shall be of such materials and designs as will be durable, not lead to corrosion of reinforcement nor cause spalling of the concrete cover.

The following methods shall be followed.

- (a) In the case of beam and slab construction, precast cover blocks in cement mortar 1: 1 1/2 about 40 x 40 mm section and of thickness equal to the specified cover shall be placed between the bars and shuttering, so as to secure and maintain the requisite cover of concrete over reinforcement.

- (b) In the case of cantilevered and doubly reinforced beams or slabs the vertical distance between the horizontal bars shall be maintained by introducing chair spacers or support bars of steel at 1.0 meter or at shorter spacing to avoid sagging.
- (c) In the case of columns and walls, the vertical bars shall be kept in position by means of removable timber templates with slots accurately cut in them or with circular blocks of cement mortar 1 : 1/1/2 suitably tied to the reinforcement.
- (d) In case of other RC structure such as arches, domes etc. cover blocks, spacers and templates shall be used as directed by the Officer-in-charge. Projecting reinforcement shall be protected from the weather by grout washing, or special covers or wrapping, and/or subsequently cleaned until completely embedded in concrete.

Concreting shall not commence until the reinforcement has been inspected and approved by the Officer-in-charge . The position of reinforcement should be checked before and during concreting, particular attention being paid to the position of top reinforcement especially in cantilever sections.

5.3.2.3 Cover

The cover of concrete to the reinforcement shall be as described in the drawings and shall be provided and maintained within a tolerance of 3 mm under or over (except where specified as a minimum)

The following table shall be adopted for general guidance.

Table 5.3 - Nominal cover to all Reinforcement (Including links) to meet durability requirements

| Exposure Classification | Examples of Exposure | Nominal Cover | | | | |
|---|-------------------------|---------------|-------|-------|-------|-------|
| | | mm | mm | mm | mm | mm |
| Mild | Indoor and Sheltered | 25 | 20 | 20* | 20* | 20* |
| Moderate | Outdoor exposed | 40 | 35 | 30 | 25 | 20 |
| Severe | Wet and Dry; Foundation | 50 | 45 | 40 | 30 | 25 |
| Very Severe | Sea Spray | - | 50 | 45 | 40 | 35 |
| Extreme | Abrasive | - | - | - | 60 | 50 |
| Maximum free water/cement ratio | | 0.65 | 0.60 | 0.55 | 0.50 | 0.45 |
| Minimum cement content (Kg.m ³) | | 275 | 300 | 325 | 350 | 400 |
| | | (300) | (325) | (350) | (400) | (450) |
| Lowest grade of concrete (See note 5) | | 25 | 30 | 35 | 40 | 45 |

Note 1 This table applies to normal -weight aggregate OPC concrete of 20mm nominal maximum aggregate size and river sand fine aggregate. In no case should the cover be less than the maximum aggregate size or diameter of main reinforcement.

Note 2 Cover values marked with asterisks () can be reduced to 15 mm provided the nominal maximum aggregate size does not exceed 15 mm subject to the conditions in Note 1. The minimum allowable cover is 15 mm.*

Note 3 The cover may be reduced by 5mm in slabs and shells, subject to the conditions in Note 1 and 2.

Note 4 The minimum cement content values in parentheses should be maintained if no water reducing admixtures are used.

Note 5 The grade requirement can be reduced by 5 if a checking regime establishes that the maximum free water/cement ratio and minimum cement content requirements are met.

Note 6 The above cover values can be reduced by 5 mm subject to the conditions in Note 1 and 2 provided a 1:3 cement : sand rendering of 10 mm 15 mm or 20 mm or equivalent is applied to concrete made to water/cement ratios of 0.65, 0.6 and 0.55 respectively.

Note 7 Cover in foundation should be treated as for 'severe' exposure conditions without any reductions in cover allowed as per Notes 3 and 6. The cover values in parentheses for the 'severe' exposure condition can be used only for foundations.

5.4 Concreting

The concrete shall be made as specified in Chapter 4 and the proportions of ingredients shall be as specified. Concrete shall be mixed by a mechanical mixer except when the Officer in-charge permits otherwise.

5.4.1 Consistency

The concrete shall be of such consistency that it will flow sluggishly into the forms and around the reinforcement without any segregation of coarse aggregate from the mortar. The consistency shall depend on whether the concrete is vibrated or hand-tamped. It may be determined by slumps of concrete for the different types of works, and shall be as given in Table 5.4 below, unless otherwise specified.

Table 5.4 Slump for Concrete

| Work | Slump (in mm) | |
|---------------------------------|----------------|--------------------|
| | Vibrators used | Vibrators not used |
| Mass concrete in RC foundation, | 10-25 | 50-75 |

| | | |
|---|-------|----------|
| footings and retaining walls. | | |
| Beams, slabs and columns | 25-40 | 75 - 100 |
| Thin RC sections or sections with congested steel | 40-50 | 125-150 |

Note: *Volume Batched Concrete of the higher slump range of 75 mm and above, shall be produced by using additional cement slurry (and not merely water) keeping the water-cement ratio and the compressive strength of concrete reasonably constant.*

The amount of water used in the concrete shall be regulated by volume or by weight as required to secure concrete of the proper consistency. Adjustment shall be made for any variation in the moisture content due to water absorbed by the aggregates and/or free water in aggregates. Addition of water to compensate for stiffening of the concrete shall not be permitted.

5.4.2 Placing of Concrete

The Officer-in-charge shall be kept advised sufficiently in advance as to when placement of concrete will commence. The concrete shall be transported from the mixer with the least possible delay in liquid tight containers or barrows and by methods which prevent the segregation or loss of ingredients. Slump loss in transit shall not exceed 25 mm. Compensation for excessive slump loss by allowing wetter consistency at the mixer resulting in higher water cement ratios, shall not be permitted. All concrete conveyors, barrows and chutes shall be primed by washing with rich cement grout before use. These shall be thoroughly washed and cleaned immediately after stopping concreting.

A record shall be kept of the time and date of all concrete pours and the subsequent removal of formwork

5.4.2.1 Concreting shall be commenced only after the Officer-in-charge has inspected the formwork and reinforcement as place and passed the same.

Shuttering shall be cleaned of all shavings, saw dust, pieces of wood, or other foreign material by the use of air and water pressure hoses. All accumulation of water or debris

shall be flushed out through the holes or opening provided for the purpose. These holes shall be neatly plugged before concreting.

5.4.2.2 In the case of concreting of slabs and beams, wooden plank or cat-walks supported directly on the centering by means of wooden blocks or lugs shall be provided to take the concrete to the place of deposition without disturbing the reinforcement in any way. Traffic shall not be allowed over the reinforcement or freshly placed concrete.

5.4.2.3 The concrete shall be deposited in its final position in such a manner as to preclude segregation of ingredients. In deep trenches and footings, concrete shall be placed through chutes as directed by the Officer-in-charge. In the case of columns and walls, the shuttering shall be so adjusted that the vertical drop of concrete is not more than 1.5 meters at a time. The progress of concreting in the vertical direction shall be restricted to one meter per minute.

The mix shall be such that there will be no excess water on the top surface on completion of compaction. In the case of deep lifts, the water content of batches at the top may have to be reduced to compensate for water gain from lower levels.

5.4.2.4 During cold weather, concreting shall not be done when the temperature falls below 4.5 °C. The concrete placed shall be protected against frost by suitable covering. Concrete damaged by frost shall be removed and work redone.

5.4.2.5 The time between mixing and placing of concrete shall not exceed 30 minutes so that the initial setting process is not interfered with.

5.4.3 Compaction

Concrete shall be compacted into a dense mass immediately after placing by means of mechanical vibrators designed for continuous operation. The Officer-in-charge may however relax this condition at his discretion for certain items, depending on the scope of the work, on the thickness of the members and feasibility of vibrating the same, and permit hand compaction instead.

Hand compaction shall be done with the help of tamping rods. Concrete shall be thoroughly compacted and completely worked around the reinforcement, embedded fixtures, duct formers and into corners of the formwork.

Compaction shall be completed before the initial setting starts, i.e. within 30 minutes of addition of water to the dry mixture.

Concrete shall be deposited continuously in layers of such thickness that no concrete is deposited on concrete which had hardened sufficiently to cause the formation of seams and planes of weaknesses within the section. If a section cannot be placed continuously, construction joints shall be located at points provided for in the plans or approved by the Officer-in-charge. If a delay exceeding one hour occurs in placing, no fresh concrete shall be placed on that already deposited until the Officer-in-charge's approval is obtained. The surface of the hard concrete is then to be prepared as specified in 5.4.4.

5.4.3.1 Use of Vibrators

The contractor shall inform the Officer-in-charge of the number and type of vibrators to be used. Stand by vibrators shall always be provided before commencement of work. External vibrators shall not be used without the approval of the Officer-in-charge.

The vibrators shall maintain the whole of concrete under treatment in an adequate state of agitation, such that de-aeration and effective compaction are attained. The rate of the supply of concrete from the mixtures shall be commensurate with this. The vibration shall continue, throughout the whole duration of the placing of concrete, the vibrators being adjusted so that the centre of vibration approximates to the centre of the mass compacted at the time of placing.

The full depth of fresh concrete shall be compacted without damaging adjacent partly hardened concrete.

Concrete shall be considered as properly compacted when the air bubbles cease to appear on the upper surface and mortar fills the spaces between the coarse aggregate and begins to cream up to form an even surface.

When this condition has been attained, the vibrator shall be stopped if using vibrating tables or external vibrators, while needle vibrators shall be withdrawn slowly so as to prevent formation of loose pockets. In case both internal and external vibrators are being used, the internal vibrators shall first be withdrawn slowly after which the external vibrators shall be stopped so that no loose pocket is left in the body of the concrete. The specific instructions

of the makers of the particular type of vibrator used shall be strictly complied with. Over vibration shall be avoided.

Shaking of reinforcement for the purpose of compaction should not be restored to. Likewise, all precautions shall be taken to prevent displacement of the reinforcement during the placing and compaction of concrete.

5.4.4 Construction Joints

Concreting shall be carried out continuously upto construction joints, the position and details of which shall be decided in advance and approved by the Officer-in-charge. Such joints shall be kept to the minimum and shall not be located in valleys. The joints shall be located taking into account the shear and other stresses. They shall be straight and at right angles to the direction of main reinforcement. Immediately prior to re-commencement of concrete on a joint, the surface of the concrete against which new concrete will be cast shall be freed from laitance and shall be roughened to the extent that the largest aggregate is exposed but not disturbed. Care shall be taken that the joint surface is cleaned immediately before the fresh concrete is placed against it. A coat of neat cement slurry at the rate of 2.75 kg of cement per sq meter shall then be applied on the roughened surface before fresh concrete is laid.

Particular care shall be taken in the placing of the new concrete close to the joint. This concrete shall be well compacted and if possible a vibrator shall be used.

Where the Officer-in-charge considers that special preparation is necessary, e.g. for an in-situ structural connection preparation shall be carried out preferably when the concrete has set but not hardened, by spraying with a fine spray of water or brushing with a stiff brush to remove the outer mortar and expose the larger aggregate without its being disturbed.

Where this treatment is impracticable sand blasting or a needle gun shall be used to remove the surface skin and laitance. Hacking of hardened surfaces shall be avoided.

5.4.4.1 Columns

In the case of columns, the joints shall be horizontal and located 100 to 150 mm below the bottom of the beam running into the column. The portion of the column above this joint shall be concrete with the beam. If a kicker (i.e. a starter stub) is used, it should be at least 70 mm high and carefully constructed. It is preferable for the kicker to be incorporated with the

previously placed concrete. Where possible, the formwork should be designed to facilitate the preparation of the joint surface, as the optimum time for treatment is usually two to four hours after placing.

5.4.4.2 Slabs and Beams

When stopping the concrete on a vertical plane in slabs and beams, an approved stop-board shall be placed with necessary slots for reinforcement bars. The construction joints shall be keyed by providing a triangular or trapezoidal fillet nailed on the stop-board. Inclined or feather joints shall not be permitted. Any concrete flowing through the joints of stop-boards shall be removed soon after the initial set.

5.4.5 Movements Joints

Movement joints shall generally be straight and conform to approved plans. The joints shall be formed with rigid formwork and stop ends suitably designed to cast the structurally separate components or parts. Filling of these joints with resilient joint fillers and the provision of copper or brass plates shall be as specified or directed.

A note on movement joints given in appendix 5B.

5.4.5.1 Contraction Joints

An interval of not less than 48 hours shall be allowed between casting of adjacent bays separated by formed contraction joints or construction joints.

5.4.5.2 Expansion Joints

Concrete shall not be placed on both sides of the joints at the same time unless otherwise approved.

5.4.6 Curing and Protection

5.4.6.1 Curing

After the concrete has begun to harden i.e. about 1 to 2 hours after its laying, it shall be protected from quick drying with moist gunny bags, sand or any other suitable material approved by the Officer-in-charge. After 24 hours of laying of concrete, the surface shall be cured by flooding with water of minimum 25 mm depth, or by covering with wet absorbent material, e.g. damp hessian or jute, coconut or straw matting, or a layer of sand about 50 mm thick. The curing shall be done for a minimum period of 7 days.

5.4.6.2 Protection

It shall be the responsibility of the contractor to prevent damage to the fresh concrete surfaces from rain indentation and physical damage. Immature concrete shall be protected from physical shock or movement and thermal shock particularly from cold weather. Exposed concrete surface shall be protected from rust marks and other disfigurement.

5.4.7 Finishing

5.4.7.1 Immediately on removal of forms, the reinforced concrete work shall be examined by the Officer-in-charge, before any defects are made good.

- (a) Work that has sagged or contains honey-combing to an extent detrimental to structural safety or architectural concept shall be rejected.
- (b) Surface defects of a minor nature accepted by the Officer-in-charge shall be rectified as given below. Surface defects which require repair when forms are removed usually consist of bulges due to movement of forms, ridges at form joints, honey-combed areas, damage resulting from the stripping of forms and bolt holes.
 - (i) Bulges and ridges shall be removed by careful chipping or tooling and the surface shall then be rubbed with a grinding stone.
 - (ii) Honey-combed and other defective areas shall be chipped out, the edges being cut as straight as possible and perpendicularly to the surface, or preferably slightly undercut to provide a key at the edge of the patch.

Shallow patches shall first be treated with a coat of thin grout composed of one part of cement and one part of sand and then filled with mortar similar to that used in the concrete. The mortar shall be placed in layers not more than 10 mm thick and each layer shall be given a scratch finish to secure bond with the succeeding layer. The last layer shall be finished to match the surrounding concrete by floating, rubbing or tooling on formed surface by pressing the form material against the patch while the mortar is still plastic.

Holes left by bolts shall be filled with mortar carefully packed into place in small amounts. The mortar shall be mixed as dry as possible, with just enough water so that it will be tightly compacted when forced into place.

Tiered holes extending right through the concrete may be filled with mortar using a pressure gun (similar to the gun used for greasing motor cars).

Normally, patches appear darker than the surrounding concrete, possibly owing to the presence on their surface of less cement laitance. Where uniform surface color is important, this defect shall be remedied by adding 10 to 20 percent of white Portland cement to the patching mortar, the exact quantity being determined by trial.

Care shall be taken to cure the material in the patches as taken with the whole structure. Curing shall be started as soon as possible after the patch is finished to prevent early drying. Damp hessian may be used but in some locations it may be difficult to hold it in place. A membrane curing compound will be most convenient in these cases.

5.4.7.2 Surface Preparation for Plastering

The surface which is to receive plaster or where it is to be joined with a brick masonry wall, shall be properly roughened immediately after the shuttering is removed, taking care to remove the laitance completely without disturbing the concrete. The roughening shall be done by hacking. Before the surface is plastered, it shall be cleaned and wetted so as to give good bond between concrete and plaster.

The reinforced concrete work shall be done to such tolerances that the thickness of plaster required for finishing the surface does not exceed 10 mm.

5.4.7.3 Surface Preparation for Floor Finishes

The surface of a reinforced concrete slab on which a screed or other finish is to be laid shall be roughened with brushes while the concrete is green. This shall be done carefully without disturbing the concrete.

5.4.7.4 Preparation for Roof Slabs

In case of roof slabs the top surface shall be finished even and smooth with a wooden trowel, before the concrete begins to set. When required, a brushed finish shall be obtained by brushing the surface with a stiff broom or wire brush while still green. This provides a slightly coarse surface.

5.4.8 Surface Finishes

This sub clause on finishes to in-situ concrete covers formed finishes, worked finishes on plastic concrete and worked finishes on hardened concrete.

The contractor shall provide form work appropriate to the required formed finish and to the dimensional tolerance it any specified.

Control samples shall be provided for the specified finish and approval of the appearance of each sample obtained from the Officer-in Charge in advance of construction.

The surface of plastic concrete shall not be wetted to assist surface working to obtain the specified finishes.

All adjacent work shall be protected from damage when finishes are worked on plastic or hardened concrete particularly when working with power driven floating, toweling or grinding.

5.4.8.1 Formed Finishes

Formed finishes shall consist of one of the following;

- (1) Basic finish
- (2) Plain finish
- (3) Fine finish
- (4) Special finish

5.4.8.1.1 Basic Finishes

A basic finish shall be appropriate for areas which are not exposed in the finished work e.g. foundations, backs of retaining walls, areas to be subsequently clad, plastered or rendered. There are no special requirements for this finish except those for dimensional tolerances. The concrete shall be fully compacted and shall be sound.

5.4.8.1.2 Plain Finish

A plain finish shall be appropriate for plain concrete surfaces exposed in the finished work. E.g. Car parks subways, circulation areas and areas to be subsequently painted.

The general requirements for plain finish shall be as follows:

- (1) The surface shall have an even finish by use of a sheet material e.g. plywood.
- (2) Panels shall be arranged in a regular pattern as a feature of the surface.
- (3) The concrete surface shall be free from voids, honey combing and other large defects. Blow holes shall not be more than 10 mm diameter.
- (4) The concrete surface shall be free from discoloration due to contamination or grout leakage but variation in color resulting from the use of an impermeable form lining may be permitted.

The tolerances for the concrete surfaces shall be as follows;

- (a) Abrupt irregularities not more than 5 mm.
- (b) Gradual irregularities expressed as maximum permissible deviation from a meter straight edge shall be not more than 5 mm.
- (c) The arises to columns, walls etc. Shall be chamfered or rounded as specified in the drawings or as directed by the Officer-in-Charge.

Plain finish shall be left as struck unless otherwise specified. Making good of small defects will normally be permitted but only after inspection by the Officer-in charge Blowholes shall be filled with mortar to an approved sample.

5.4.8.1.3 Fine Finish

Fine finish shall be adopted for areas of high aesthetic importance and generally only for internal work. The contractor shall provide the control sample of fine finish in an approved location in advance of construction.

The general requirement for fine finish shall be as follows;

- (i) A smooth even finish shall be produced with an impervious sheet material e.g. plastic faced plywood.
- (ii) Panels shall be mad as large as practicable and arranged in an approved regular pattern as a feature of the surface.
- (iii) Blow-holes less than 5 mm will be permitted but otherwise the surface shall be free from voids, honey combing and other defects.

- (iv) Variation in color resulting from the use of impermeable form lining will be permitted but the surface shall be free from discoloration due to contamination or grout leakage.
- (v) Cover spacers shall not be used without the approval of the Officer-in-Charge.

Tolerances for the fine finished surfaces shall be as follows;

- (a) Abrupt irregularities in the surface shall not be more than 3 mm.
- (b) Gradual irregularities expressed as maximum permissible deviation from a one meter straight edge shall not be more than 3 mm
- (c) Arises of columns, walls etc shall be chamfered/rounded as detailed in the drawing or as specified by the Officer-in-Charge.

Formwork ties shall not be used except with the permission of the Officer-in-charge.

Making good of fine finished concrete will not be permitted and the surface shall be left as struck.

Blow holes shall be filled with mortar to an approved sample.

5.4.8.1.4 Special Finish

Special finishes to concrete surfaces like rough board finish, ribbed finish, coffered/Troughed etc. shall be provided by the Contractor to the specific requirements and tolerances indicated in the drawings.

5.4.8.2 Worked Finishes: Plastic Concrete

Worked finishes (normally to horizontal surfaces) shall be produced by working the concrete when still in the plastic condition.

The worked finishes on plastic concrete shall be one of the following:

- (a) Tamped Finish
- (b) Scored Finish
- (c) Floated Finish
- (d) Trowel led Finish

5.4.8.2.1 Tamped Finish

The surface of plastic concrete shall be stamped with the edge of a board or beam of adequate size and weight to give an even texture of parallel ribs. The concrete surface shall thus be given an overall ribbed affect. It shall be noted that the tamping shall be started with very little bleeding water present on the surface.

5.4.8.2.2 Scored Finish

This type of finish which gives an overall roughened surface to the concrete and shall be obtained by scoring (scratching) the concrete surface at the appropriate time with a stiff brush, metal comb, trowel or a length of mesh reinforcement.

5.4.8.2.3 Floated Finish

The surface shall be floated with a wooden float to give an even, slightly coarse texture with no ridges or steps. Alternatively skip float or power float may be used to give the required finish. Floating has to be timed properly to achieve the best results.

5.4.8.2.4 Trowel led Finish

After obtaining an initial finish using a wooden float/power float a fine smooth finish shall be given to concrete surfaces by hand toweling or power toweling. Power toweling shall be adopted for large unbroken areas with few ducts, recesses etc. The timing of power toweling in relation to the ambient condition of concrete shall be such that the concrete shall be sufficiently stiff to take the weight of the machine and the operator, yet sufficiently workable for the toweling to be effective. Vacuum dewatering may be adopted to overcome this timing problem, if so directed.

5.4.8.3 Worked Finishes: Hardened Concrete

Hardened concrete shall be given the following surface finishes as specified.

- (a) Abrasive blasted Finish
- (b) Tooled Finish
- (c) Power ground floor Finish

Finishes on hardened concrete noted above shall be worked over a formed finish or worked finish on plastic concrete.

5.4.8.3.1 Abrasive Blasted Finish

Abrasive blasted finish shall be carried out over a plain/fine/floated finish. These shall conform to approved samples and shall be carried out within 7 days of striking of formwork. The surface shall be blasted with an approved abrasive to even texture and to the depth of exposure specified. The minimum depth of exposure shall be 1 mm for light plastered finishes. Abrasive blasting shall be stopped short of arises with regular margin of 40 mm or as otherwise directed.

5.4.8.3.2 Tooled Finish

Tooled finishes shall be obtained over an initial plain finish surface or a ribbed finish surface by using a snub-nose tool/Disc head bush hammer/combed chisel or other approved tools. Tooling shall be carried out only on a concrete which is at least 21 days old and has a compressive strength of not less than 20 N/mm² when tooling is carried out. Tooling shall be stopped short of arises with a regular margin of 40 mm or as otherwise directed.

5.4.8.3.3 Power Ground Floor Finish

Power grinding shall be used to produce a hard wearing surface suitable for the direct application of thin sheet or tile covering. Grinding shall be used as a finishing technique and shall not be used to correct gross irregularities in the surface. The objective shall be to remove the thin, weak surface layer of concrete (about 1 mm thick) to produce a surface which is less prone to dusting and wear, more coarse and slip resistant.

A sample shall be provided by the Contractor in an approved location. Power grinding shall be carried out on a floated finish obtained with specified tolerances. (The normal gradual irregularities of the surface shall be not more than 2 mm on a 1 meter straight edge.) Power grinding shall normally be done dry and within 7 days of concreting. After grinding, all dust shall be swept away and the surface thoroughly washed down. To reduce dusting, a surface hardening solution may be applied to the specification of the manufacturer, if so directed by the Officer-In-Charge.

5.4.9 Sampling and Compliance Criteria For Strength of Concrete

5.4.9.1 General

Sampling and testing of concrete shall be as per B.S. 1881.

The characteristic strength of concrete on which the structural design is based is that 28 day cube strength below which not more than 5% of the test results may be expected to fall.

Compliance with the specified characteristic strength should generally be judged by tests made on cubes at an age of 28 days. In order to get an idea of the quality of the concrete sooner, compressive strength test at 7 days may be used to test compliance with the specified characteristic strength.

For this purpose the 7 days strength may be taken to be 75% of the 28 day cube strength. The rate of sampling shall generally be as given below unless otherwise decided by the Officer-In-Charge.

One sample shall be taken from any one batch selected randomly to represent an average volume of not more than 20 cubic meters, 20 batches or 1/4 of the total quantity of concrete under consideration for testing whichever is the lesser volume, but not at a rate less than 1 sample per day per grade.

5.4.9.2 Testing Plan and Compliance Criteria

Three test specimens shall be prepared for compliance and all the specimens shall be cured as follows:

- (a) for 28 days
- (b) by any other regime of curing agreed between the producer and the purchaser (e.g. 7 days normal curing or accelerated curing at an elevated temperature) that is capable of predicting the strength of 28 days.

To assess compliance as regards compressive strength, the first result alone cannot be used to judge compliance with the specified characteristic strength.

Compliance with the characteristic strength is based on groups of four consecutive test results. Compliance with the specified characteristic strength may be assumed if the average strength determined from any group of four consecutive test results and if each individual test result complies with the appropriate limits in columns A and B of Table 5.5 respectively.

When there are less than four results, i.e. at the start of a job or on small jobs, the average of the first 2 or first 3 results, and the individual results should comply with the appropriate limits in columns A and B of Table 5.5 respectively.

For a test result, the difference between the strength of two specimens prepared from the same sample shall not exceed 5 N/mm².

Table 5.5 - Compressive Strength Compliance Requirements

| A | | | B | | |
|-----------------|-------------------------------------|---|-----------------|-------------------------------------|---|
| Specified Grade | Test Results | Average of first 2 of first 3, or of 4 consecutive test results exceeds the specified characteristic strength by at least | Specified Grade | Test Results | Any individual test result is not less than the specified characteristic strength minus |
| C 20 and above | first 2 first 3 Consecutive 4 | 1 N/mm ² 2 N/mm ² 3 N/mm ² | C 30 and above | first 2 first 3 Consecutive 4 | 3N/mm ² 3 N/mm ² 3 N/mm ² |
| Below C 20 | first 2 first 3 Consecutive 4 | 0 N/mm ² 1 N/mm ² 2N/mm ² | Below C 30 | first 2 first 3 Consecutive 4 | 2N/mm ² 2N/mm ² 2N/mm ² |

Note 1 If the work is of minor nature or when the total volume of concrete is small, the following alternatives may be used

- (a) the average value of 3 cubes made from the same sample shall equal or exceed the characteristic strength
- (b) the lowest individual strength of any cube shall not be lower than 0.85 of the characteristic strength, and
- (c) the allowable range (maximum minus minimum value) of the strength of the 3 cubes made from the same sample shall not exceed 20% of the average value of the 3 cubes

Note 2 The quantity of concrete represented by a group of 4 consecutive test results shall include the batches from which the first and last samples were taken together with all intervening

batches. Similarly the first 2 or 3 results shall be taken as representing all the intervening batches. For the individual test results requirements given in column B of Table 5.5 only the particular batch from which the sample was taken shall be at risk.

5.4.9.3 Compliance Criteria for prescribed and volume batched mixes

The testing plan and compliance criteria can be as for designed mixes above, based on the equivalent grades specified for the prescribed and volume batched mixes. If compliance is based on strength in the manner, the cement content and water/cement ratio requirement can be seemed to have been satisfied.

On the other hand, compliance can be assessed, without strength testing, by either observation of the batching or examination of the autographic records of the batch weights used. Such an individual assessment of the mix proportions shall be within + 5 % of the values specified, and the mean of any 4 consecutive assessments of cement content shall not be less than the specified value. Account shall be taken of the adjustments permitted in Note 2 of Appendix 4 D.

Appendix 5 A

REINFORCED CEMENT CONCRETE

| Maximum Anchorage Length of Single Bars | | | | | |
|---|-----------|------------|-----------|-------------|-----------|
| Concrete Grade | Code used | Tension | | Compression | |
| | | Mild Steel | TOR Steel | Mild Steel | TOR Steel |
| 20 (i.e. 1:2:4 mix) | BS 8110 | 44 | 450 | 360 | 360 |
| 25 | BS 8110 | 390 | 400 | 320 | 320 |

Notes BS 8110 Values calculated for single rods, taking

Area of Rod = ; Effective Perimeter = 4

The tensile stress = 0.87 fy

The compressive stress = 0.87 fy

For TOR Steel fy = 460 N/M. M²

For Mild steel fy = 250 N/M.M²

Average Anchorage Stress

| fy. | Tension | | Compression | |
|--------------------------|-----------|-------------|-------------|------------|
| | Con.Gr.20 | Con. Gr. 25 | Con.Gr. 20 | Con.Gr. 25 |
| 460 N/mm ² | 2.24 | 2.50 | 2.82 | 3.15 |
| 250 N/mm ² | 1.25 | 1.4 | 1.57 | 1.75 |

Note : Lapping (as per clause 3.11.6.5 BSCP 110) When bars are lapped, the length of the lap should at least equal the anchorage length required to develop the stress in the smaller of the two bars lapped, except that for deformed bars in compression the length of the lap should be 25% greater than the anchorage length required for the smaller bar.

The length of lap provided however, should be less than 15ϕ or 300 mm whichever is greater.

Appendix 5 B

Movement Joints - shall be as specified or directed.

In general movement joints in the structure should pass through the whole structures in one plane. Movement joints may be of the following types

- (a) Contraction Joint - This has a deliberate discontinuity but no initial gap between the concrete on both sides of the joints as it is intended to permit contraction of the concrete.

In a complete contraction joint -both concrete and reinforcement are interrupted.

In a partial contraction joint - only the concrete is interrupted while the reinforcement runs through.

- (b) Expansion Joint - A joint with complete discontinuity in both reinforcement and concrete intended to accommodate either expansion or contraction of the structure. Generally a wide gap between the adjoining parts of the structure is provided.
- (c) Sliding joint - a joint with complete discontinuity in both reinforcement and concrete at which special provision is made to facilitate relative movement in the plane of the joint.
- (d) Hinged joint - a joint specially designed and constructed to permit relative rotation of the members at the joint.
- (e) Settlement joint - a joint permitting adjacent members or structures to settle or deflect relative to each other.

A joint may be designed to fulfill more than one of the above requirements.

CHAPTER 6

BRICK WORK AND BLOCK WORK

Definitions

Bat : A portion of a brick either especially manufactures or formed on site by cutting a whole brick across its length.

Bond : A disposition of units in a wall usually designed to ensure that the cross joints in each course are not less than one quarter of the length of a unit from those in adjacent courses.

Bricks

A masonry unit not exceeding 337.5 mm ($13\frac{1}{2}$ ") in length, 225 mm (9") in thickness or 112.5 mm ($4\frac{1}{2}$ ") in height. (The height is taken to be the vertical dimension perpendicular to the base when

the unit is used in its normal aspect. The height of a brick shall not less than 38 mm ($1\frac{1}{2}$ "). If less than this dimension, it shall be classified as a tile.

Blocks

A masonry unit which when used in its normal aspect exceeds the length or width or height specified for bricks.

Solid Blocks

In which small holes passing through or nearly through the brick do not exceed 25% of its volume or in which frogs (depressions in the bed faces of a brick) do not exceed 20% of its volume.

Hollow Blocks

In which holes passing through the unit exceed 25% of its volume.

Coordinating size: The size of a coordinating space allotted to a masonry unit including allowances for joints and tolerances.

Work size: The size of a masonry unit specified for its manufacture, to which its actual size should conform within specified permissible tolerances.

Compressive Strength: The average value of the crushing strengths of ten masonry units tested in accordance with BS.

Common: Suitable for general building work but having no special claim to give an attractive appearance.

Facing: Specially made or selected to give an attractive appearance when used without rendering or plastering or other surface treatment for the wall.

Brick work & Block work

As assemblage of units (brick or blocks) bonded together with mortar to form a wall including piers or columns.

Closer

A portion of a unit used to maintain bond, either specially manufactured or formed on site by cutting a whole unit along its length.

Corbel

A unit cantilevered from the face of a wall to form a bearing.

Cornice

A projection, generally continuous, from the facade of a building or part of a building or wall.

Course

A layer (e.g. a course of brickwork or blockwork) which includes a layer of mortar as well as a layer of units.

Over Sailing Course

Brick course projecting from a wall for the sake of appearance only as distinct from corbels which are load carrying.

Damp-proof Course

A layer, or layers, of materials laid or inserted in a structures to prevent the passage of water.

Efflorescence

An encrustment of salt left by evaporation.

Flashing

A sheet of impervious material fixed to a structure and dressed to cover an intersection or joint where water would otherwise penetrate.

Footings

A projecting course or courses formed below the base of a wall to distribute the load.

Frog

A purpose-made indentation in either or both of the two largest faces of a brick.

Header

A unit with its end showing on the face of the wall.

Indenting

The omission of units to form recesses into which future work can be bonded.

Jamb

That part of a wall at the side of an opening (see reveal).

Joint

A junction between walling units.

Bed joint - The mortar layer upon which walling units are set.

Cross joint - A joint, other than a bed joint, normal to the face of a wall.

Wall joint - A joint parallel to the face of a wall.

Masonry Unit

A block, a brick or a fixing unit.

Pad stone (Template)

A strong block bedded on a wall to distribute a concentrated load, sometimes known as a template.

Parapet

Top section of a wall where it conceals the gutter of the roof.

Partition wall

Any internal wall primarily intended for sub-division of space.

Pier

A thickened section forming an integral part of the wall, placed at intervals along the wall primarily to increase the stiffness of the wall or to carry a vertical concentrated load.

Pilaster

Attached pier.

Pillar or Column

A detached masonry support, rectangular, circular, or elliptical in shape.

Plinth

A projecting base of an external wall which gives additional stability.

Pointing

The refilling and finishing of joints from which mortar has been raked out.

Quoin

An external corner.

Reveal

The visible part of each side of a recess or opening in a wall (see 'jamb')

Scaffolding

A temporary erection of bamboo, timber, or steel work, used in the construction, alteration, demolition or repairs of a building to support or to allow the hoisting or lowering of workmen, their tools and materials.

Sill

Work forming the lower boundary of door or window opening.

Stretcher

A unit laid with its length in the direction of the wall.

String Course

A distinctive course or band in a wall, usually horizontal and sometimes projecting and molded.

Template

A pattern, usually of sheet material, used as a guide for setting out particular work.

Toothing

Units left projecting to bond with future work.

Weathering

This term is used to describe both :-

(i) the cover applied to, or the geometrical form of, a part of a structure to enable it to show rain water.

or

(ii) the effect of climatic and atmospheric conditions on the external surfaces of material.

6.1 Materials**6.1.1 Common Burnt Clay Bricks****General**

Bricks shall be hand or machine moulded. They shall be regular in shape with good clean finishes, free from lumps of unslaked limestone, etc.

Their surface shall be free from striations, laminations, pitting, cracks etc. They shall be uniform in color and must be well burnt so as to give a clear ringing sound when struck.

When broken, the fracture shall give a close grained uniform texture and color and shall be free from black core or any sign of being imperfectly burnt.

The dimensions of bricks shall be 220 mm x 105 mm x 65 mm (8.7" x 4.1" x 2.6").

The general and specific requirements are tabulated below in Table 6.1

| Description | Type I | Type II | |
|---|--|------------------------------------|------------------------------------|
| | | Grade I | Grade II |
| Method of manufacture | Wire-cut, machine made | Hand-made | Hand-made |
| Average compressive strength not less than | 10 N/mm ² (1450 p.s.i.) storeyed | 4.8 N/mm ² (700 p.s.i.) | 2.8 N/mm ² (410 p.s.i.) |
| Use in locations (unless otherwise specified) | Load bearing multi storeyed | Two-storeyed construction | Single storey construction |
| Maximum water absorption | 18% | 28% | 28% |
| Efflorescence | Slight | Moderate | Moderate |
| Nominal dimension of individual bricks | 220 mm x 105 mm x 65 mm (8.7"x4.1"x2.6") | | |
| Overall dimension of 24 Bricks | L 5280 \pm 75 mm (207.93 \pm 3.0 in) B 2520 \pm 40 (99.2 \pm 1.6 in) D 1560 \pm 40 (61.4 \pm 1.6 in) | | |
| Other features | The bed faces shall be provided with grooves, frogs (depressions) or holes to ensure adequate bonding. | | |

6.1.1.1 Sampling and testing of bricks

The bricks shall be sampled and tested for dimensions, general requirements, compressive strength, water absorption and efflorescence as per BS. Acceptance criteria shall be as set out in the same standard. The testing methods are given in appendix 6A.

6.1.2 Pre-cast blocks/bricks

General

These shall be composed of cement mortar/cement concrete in specified proportions, or the proportions needed to achieve the specified compressive strength. These shall generally conform with B.S. 6073 Part I and Part 2.

6.1.2.1 Materials

Cement - shall be Ordinary Portland Cement conforming to BS 12.

Aggregates - shall be natural aggregates conforming to BS 882 except that the fine and/or coarse aggregates need not be graded.

Admixtures - Use of admixtures shall be not permitted without the prior approval of Officer-In-charge.

6.1.2.2 Sizes and shape

The blocks/bricks shall be true to shape with good, clean arises. The minimum thickness of the external shell of hollow and cellular blocks shall be not less than 15 mm or 1.75 times the nominal maximum size of the aggregate whichever is the greater.

The maximum size of bricks shall be 337.5 mm x 225 mm x 112.5 mm. The size of bricks shall generally conform to the work sizes in B.S. 6073 Part 2, Table 2 given below :

Work sizes of Bricks;

290 x 90 x 90 mm

215 x 103 x 65 mm

190 x 90 x 90 mm

190 x 90 x 65 mm

The size of blocks shall generally conform to the work sizes in BS 6073 Part 2 Table 1 given below :

Table 6.2 - Work sizes of blocks (ref. Table No. 1 of BS. 6073: Part 2: 1981)

| Thickness mm | | 60 | 75 | 90 | 100 | 115 | 125 | 140 | 150 | 175 | 190 | 200 | 215 | 220 | 225 | 250 |
|--------------|-----------|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Length mm | Height mm | | | | | | | | | | | | | | | |
| 390 | 190 | x | x | x | x | x | | x | x | | x | x | | | | |
| 440 | 140 | x | x | x | x | | | x | x | | x | x | | | x | |
| 440 | 190 | x | x | x | x | | | x | x | | x | | x | x | | |
| 440 | 215 | x | x | x | x | x | x | x | x | x | x | x | x | x | x | x |
| 440 | 290 | x | x | x | x | | | x | x | | x | x | x | | | |
| 590 | 140 | | x | x | x | | | x | x | | x | x | x | | | |
| 590 | 190 | | x | x | x | | | x | x | | x | x | x | | | |
| 590 | 215 | | x | x | x | | x | x | x | x | | x | x | | x | x |

6.1.2.3 Strength requirements

Bricks/Blocks of thickness 75 mm or more when tested for compressive strength shall comply with the followings:

- the average crushing strength of 10 bricks shall be not less than 7.0 N/mm²
- the average crushing strength of 10 blocks shall be not less than 2.8 N/mm²
- the coefficient of variation for the sample shall not exceed 20%

Blocks less than 75 mm shall be tested for transverse strength in accordance with the code and the average transverse strength of 5 blocks shall be not less than 0.65N/mm²

6.1.2.4 Manufacture

Cement mortar used for manufacture of bricks shall be 1:6 or other proportion needed to achieve the specified compressive strength and the mortar shall be of stiff consistency.

Cement concrete for blocks/bricks shall be 1:3:6 (14 mm) or other proportions needed to achieve the strengths specified. Concrete shall be of the required consistency to suit the moulds and the methods of compaction.

The units shall be manufactured by machines of approved make. In the absence of machines, they shall be cast in properly designed rigid steel moulds or wood moulds lined with galvanized steel sheets. The mould surfaces shall be cleaned and smeared with a suitable oil after each casting. Hand tamping shall be with 16 mm diameter steel rods and shall be continuous after filling the first 25 mm. The units as cast, shall be dense and solid as they come from the block making machines or moulds. The units showing cavities of any kind must be broken up immediately however, the concrete may be re-used the time since mixing has not exceeded 30 minutes. Under no circumstances shall the units be plastered at any stage to cover up defects.

Units which are too smooth to provide a key for the final plaster coating may be bristle brushed to provide a slightly rough surface after they have hardened for 6 hours.

Curing shall be carried on for 14 days. The units shall be cured for the first seven days by immersion in water commencing not earlier than 16 hours after casting they shall thereafter be kept wet by stack curing for a further period of seven days, the units being stacked to a height of not more than 1.2 meters. In the case of hollow blocks the cavities shall be filled with sand and water shall be supplied as required to ensure their being wet throughout the day and night. On sunny and windy days, the top and side faces of stacks shall be protected with cadjans or hessian canvas which shall be removed at frequent intervals for watering. The units shall be built into the work not earlier than 4 weeks from casting.

6.1.2.5 Sampling and testing of blocks

This shall be as per clause 13 of BS 6073 Part I.

The units shall be made in batches, and from each batch of 1,000 not more than 15 units will be selected at random for testing the compressive strength and drying shrinkage.

In the case of blocks less than 75 mm thick, 10 blocks shall be selected for testing the transverse strength and drying shrinkage. The further preparation of the selected units for testing as described in the British Standard is to be done at the site, by the contractor who shall in the presence of the Officer-in charge, pack the units in approved packing cases with suitable packing material to ensure the units remaining damp during transit and deliver them at the approved testing station at his own expense. The cost of the actual test shall be borne by the owner. In the event of the units tested failing to meet the specified strength requirements, they shall be (at the discretion of the Officer-in-charge) relegated to some

lesser category or condemned. In the former case they shall be suitably marked to avoid confusion and in the latter case they shall be removed from the site without delay.

6.2 Brickwork (Clay Brick)

6.2.1 Mortars for Brickwork

These shall conform to Chapter 3.

Mortar for brickwork shall be generally as given below in Table 6.3 unless otherwise specified.

| Type of Mortar | Mortar Designation | Mix by volume Masonry | | | | Location |
|---------------------|--------------------|-----------------------|--------|------|-------|--|
| | | Cement | Cement | Lime | Sand | |
| Cement-sand | iv | 1 | - | - | 8 | All walls above ground level except 4 1/2" brick work -do- -do- |
| cement-lime | iv | 1 | - | 2 | 9 | |
| sand | iv | - | 1 | - | 5 | |
| Masonry cement sand | | | | | | |
| Cement-sand * | iii | 1 | - | - | 5 | in 4 1/2" brick and in walls below ground level where specified. -do- |
| cement -lime | iii | 1 | - | 1 | 5 | |
| sand | iii | - | 1 | - | 4 | |
| Masonry cement | | | | | | |
| Cement-sand * - | ii | 1 | - | - | 3 | -do- |
| cement-lime | ii | 1 | - | 1/2 | 4 | -do- |
| sand | ii | - | 1 | - | 2 1/2 | -do- |
| masonry cement | | | | | | |
| cement -sand * | i | 1 | - | - | 3 | -do- |

Note : (1) * Plasticizer of approve manufacture shall be used if directed by the Officer- in charge.

(2) The gauge box for cement shall be 400 x 350 x 290 mm or 300 x 300 x 350mm

The corresponding gauge box for lime and sand shall be 400 mm x 350 mm x 250 mm or 300 x 300 x 300 mm respectively.

6.2.2 Handling of Bricks and Preparation

Bricks shall not be handled in baskets, thrown from a height or in other manner that would destroy the sharpness of the edges. In no case shall bricks of different dimensions be used in the same-work except when specially permitted by the Officer-in charge.

In exposed brick work, selected bricks of the specified class shall be used for the face work.

The bricks shall be wetted with water (immersed in water) before use on works. Bricks required for masonry with mud or fat lime need not be wetted. The tops of walls left off shall be wetted before the work is recommenced.

6.2.3 Laying and Jointing

Bricks shall be laid in English bond unless otherwise specified. Half or cut bricks shall not be used except where necessary to complete the bond; Closers in such cases shall be cut to the required size and used near the ends of walls. In all load bearing walls the bricks shall be laid with frogs upwards and the frogs shall be filled with mortar.

A layer of mortar shall be spread on full width over a suitable length of the lower course. Each brick shall be properly bedded and set home (in position) by gentle tapping with the handle of a trowel or wooden mallet inside faces of the set bricks shall be buttered with mortar and the next brick to be laid shall be pressed against it. All bricks in every course shall be grouted full with mortar using the trowel for chasing in for this purpose.

The thickness of mortar joint shall not exceed 10 mm.

6.2.4 Raising of Walls

The quoins shall be set out and built up in advance of the main body of the brick walling.

The walls shall be carried up uniformly in all cases where the nature of the work admits it. No part shall be left more than one meter below the rest of the work. The work shall not be built higher than 1.5 m in one day. The courses shall be kept perfectly horizontal and every fourth course shall be checked for level and plumb. Courses shall be break joints. At the end of the day's work and where it is not possible to raise the adjoining portion uniformly and in gable walls, the work shall be raked back according to the bond, at an angle not steeper than 45°. All Perpendes, Quoins etc. shall be kept strictly true and square and the

whole properly bonded together and brought to final levels at each floor. Over hand laying shall not be used without approval. Panel walls or non load bearing walls shall not but against the concrete beams or slabs.

The lateral stability of walls which are free standing during construction shall be ensured by adequate shoring and scaffolding until the roof or floor providing the necessary stability is constructed.

6.2.5 Curing and Protection

Brick work shall be protected from rain by suitable covering when the mortar is green. Brickwork in cement/composite/lime mortar (except fat lime mortar) shall be kept constantly moist on all faces for minimum period of seven days. In the case of masonry with fat lime mortar, curing shall commence two days after laying and shall continue at least for seven days thereafter.

6.2.6 Fixtures Etc.

All iron fixtures like hold fasts, pipes, etc. which are required to be built in to the wall shall be embedded in their correct positions in cement mortar or cement concrete as specified.

6.2.7 Raking of Joints for Plaster

When the face work is to be plastered or joints alone pointed upon, the joints shall be raked to a minimum depth of 12 mm by a raking tool during the progress of work or when the mortar is still green. When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. The face and top of courses of the brick work shall be cleaned thoroughly of all mortar droppings on the same day.

6.2.8 Brick on Edge Coping

The top course of all plinths, the top of walls below reinforced concrete parapets, steps etc. shall be brick on edge with extra fine vertical joints not exceeding 3 mm in thickness. Bricks forming the corners of all such courses are to be properly radiated and keyed in to position.

6.2.9 Treatment at Ends of Beams Etc.

The ends of steel beams and roof trusses shall rest in recesses having 15 mm space for free circulation of air and provided with perforated zinc sheeting.

6.2.10 Corbelling

Corbelling shall be effected by a one fourth brick projection (in every course) for ordinary work and a one eighth brick projection where greater strength is required.

6.2.11 Damp-Proof Course

This shall conform to clause 11.1

6.2.12 Scaffolding

For all exposed brick work, double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong and tied together with horizontal pieces over which scaffolding planks shall rest. Alternatively steel scaffolding may be resorted to, in which case the arrangements shall be approved by the Officer-in-charge.

For all other brick work in buildings single scaffolding shall be provided. In such cases, the inner end of the horizontal scaffolding pole shall rest in a hole provided only in the header course for this purpose. Only one header for each pole shall be left out. Such holes for scaffolding shall however, not be allowed in pillars/columns less than one meter in width, or immediately near the skew back of Arches. The holes left in masonry work for scaffolding purposes shall be completely packed and made good before plastering.

Note: - In the case of special type of brick work, scaffolding shall be got approved by the Officer-in-charge in advance.

6.2.13 Half Brick Masonry

The work shall be done in the same manner as specified in 6.2.4 except that all courses shall be laid as stretchers. The proportion of cement mortar shall generally be one part of cement to 5 parts of sand.

6.2.14 Reinforced Brickwork

In special cases such as long unsupported partition walls where reinforcement is considered necessary, 2 numbers of 6 mm diameter rods shall be provided at every alternate course unless otherwise specified. The rods shall be straight and free from rust and loose flakes. They shall be placed over cement mortar beds of 1:3 composition. 10 mm thickness of mortar shall first be laid, the rods laid and then covered with a bed of 10

mm mortar immediately. The rods shall be fully embedded in the mortar. At the ends, the rods shall be bent up for half the thickness of the course.

6.2.15 Honey-Comb Brickwork

Standard or specified bricks shall be used for this class of work and they shall be laid on cement mortar 1:3 or as otherwise specified.

The thickness of brick honey-comb shall be half brick or one brick as specified. Openings shall be equal and alternate in every course and the bearing width, on each side shall be 20 mm minimum. The bond used shall be heading throughout in one brick thick honey-comb, and stretchers throughout in half brick thick honey-comb work. The bricks shall be thoroughly bedded in mortar and jointed and the edges struck flush and finished smooth as the work proceeds.

6.2.16 Brickwork in Arches

Bricks for Arch work shall be specially selected and shall be free from defects of any sort.

The bricks shall be laid in concentric half brick rings with break joints (i.e. staggered joints). The arch work shall be carried out from both ends simultaneously and keyed in the centre. The bricks shall be buttered with mortar and well pressed in to their positions so as to squeeze out a part of the mortar and leave the joints thin and compact. All joints shall be full of mortar and the thickness of joints shall neither be less than 5 mm nor more than 15 mm in all arches; the voussoir joints shall be normal to the curve at these points.

Bricks forming skew back joints shall be specially moulded or cut so as to radiate thinly, and defects in this particular case shall not be remedied by the extravagant use of mortar nor shall any parthing by chips be allowed.

Joints in any two consecutive rings shall not come in the same radial plane.

The arch work shall be quickly and evenly done and kept moist so that no portion of the arch hardens or sets before the whole arch is completed.

6.2.16.1 Centering for Arches

In all centers the upper bearing surface shall be very correctly formed to the curve of the intrados of the arch. The centering shall be strong enough to bear the dead load and live

load coming upon it during construction without any appreciable deflections. For spans longer than 2 meters, timber centers shall be used and shall be provided with hard wood wedges for slackening. For larger span arches special plans for centering shall be prepared and prior approval of the Officer in charge obtained.

In all centers the arrangement shall be such that the slackening can be effected without any vibration being transmitted to the arch, and in the case of a series of arches that the centers can all be slackened simultaneously. The time after which this slackening has to be done shall be carefully decided.

When lime mortar is used, centers will ordinarily be slackened within 24 hours of the completion of the arch. Care however, shall be taken to see that the centering is not eased while the mortar in the last joint is so soft that it will be squeezed out, but at the same time centers will be slackened while the mortar in the joints is still moist so as to allow the arch to compress itself and bring all the joints to fair bearing.

In the case of a segmental arch, care shall be taken to see that the skew backs are secure, and they shall be given a week's time to set.

In the case of semicircular, elliptical or other arches springing from a horizontal joint, the adjacent wall shall be built up to two thirds of the height of the arch before slackening centers.

6.2.17 Joining Old Work with New Work

New work shall be bonded carefully to existing work by cutting pockets into existing walls; the pockets shall not be less than 10 mm deep, with a width equal to the full thickness of the new work. The spacing and height of each pocket shall be as follows; for joining of

Brick to Brick - 4 courses high and at 8 course centers.

Brick to Block,

Block to Brick every alternate block course.

Block to Block

The new walling shall be bonded well into the pockets with all voids filled solid with mortar.

6.3 Masonry With Cast Block/Brick

Unless otherwise specified, the blocks shall be built in cement mortar 1:5, with joints not exceeding 10 mm in thickness. The blocks shall not be wetted before use.

Concrete Blockwork and brickwork shall be reinforced for construction in cyclone-prone areas.

Where concrete is to be laid over hollow block masonry, this shall be done over a specially cast hollow block course with the top of the cavities filled with concrete to a depth of at least 25 mm.

Where the space between the block course and reinforced or plain concrete above that course is less than the height of a block, the same shall be filled with cement concrete 1:3:6 (20 mm) or as specified.

The cavities between the reveal of any opening and the block work shall be filled up with cement concrete 1:3:6 (20 mm) for the length of a block.

Appendix 6A - Test for Bricks

1. Checking the Dimensions

The bricks selected in accordance with BS shall be grouped into one or more sets of 24 bricks. The overall dimensions shall be measured by placing each set of 24 bricks in contact in a straight line on a level surface. Any blisters or other small projection together with any loose particles of clay shall be removed before the bricks are assembled for measurement. The overall length of each set of assembled bricks shall be measured with a steel tape, or other suitable inextensible measure long enough to measure the whole row at once. Measurement by repeated application of a short rule or measure shall not be permitted. If the measured dimensions of each set of 24 bricks falls within the limits specified below the bricks shall be considered to have passed this test.

$$L = 5280 \pm 75 \text{ mm } (207.9 \pm 3")$$

$$B = 2520 \pm 40 \text{ mm } (99.2 \pm 1.6")$$

$$D = 1560 \pm 40 \text{ mm } (61.4 \pm 1.6")$$

2. Determination of Compressive Strength

Each brick to be tested shall be rubbed down as necessary to obtain a smooth plane surface on each face to receive the load. The bricks shall be immersed in water at room temperature for 72 hours. The bricks shall be removed and allowed to drain at room temperature, wiped free of surplus moisture and subjected to the test within 90 minutes of immersion. They shall be placed between two 3 - play plywood sheets 4 mm thick, and carefully centered between the platens of the machine.

One of the platens of the testing machine shall have a ball seating in the form of a portion of a sphere the centre of which coincides with the centre of the face of the plate. The load shall be applied in the direction of the thickness of the brick at a rate of 14 Mpa (2.0×10^3 1 bf/in) per minute until failure occurs. The compressive strength shall be calculated by dividing the maximum load on failure by the area of the face on which the load is applied and shall be expressed in Mpa (1bf/in²). If the arithmetic mean of the compressive strengths of the bricks tested does not fall below the relevant value specified in Cl. 6.1.2.3 the bricks shall be considered to have passed this test.

Note : For the purpose of this test the brick shall be deemed to have failed when there is a momentary decrease in the rate of advance of the indicator of the testing machine, combined with fracture of the brick.

3. Determination of Water Absorption

The bricks shall be dried to constant mass in a well ventilated oven at 100°C. They shall then be cooled to approximately room temperature and weighed.

Note : In a ventilated room bricks properly separated require about four hours for cooling unless an electric fan passes air over them continuously , in which case about two hours may suffice.

The dry bricks shall be totally immersed without preliminary partial immersion, in clean water at room temperature for 24 hours. As far as possible, the water shall have free access to all surfaces of the bricks. Each brick shall then be removed, the surface water wiped off with a damp cloth, and the brick weighed in a balance sensitive to about 0.1 per cent of the weight of the brick. The weighing of each brick shall be completed within three minutes after its removal from the water.

The percentage of water absorption by mass shall be calculated as

$$\text{The percentage of water absorption} = \frac{M_2 - M_1}{M_1} \times 100$$

where M_1 = mass of the dry brick and

M_2 = mass of the brick after 24 hours immersion in cold water.

4. Test for Efflorescence

Place the ends of the bricks in a shallow flat bottom dish having an area of approximately 0.10 m² (160 in²), containing distilled water, the depth of immersion in water being 25 mm (1.0 in) . Place the whole arrangement in a well ventilated room until all the water in the dish evaporates. When the water has been absorbed and bricks appear to be dry, place a similar quantity of water in the dish and allow it to evaporate as before . Examine the bricks for efflorescence when the bricks are dry and report the results.

The liability to efflorescence shall be reported as 'nil' , 'slight' , 'moderate' heavy or 'serious' in accordance with the following definitions.

(a) Nil - When there is no perceptible deposit of efflorescence.

- (b) Slight - When not more than 10 per cent of the area of the brick is covered with a thin deposit of salts.
- (c) Moderate - When there is a heavier deposit than 'slight' and covering upto 50 percent of the area of the brick surface but unaccompanied by powdering or flaking of the surface.
- (d) Heavy - When there is a heavy deposit of salts covering 50 percent or more of the brick surface but unaccompanied by powdering or flaking of the surface.
- (e) Serious - When there is a heavy deposit of salts accompanied by powdering and/or flaking of surfaces and tending to increase with repeated wettings of the specimen.

CHAPTER 07

STONE WORK

7.0 Definitions

Ashlar

Stone masonry using dressed stone blocks of given dimensions having faces perpendicular to each other and laid in course, with fine joints not exceeding 5 mm thick.

Bed Joint

The joint where one stone presses on another for example, a horizontal joint in a wall or a radiating joint between the voussoirs of an arch.

Bond

An interlocking arrangement of structural units in a wall to ensure stability

Bond stone (through stone)

Selected long stones used to hold a wall together transversely.

Corbel

Cornice See chapter 6

Courses

Cramp

A small piece of metal or the hardest or toughest stone procurable, sunk in mortices and fixed across joints as additional ties. The ends of metal cramps are bent at right angles and stone cramps are dovetailed.

Dowels

Dowels are small section of metal, stone or pebbles bedded with mortar in corresponding mortice in bed or side joint of adjacent stones.

Hammer Dressing

Rough surfacing to a stone by means of a spall hammer.

Jamb

See Chapter 6

Natural Bed

The plane of stratification that occurs in sedimentary rocks.

Parapet

Quoin See chapter 6

Random

Of irregular size and shapes

Reveal

See chapter 6

Rubble Masonry

Masonry built of stones either irregular in shape as quarried or squared and only hammer dressed and having comparatively thick joints. Stones for rubble masonry are as far as possible, angular.

String course

See chapter 6

Template or bed block

See chapter 6

7.1 Cabook Work

Cabook for masonry shall be of the best quality and obtained from an approved source. This shall be regular in size true in shape and cut to standard sizes of at least 365 x 125 x 125 mm and shall be thoroughly seasoned before using for masonry.

All cabook masonry shall be in lime mortar, 1 lime, 2 1/2 sand, unless otherwise specified.

7.2 Random Rubble Masonry

Random rubble masonry work shall be constructed as follows:

- Provide one bond or through stone per 0.5m² of wall surface.
- Chips shall not be greater than 20% of the quantity of stone masonry.

- Plastered face bushing shall not be greater than 10.
- Exposed face bushing shall not be greater than 40.
- Width of all joints in the face of the random rubble masonry walls shall not be more than 25mm.

7.2.1 Materials

7.2.1.1 Stone

Stone shall be of the type specified. It shall be hard, sound, free from decay, weathering and defects like cavities, cracks, flaws, sand holes, veins patched of soft or loose materials etc. It shall be obtained from an approved quarry. Stone with a rounded surface shall not be used.

Samples

The contractor shall submit samples of stones representing the range of variations to be used in the work and obtain the approval (of appearance) from the officer - in - charge.

Size of Stone

Normally stones used shall be small enough to be lifted and placed by hand.

The lengths of the stone shall not exceed three times the height and the breadth on base shall not be greater than three - fourth of the thickness of wall (except for through stones) nor be less than 150 mm. The height of a stone may be 300 mm maximum.

Dressing

Stone shall be hammer dressed on the face, the side and the beds, to enable it to come into close proximity with the neighboring stone. The 'bushing' in the face shall not project more than 40 mm on an exposed face and 10 mm on a face, to be plastered.

7.2.1.2 Mortar

The mortar used for jointing shall be as specified and conform to requirements in Chapter 3.

7.2.2 Laying

All stones shall be clean and free of dust and shall be wetted before use. Chips, spalls etc. shall be washed clean with water to ensure a clean surface for the mortar to adhere to.

The stone shall be laid on their natural bed on a full even bed of mortar. Every stone shall be carefully fitted to the adjacent stones, so as to form neat and close joints. Stones may be brought to level courses at plinth, window sills and roof level. Leveling up at plinth level, window sills and roof level shall be done with concrete comprising one part of the mortar a used for the masonry and two parts of graded stone aggregate of 20 mm nominal size. The bond shall be obtained by fitting in the adjacent stones closely, and by using bond stones.

Face stones shall extend and bond well into the backing. These shall be arranged to break joints as much as possible and to avoid long vertical lines of joints.

The hearting or interior filling of the wall shall consist of rubble stones which may be of any shape but shall not pass through a circular ring of 150 mm inner diameter. The thickness of these stones in any direction shall not be less than 100 mm. These shall be carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar, chips and spalls of stone being used wherever necessary to avoid thick mortar beds or joints and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The hearting will be laid nearly level with facing and backing, except that at about one meter intervals, vertical 'Plums' projecting about 150 mm to 200 mm shall be firmly embedded to form a bond between successive courses.

The chips shall not be used below the hearting stone to bring these upto the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting, and these shall not exceed 20% of the quantity of stone masonry.

The wall shall be carried up truly plumb or to the specified batter. The masonry in a structure shall be raised uniformly. Where the masonry of one part has to be delayed, the work shall be raked back at an angle not steeper than 45°. Tothing in stonework shall not be allowed.

7.2.2.1 Bond Stones/Through Stones

A sufficient number of bond stones or through stones shall be used in building the wall. At least one through stone shall be built into the wall at intervals of 1.8 m horizontally and 0.6 meter vertically. Such stones shall be at least 150 mm square at the face and shall run through the full thickness of the walls upto 600 mm in thickness. In case of walls exceeding

600 mm in thickness more than one stone may be used to run through the full thickness of the wall with overlaps of not less than 150 mm.

In case of highly absorbent types of stones (porous lime stone and sand stone etc.) the bond stone shall extend about two-third into the wall. Through stones in such cases may give rise to damp penetration. Therefore, for all thicknesses of such walls, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided.

Where bond stones of suitable lengths are not available cement concrete blocks of 1:3:6 mix (1 cement : 3 sand 6 graded stone aggregate 20 mm nominal size) conforming to the sizes mentioned above shall be used.

All bond stones in stone masonry shall be marked suitably for identification as directed by the Officer-in-charge.

7.2.2.2 Quoins

The quoins shall be of selected stones neatly dressed with the hammer or chisel to form the required angle, and laid header and stretcher alternately. The quoins shall be set out and built up in advance of the main body of the rubble walling.

7.2.2.3 Joints

Stones shall be so laid that all joints are fully packed with mortar and chips. Face joints shall not be more than 20 mm thick.

When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of work, when the mortar is still green.

7.2.3 Scaffolding

Single scaffolding having one set of vertical supports shall be allowed. The supports shall be sound and strong, tied together by horizontal pieces over which the scaffolding planks shall be fixed. The inner end of the horizontal scaffolding member may rest in a hole provided in the masonry. Such holes, however, shall not be allowed in pillars under one meter in width or near the skew-back of arches. The holes left in masonry work for supporting scaffolding shall be filled with a proper sized stone and packed completely, or if allowed made good with cement concrete 1:3:6 (20mm).

7.2.4 Curing

Masonry work in cement or composite mortar shall be kept constantly moist on all faces for a minimum period of seven days. In the case of masonry with fat lime mortar curing shall commence two days after the laying of masonry and shall continue for at least seven days thereafter.

7.2.5 Protection

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

7.3 Coursed Rubble Masonry

7.3.1 Materials

7.3.1.1 Stone

Shall be as specified in 7.2.1

Size of Stone

Shall also be as specified in 7.2.1.1

Dressing

Face stones shall be hammer dressed in all beds and joints, so as to give them an approximately rectangular block shape. These shall be squared on all joints and beds.

The bed joint shall be rough chisel dressed for at least 80 mm back from the face, and side joints for at least 40 mm such that no portion of the dressed surface is more than 6 mm from a straight edge placed on it. The bushing on the face shall not project more than 40mm on an exposed face or 10 mm on a face to be plastered. The hammer dressed stone shall also have a rough tooling for a minimum width of 25 mm along the four edges of the face of the stone, when stone work is to be exposed.

7.3.1.2 Mortar

The mortar for jointing shall be as specified and conform to the requirement of Chapter 3.

7.3.2 Laying

All stones shall be clean and free of dirt and shall be wetted before use. They shall be laid on their natural bed on a full and even bed of mortar. The walls shall be carried up truly plumb or to the specified batter. All courses shall be laid truly horizontal and all vertical

joints shall be truly vertical. The height of each course shall not be less than 150 mm nor more than 300 mm.

Face stones shall be laid as headers and stretchers alternately. No pinning shall be allowed on the face. No face stone shall be less in breadth than its height and at least one third of the stones shall tail into the work for a length not less than twice their height or full thickness minus 150 mm whichever is less.

The hearting or the interior filling of the wall shall consist of stones carefully laid on their proper beds in mortar, chips and spalls of stone being used where necessary to avoid thick beds of joints of mortar and at the sometime ensuring that no hollow spaces are left anywhere in the masonry. The chips shall not be used below the hearting stone to bring these upto the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10% of the quantity of stone masonry.

The masonry in a structure shall be carried up regularly but where breaks are unavoidable, the joints shall be raked back at an angle not steeper than 45°. Toothing shall not be allowed.

7.3.2.1 Bond Stones

These shall be as specified in 7.2.2.1 and a bond stone or a set of bond stones shall be inserted 1.5 to 1.8 meters apart, in every course.

7.3.2.2 Quoins

The quoins shall be of the same height as the course in which these occur. These shall be at least 450 mm long and shall be laid stretchers and headers alternately.

These shall be laid square on the beds, which shall be rough-chisel dressed to a depth of at least 100 mm. In case of exposed work, these stones shall have a minimum of 25 mm wide chisel drafts at four edges, all the edges being in the same plane.

The quoins shall be set out and built up in advance of the main body of the rubble walling.

7.3.2.3 Joints

All bed joints shall be horizontal and all side joints vertical. All joints shall be fully packed with mortar and face joints shall not be more than 10 mm thick.

When plastering or painting is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise, the joints shall be raked to a minimum depth of 20 mm by a raking tool during the progress of work when the mortar is still green.

7.3.3 Curing and Scaffolding

Those shall be as specified under 7.2

7.4 Ashlar Masonry

This is a fine chisel dressed or sawn stone work built to very close tolerances and shall be built only by masons specially skilled in this type of work.

For detailed specifications on Ashlar masonry refer Indian Standard 1597 pt. II Code of Practice for construction Ashlar Masonry.

7.5 Stone Veneering Work

Stone lining up to 80 mm shall be treated as stone veneering work and lining of greater thickness as plain Ashlar Masonry.

In this work, the stones are cut into slabs of required thickness along planes parallel to their natural bed, dressed to very close tolerances, laid and secured to the backing masonry of brickwork or other work by cramps of adequate design and with high resistance to corrosion.

For detailed specification see Indian Standards 4101 Pt. I stone facing.

CHAPTER 08

WOOD WORK

8.0 Definitions

General

Conversion

The process of sawing timber from the log.

Hardwood

Conventionally, the timber of broad-leaved trees belonging to the botanical group-Angiosperms.

Softwood

Conventionally, timber of coniferous trees belonging to the botanical group Gymnosperms. Commercial timbers of this group are practically confined to the class Coniferae or conifers.

Structural Timber

Timber used in framing and load-bearing structures where strength is the major factor in selection and use.

Veneer

A thin sheet of wood produced by rotary-cutting or slicing.

Seasoning and Conditioning

Oven Dry

A state of timber when it does not less moisture when placed in a ventilated oven at $(103 \pm 2)^{\circ}\text{C}$.

Seasoning/Drying

The process of drying timber to a moisture range appropriate to the conditions and purposes for which it is to be used.

Air Seasoning

The process of drying timber by exposure to natural atmospheric conditions.

Kiln Seasoning

The process of drying timber in a kiln.

Defects, Blemishes and Imperfections

Blemish

Any features that mars the appearance of timber or other product without affecting its technical quality.

Bow (Camber)

A curvature of a piece of timber in the direction of its length.

Cup (Ping)

A curvature occurring in the cross section of a piece.

Decay / Rot

Decomposition by fungi and other micro-organisms resulting in softening, progressive loss of strength and weight and often a change of texture and color.

Decay / Fault

Any feature that lowers the technical quality or commercial value of timber or other material and may therefore lead to its rejection or to its relegation to a lower grade.

Dry Rot

A type of decay of timber in buildings, caused by the true dry rot fungus, *Merutius lacrymans* (a brown rot).

Imperfection

Any feature that mars the appearance or lowers the technical quality of timber or other product, but does not make it unacceptable in relation to the relevant specification or grading rules or make it unacceptable for its immediate purpose where there is no specification or rule on which to base a decision.

Knot

A portion of a branch enclosed in the wood by the natural growth of the tree.

Shake

A separation of the fibers along the grain due to stresses developing in the standing tree, or in felling or in seasoning.

Split

A separation of the fibers along the grain forming a crack or fissure that extends through the piece from the surface to another.

Termite Damage

Damage characterized by irregular honey combing or wide channels; bore-dust (frass) is usually present; that of the subterranean termite is cemented together with mud, whereas the bore-dust of drywood termites is granular and dry. The damage may affect standing trees, logs or stored timber mostly when in contact with the ground; it occurs mainly in tropical climates.

Twist/Winding

Spiral distortion.

Warping

Distortion in converted timber causing departure from its original plane, usually developed during seasoning.

Balanced Construction

A construction such that the forces induced by changes in moisture content will not cause warping. In practice this means that corresponding veneers or layers on either side of the centre line are of the same species and thickness and are laid with the grain in the same direction.

Blackboard

A composite board having a core made up of strips of wood each not more than 30mm wide, laid separately or glued or otherwise joined together to form a slab to each side of which is glued one or more outer veneers with the direction of the grain of the core strips running at right angles to that of the adjacent veneers.

Core

The inner layer or layers of a piece of plywood, batten board blackboard or laminated board.

Face

The surface of plywood, battenboard, blackboard or laminated board by which the grade or quality is chiefly judged.

Where both surfaces are of the same quality both are described as faces.

Faced Plywood

Plywood faced with a material other than wood e.g. metal or plastics.

Gluing/Bonding

The process of uniting by means of an adhesive, two or more pieces of wood. When used without qualification the term implies a process characterized by continuity of the union over the whole area of contact.

Laminated Wood

An assembled product made up of layers of wood and adhesives in which the grain of adjacent layers is parallel.

Ply

An individual layer in plywood. Usually a ply is a single veneer.

Plywood

A product of balance construction made up of plies assembled by gluing; the chief characteristic is the crossing of alternate plies to improve the strength properties and minimize movement in the plane of the board.

Multi-Ply

Plywood formed of more than three plies.

Veneered Plywood

Plywood faced with a decorative wood veneer.

Fiber Building Board

Fiber building board sheet material usually exceeding 1.5 mm in thickness manufactured from fibers of lignocelluloses material with the primary bond derived from the felting of the fibers and their inherent adhesive properties. Bonding, impregnating or other agents may be added during or after manufacture to modify particular properties of the board.

Hardboard

See standard hardboard and tempered hardboard.

Wood Chip Board and other Particle Boards**Particle Board**

Panel material manufactured under pressure essentially from particles of wood and/or other ligno-cellulosic fibrous material (for example, woodchips, sawdust, flax chivers etc.) with or without the addition of an adhesive, hydraulic binders being excluded.

Wood Chipboard

Particle board made from particles of wood bonded with synthetic resin and/or other organic binder.

Carpentry

Permanent carpentry other than roofs.

Boarding

Wooden covering to a floor, wall, roof etc.

Carcassing Timber/Framing Timber.

Timber used in the structural work of a building.

Cleat

A block fixed to a main member to provide a bearing or to resist a thrust.

Laminated Member

A solid member built up of comparatively thin boards connected together by nails, screws, bolts connectors or adhesives.

Match boarding

Tongued and grooved boarding with a 'V' or beaded (see bead) edge.

Roofs

Laminated Roof Truss

A roof truss in which the members are built-up from several thicknesses nailed or bolted together at their intersections.

Sprocket

An additional piece fixed to the top or side of rafter at the eaves to give an inclination less than that of the roof.

Verge

The overhanging edge of the roof covering at a gable.

Joinery

Architrave

Moulding or fillet round an opening fixed to the face to cover the joint between joinery and the adjoining work.

Doors

Flush Door

A door having two plane faces which entirely cover and conceal its structure.

Framed And Ledged Door

A door having rails and stiles framed together and filled in one face with vertical boarding of lesser thickness than the surrounding framing. The vertical boarding overruns the middle and bottom rails which are of less thickness than the top rail and stiles.

Framed Ledged And Braced Door

A framed and ledged door fitted with diagonal brace or braces.

Ledged Door

An unframed door composed of vertical boards fixed to horizontal ledges.

Ledged and Braded Door

An unframed door composed of vertical boards fixed to horizontal ledges and diagonal brace or braces.

Paneled Door

A door having stiles, rails and (some-time) muntins framed together with the space filled in with panels.

Grounds

A sawn or wrought member on which another finishing for example a skirting, is fixed.

Lipping

A strip of wood or other material applied to the edge of a flush door, table top, etc.

Mortice

A hole or slot to receive a lock.

Note :- This term applies only when the lock is let in from the edge into the middle of the thickness of the member, not when it is recessed from one face of the member.

Moulding

1. A contour cut upon a member for ornament.
2. A moulded member.

Mullion

An intermediate vertical member of a window frame, door frame or similar structure.

Muntin

An intermediate framed vertical member of a paneled door or other piece of framing.

Nosing

The projecting edge of a tread or board, often rounded.

Panel

A filling to a space surrounded by framing.

Rail

A framed horizontal member of a sash, door or other such piece of framing.

Rebate

A step-shaped reduction formed on the edge of a member.

Stile

A framed vertical outer member of a door or sash.

Aclosing stile - The stile of a door or sash which

Locking stile - closes against the jamb or mullion

Striking stile - of the surrounding frame and against which the opening appears when the door or sash is opened.

Hanging stile

A stile by which a door or sash, is hung.

Meeting stile

The abutting stiles of a pair of doors or sashes.

Transom

An intermediate horizontal member of a window frame door frame or similar structure.

Wrot

Planned on one or more surfaces.

joints used in carpentry and joinery.

Built Joint

a plain square joint between two members.

Cogged Joint

A joint where one member is supported upon another which it crosses, with part of its width housed into the other.

Combed Joint or Corner Locked Joint or Laminated Joint

An angle joint in which the parts of the meeting sections of the respective members are cut away so that the remaining projections on each fit into the slots formed in the other.

Dovetail

A splayed shape cut in the end of a member where it is joined to another, wider at the extreme end than at the shoulder, so that when fitted into a recess of corresponding shape it will resist withdrawal by tension in the direction of its length.

Dowel

A cylindrical piece of wood used for positioning and fixing one member to another.

Finger Joint

A heading joint, joined by interlacing tapered projections on the ends of members.

Key

1. A wedge passing through a hole in a projecting tenon.
2. A piece of wood inserted in a joint to prevent movement between adjacent surfaces.

Keyed Joint

A joint that is located or secured by a key. Keys are used in various types of joints such as keyed tenons, keyed scarged joints, keyed heading joints, keyed lapped joints etc.

Lapped Joint

A joint in which one member overlaps the other, and is secured by nails, bolts, adhesives, or other means.

Mitred Joint

A built joint between two members meeting at an angle with the respective ends cut to complementary angles.

Mortice

A hole or slot to receive a tenon of corresponding size which may or may not penetrate the full width or thickness of the member in which it is formed.

Mortice and Tenon Joint

A joint in which a tenon on the end of one member is fitted into a mortice cut in the other member.

Notched and Cogged Joint

A joint in which a notched member is supported by another member in which a cog has been formed.

Tenon

A projection at the end of a framed member, of lesser cross section than the member, intended to fit into a corresponding mortice in the other member to which it is thereby joined.

8.1 Materials

8.1.1 Timber

General

Timber for constructional purposes shall be of the specified species and of the best quality, thoroughly seasoned, sawn square, and free from sap, shakes, cracks and waney edges. It shall be free from decay and insect attack. It shall not contain loose or dead knots and other defects. Sound knots if they exist, shall be of such size and location as will be permissible for the relevant structural or joinery work.

The species recommended for use by the Forest Department are given in Appendix 8 A. Where a choice of more than one species is allowed, only one variety shall be used for any particular class of work.

The density of timber used for building purposes should not, in general, be less than 640 kg/m³ (40 lb/ft³) at 12% moisture content.

In general, the quality of building timber shall conform to BS 5268. The sizes of structural and non-structural timber components shall be as specified.

Any timber brought to the site, which in the opinion of the Officer-in charge does not conform to the required standard shall be rejected and shall then be removed from the site by the contractor at his own cost within 24 hours of notice to do so.

Tolerances

The tolerance for dimensions of timber both sawn (unplaned) and finished (planed) shall conform BS 5268 which is reproduced below:-

a. Sawn (unplanned)

| Nominal dimension (mm.) variation | Maximum permissible (mm) | |
|--------------------------------------|-----------------------------|-----|
| | | |
| Upto 25 | - 0 | + 2 |
| Over 25 to 50 | - 2 | + 3 |
| Over 50 to 150 | - 3 | + 6 |
| Over 150 | - 6 | + 6 |

b. Finished (planed)

| Nominal dimension (mm.) | Maximum permissible variation (mm) | |
|-------------------------|---------------------------------------|-----|
| | | |
| Upto 25 | - 0 | + 1 |
| Over 25 to 50 | - 1 | + 2 |
| Over 50 to 150 | - 2 | + 3 |
| Over 150 | - 3 | + 3 |

Grain Slope

In structural timber, the slope of the grain shall not exceed 1 in 8. Slope shall be measured over the worst face and over a distance of not less than 200mm.

For timber to be used for door and window frames and shutters, the slopes shall not exceed 1 in 8. In paneling however, sloping grain may be permitted to any extent.

8.1.1.1 Moisture Content and Seasoning of Timber

Timber seasoned under controlled conditions shall be used, as green timber is liable to shrinkage and warping and is easily affected by wood destroying and sap-staining fungi.

The moisture content of the timber at the time of fabrication shall be within 3% of the moisture content likely to be attained by the timber in service.

Seasoning of green timber in air, kiln or both, shall conform in all respects to BS 5268. Seasoning techniques shall be such that seasoning defects like end splits, surface cracks warping etc. are minimized. The moisture content of air seasoned timber shall be not more than 15% and that of kiln seasoned timber not more than 12%.

8.1.1.2 Preservative Treatment

Special preservative treatment such as Pressure Diffusion, vacuum or immersion treatment shall be carried out where necessary in consultation with the Forest Department. Guidance may be obtained from BS 5268 : Part 5 for structural timbers and BS 5589 for joinery work.

Unless otherwise specified, all parts of wood work resting on or set in masonry, shall be painted with two coats of hot tar which shall be applied without disfiguring exposed faces. 40 mm wide recesses shall be left for free circulation of air around the ends of all beams, and the recesses protected with perforated zinc sheet.

Timber buried in the ground shall be tarred. No timber shall be tarred, oiled or painted before inspection and approval by the Officer-in charge.

8.1.2 Adhesives

Adhesives used for joinery work shall conform to one of the following :

| | |
|-----------|--|
| B.S. 745 | Animal glues for wood |
| B.S. 1444 | Cold setting casein glue for wood |
| B.S. 1203 | Synthetic resin adhesive (phenolic and aminoplastic for plywood) |
| B.S. 1204 | Synthetic resin adhesive (phenolic and amino plastic for wood) |

For structural gluing one of the latter three glues shall be used as specified.

Regarding storage, mixing and use of adhesives, the instructions of the manufacturer shall be followed.

8.1.3 Fasteners

Wire Nails

Wire nails (oval, chequered head, lost head, round or panel pins) shall conform to the following standards.

Steel nails - BS 1202 : Part I

Copper nails - BS 1202 : Part II

Where not specified, the gauge of the nails shall be suited to the timber being used and their length shall give a sound and secure fixing. Nails or screws used with reactive timbers shall be of nonferrous metal.

Nails used in wood work likely to be subjected to moist conditions (as in the case of external work) shall have the specified protective coating.

Wood Screws

These shall be made of steel wire or brass wire and shall conform to BS 1210. The finish (oxidized, anodized, galvanized etc.,) shall be as specified.

Coach Screws

These shall conform to BS 1494 Part 2. The finish shall be as specified.

Black Bolts, Screws And Nuts

These shall conform to BS 4190 with the specified finish.

Washers

These shall be made of steel or brass and shall conform to CS 238 or BS 4320.

Steel Gussets

These shall be manufactured to the profiles shown on the drawings and made from steel plates conforming to BS 4360. Thickness of plates and the finish shall be as specified.

Mild Steel Connectors

These shall conform to BS 1579

Other Fixing Devices

Expanding bolts and nuts, joist hangers, framing anchors, tie down straps, anchor bolts etc. shall be as specified in respect of materials, size, gauges and the finish.

Plugs

These shall be of durable timber like teak of specified sizes.

Dowels

These shall be Mild Steel rods of 16 mm diameter and of adequate length.

Holdfasts

These shall be of mild steel flats 25 mm x 6 mm x 250 mm long, turned up and with 2 Nos. 3mm holes drilled at one end, and finish tailed at the other end.

8.1.4 Plywood, Hardboard, Block Board, Chip Board etc.

These shall conform to the relevant British Standards as noted below:

- | | | |
|--------------------------------|---|------------------|
| 1. Plywood for general purpose | - | BS 1455 |
| 2. Plywood for exterior use | - | BS 1455 bonding |
| W.B.P. (Grade 1 | - | where varnished, |
| Grade 2 | - | where painted, |
| Grade 3 | - | where hidden. |
| 3. Block board | - | BS 3444 |
| 4. Wood chipboard | - | BS 5669 |
| 5. Hard board | - | BS 1142 |

8.2 Structural Timber and Timber Roof Work

General

Structural timber and timber roof work shall be fabricated in accordance with detailed drawings and shall generally conform to BS5268 : Part 2 in regard to workmanship.

The contractor shall provide details of the work as necessary to help ensure co-ordination with related building elements and services. He shall provide fabrication/installation drawings and obtain approval before starting fabrication. Where directed he shall provide samples for intended connection before commencing actual fabrication.

Proprietary products shall be used to manufacturers' recommendations.

Fabrication

The sizes of timber sections unless otherwise stated are basic (nominal) sizes. Tolerance on sizes shall be as per Section 8.1

All timber shall be sawn, planed, drilled or otherwise machined to the correct size and shape in accordance with drawings and specifications. Dimensions and spacings shall not be scaled from the drawings. Pieces damaged by splitting or bruising shall not be used.

Mating and bearing surfaces shall be finished to ensure close contact over the whole area. These surfaces shall have a good sawn or planed finish and treated with the specified preservative. Bearing surfaces of notches and other cuttings shall be true and smooth and in appropriate relation to the other surfaces of the piece.

8.2.1 Joints

8.2.1.1 Nailed Joints

Wire nails shall be of the gauge shown in the drawings and at least 20 mm. longer than the full thickness of the assembly to be secured; the projecting portion shall be clinched over at right angles to the grain to resist withdrawal.

All nails shall be soaked in hot boiled linseed oil and allowed to drain immediately before fitting. All nails shall be driven, unless the nails are of large gauge or the timbers are likely to be split in which case holes shall be drilled in one operation through all the members held in position. The holes shall be approximately 20 percent smaller in diameter than the nails.

8.2.1.2 Screwed Joints

Lead holes shall be used in making screwed joints; the diameter of the hole for the shank shall be equal to the diameter of the shank; for the threaded portion, the diameter of the hole shall not exceed the diameter of the root of the screw thread adjacent to the shank defined in clause 42.1 of BS 5268 : Part 2. Care shall be taken to avoid placing screws in an end split.

8.2.1.3 Bolted Joints

Bolt holes shall be drilled to diameters as close as possible to the nominal diameter of the bolt but not more than 2 mm larger than the bolt diameter. Care shall be taken to

avoid placing a bolt in an end split. At least one complete thread shall protrude from the nut.

A washer shall be fitted under the head of each bolt and under each nut. The minimum sizes of washers are given in the Table 8.1 below:

| Diameter of bolt washed | Minimum thickness of washer | Minimum side of square or dia. of washer |
|----------------------------|--------------------------------|---|
| mm | mm | mm |
| 9.5 | | |
| 12.7 | 3 | 51 |
| 15.9 | | |
| 19.0 | 5 | 64 |
| 22.2 | | |
| 25.4 | | |
| 28.6 | | |
| 31.8 | 6 | 76 |

Structural connections using steel plates. Split rings etc. shall be as per BS 5268 : Part 2.

Note :- Laminated Roof trusses

Unless otherwise specified, all members of laminated roof trusses shall be connected with wire nails with a washer at each end of the nails.

8.2.2 Preservative Treatment of Cut Surface

Cutting of timber after preservative treatment shall be avoided. However, when it is unavoidable, a liberal application of preservative shall be made to the cut surfaces.

8.2.3 Assembly of Structural Units

Assembly of structural units shall be done on a level bed and in such a way as to avoid damage to any of the members. The finished structural units shall conform to drawings and specifications. Twisted or damaged members shall be replaced before erection on the site.

Before proceeding with bulk production, a complete assembly of each type of framed truss or other structural unit shall be checked for accuracy. A similar check shall be carried out from time to time to control the wear and tear on templates and gauges.

Timber members of built up units shall be marked in accordance with a marking diagram.

8.2.4 Storage

Timber components shall not be exposed to high humidity and all materials and assemblies shall be protected against exposure to the weather, wetting, damage, decay and insect attack.

8.2.5 Painting

Where painting of the timber is specified, all parts of assemblies or individual pieces shall be protected with a priming paint complying with BS 2521 or BS 2522 and one undercoat before one undercoat before leaving the factory.

Steel components other than bolts, connectors and washers shall be thoroughly cleaned to remove all loose scale and rust and painted with one coat of genuine red lead paint before dispatch to the site.

8.2.6 Transport

All materials and assemblies shall be protected from the weather, and suitable measures shall be taken to protect the surfaces during hoisting and fixing.

8.2.7 Handling, Hoisting and Fixing

The over-stressing of members during handling shall be avoided. In the case of framed arches, portal frames, trusses etc. special care shall be taken to avoid distortion in hoisting from the horizontal to the vertical position. Where lifting points or methods of lifting are not indicated on the drawing guidance shall be sought from the Officer-in-charge. On completion of erection, all joints shall be inspected and care taken to ensure that all bolts are tightened without crushing the wood under the washers.

8.2.8 Testing and Acceptance

When testing of a timber structure or component becomes necessary due to doubt about the adequacy in designing, quality of material, etc. the test and acceptance criteria shall be as per Section 8 of BS 5268 : Part 2.

8.3 Joinery

General

Joinery work shall consist of the manufacture, delivery to the site and fixing in the building of all joinery described in the specification and shown on the drawings including the supply and fixing of -

- (a) Metal straps, lugs and dowels
- (b) Priming and application of preservative
- (c) All iron mongery specified or shown in the drawings.

The joinery work shall be of the workmanship conforming generally to BS 1186 : Part 2.

The joinery work shall be completed ready for the respective finishes.

8.3.1 Dimensions

All wrot timber is to be sawn, planed, drilled or otherwise machined or worked to the correct sizes and shapes shown in the drawings or specified. Tolerance on timber sizes shall be as per Clause 8.1.1

8.3.2 Exposed Faces

All timber that is to be exposed in the finished surfaces of joinery works shall be wrot on the appropriate faces unless otherwise specified.

8.3.3 Natural Finish

When natural finish or finish for staining, clear polishing, or varnishing is specified, the timber in adjacent pieces shall be matched for color and grain. The surface finish shall be as specified.

8.3.4 Shrinkage

The arrangement, jointing and fixing of joinery works shall be such that shrinkage in any part and in any direction shall not impair the strength and appearance of the finished work, and shall not cause damage to contiguous materials or structures.

8.3.5 Fabrication

All necessary mortising, tenoning, grooving, matching, tonguing, housing, rebating, and all other works necessary for correct jointing, shall be in conformity with BS 1186. All metal plates, screws, nails and other fixing that may be directed by the Officer-in charge or that may be necessary for the proper execution of the joinery works specified shall be the responsibility of the contractor. All works necessary for the proper construction of all framings, linings, etc and for their support and fixing in the building shall be carried out to approval.

8.3.6 Joints

The joinery shall be constructed as shown in the detail drawings. Where joints are not specifically indicated they shall be the recognized forms of joints for each position. The joints shall be made so as to comply with BS 1186: Part 2. Glued joints shall be used where provision need not be made for shrinkage or other movements in the connections, and where sealed joints are required. All glued joints shall be cross-tongued or otherwise reinforced. All nails, springs, etc. shall be punched and puttied. Surfaces in contact shall have a good sawn or planed finish. All cutting edges of tools shall be sharp to avoid burnishing. The surface of plywood to be glued shall be lightly dressed with sand or glass paper. The sand or glass paper must not be allowed to clog and cause burnishing.

Members to be joined by gluing are to be of similar conversion. All surfaces to be glued shall be kept clean, free from dirt, dust, sawdust, oil and any other contamination. Adequate pressure shall be applied and maintained whilst the glue is setting.

8.3.7 Moulding

All moulded work shall be accurately worked to the full size details shown in drawings. All mouldings shall be worked on the solid timber except where otherwise stated.

8.3.8 Bent Work

Where bending is specified, the work shall be performed by saw-kerfing, keying, backing-a-veneer, laminating or steaming and shall be carried out to the satisfaction of the officer-in charge.

8.3.9 Circular Work

When circular work is specified, it shall be built up with an appropriate number of pieces out to the required shapes. The pieces shall be put together in two (or three) thicknesses so that they break joint, and shall be secured with hardwood keys and wedges or with hardwood pins (whichever is more appropriate).

8.3.10 Veneering

This shall be carried out in an approved manner, and to the entire satisfaction of the architect.

8.3.11 Scribing

All skirtings, architraves, plates and other joinery works shall be accurately scribed to fit the contour of any irregular surface against which they may be required to form a close but connection.

8.3.12 Weathering

All weathering surfaces, throatings, grooves and joints, etc. and all open connections in external joinery works shall be properly executed so as to provide a reasonable degree of weather resistance.

All reasonable measures shall be taken to check or prevent capillary penetration of water in the joints and open connections of external joinery works, and in all other positions where joinery works may be exposed to water.

8.4 Door and Window Frames

General

The frames shall be wrot, framed and fixed in position as specified in drawings. The scantling of specified timber, shall be planed smooth and accurate to the dimensions shown in drawings. Rebates, roundings, and mouldings shall be made before assembly patching or plugging of any kind shall not be permitted except as specified. Tolerance on sectional dimensions of timber shall

In general joinery work shall conform to requirements of Section 8.3

8.4.1 Joints

These shall be of mortice and tenon type, simple neat and strong. Tenons shall be formed on the posts of frames. Mortice and tenon joints shall fit in fully and accurately without wedging or filling. The joints shall be glad and the frames put together and kept pressed in position by means of a press and pinned with hardwood pins of at least 10 mm diameter.

8.4.2 Surface Treatment

Wood work shall not be painted, oiled or otherwise treated before it has been approved by the Officer-in charge. All portions of timber abutting against masonry or concrete or embedded in ground shall be painted with approved wood primer or preservative.

8.4.3 Fixing in Position

Before fixing, the backs and ends of frames shall be coated with 2 coats of boiling tar or solignum. When frames are to be built into masonry these shall be braced and protected as necessary to prevent distortion and damage during construction of the brick-work.

The frames shall be positioned accurately, plumbed, leveled and aligned as necessary. The timber frames, unless otherwise specified, shall be fixed at centres not exceeding 600 mm with at least one fixing located 150 mm from each end of jambs and one adjacent to each hanging point of doors/window shutters. Generally at least 3 fixings per side of each door frame and 2 fixings per side of each window frame shall be provided. The fixing device shall consist of a hold fast as described in Clause 8.1.3 embedded in concrete, or stout steel screws driven into hard wood plugs embedded in the walls, or other approved cramps of a suitable design.

The feet of all door frames and posts shall not be buried into the concrete floor but shall be fitted to specially cast cement spur block projecting above the floor. 16 mm dia iron dowels shall be provided connecting the spur stone and the frame. The spur stone shall be such that the architraves if any, and the coved floor finishes shall be accommodated producing a neat clean finish with no corners which can hold dust or vermin.

8.5 Sashes for Doors, Windows, Fanlights Etc.

General

The specified timber shall be planed smooth and accurate to the full dimensions rebates, roundings mouldings shall be made before assembly. Patching or plugging of any kind

shall not be permitted except as specified. The sashes shall be wrot, framed and fixed in position as per detailed drawing and as directed by the Officer-in charge.

Note:- Joinery work for doors and windows etc. shall be started immediately after commencement of the building work. The components shall be stored clear off the floor in a dry and covered area allowing for free circulation of air. Pressing and securing of joints shall be carried out at the time of fixing frames or shutters.

(a) Joinery Work

All members of the door sashes shall be straight without any warp or bow, and shall have smooth well planed faces at right angles to each other.

The corners and edges of panels shall be finished as shown in drawings, and these shall be feather-tongued into stiles and rails. Sash bars shall have mitred joints with the stiles. Stiles and rails shall be properly and accurately mortised and tenoned. Rails which are more than 180 mm in width shall have to tenons. The thickness of each tenon shall be approximately one third the finished thickness of the members and the width of each tenon shall not exceed five time its thickness. The tenons shall pass through stiles for at least 3/4th of the width of the stile. Muntins and glazing bars shall be stubtenoned to the maximum depth which the size of the member would permit or to a depth of 25 mm, whichever is less. When assembling a leaf, stiles shall be left projecting as a horn. The stiles and rails shall have 12 mm grooves in the paneled portion for the panel to fit in.

The depth of rebate in the frames for housing the sashes shall in all cases be 12.5 mm; the rebate in the sashes, for closing in double sash doors or windows shall be less than 20 mm. In the case of double leaved sashes the meeting of the stiles shall be rebated 20 mm and the rebate shall be splayed.

In general, the joinery work shall conform to the requirements of Clause 8.3

The joinery work shall be assembled and passed by the Officer-in charge before the joints are presses and secured by hard wood or bamboo pins of about 6-10 mm diameter. The horns of stiles shall be sawn off.

(b) Gluing of Joints

The contact surfaces of tenon and mortice joints shall be treated before putting together with bulk type synthetic resin adhesive of a make approved by the Officer-in charge. Sashes shall not be painted, oiled or otherwise treated before they are fixed in position and passed by the Officer-in charge.

(c) Bending

Timber, plywood, hardboard and particle board panels shall be fixed only with grooves but additional beading may be provided either on one side or on both sides.

In so far as glass panels are concerned, beading shall always be provided without grooves. Where beading is provided without grooves the beading shall only on one side, the other side being supported by a rebate from the stiles.

For external doors and windows beading shall be fixed on the outside.

(d) Fittings

Fittings shall conform to the requirements of Chapter 10. Details of fittings shall be as specified.

(e) Wooden Cleats and Blocks

Wooden cleats and blocks shall be fixed to doors and windows as specified or as directed by the Officer-in charge. The size and shape of cleats and blocks shall be as approved by the Officer - in charge.

(f) Tolerance

A tolerance of ± 1.5 mm shall be allowed on heights and widths of sashes.

8.5.1 Ledged, Braced and Battened Sashes

The thickness of the doors shall be the thickness of the battens only and not the combined thickness of battens and braces.

Planks for battens shall be 75 mm to 100 mm wide and 20 mm thick unless otherwise specified. These shall be planed smooth and provided with rebated joints rebated at least 12 mm. The tolerance on sizes of battens ledges and braces shall conform to Sub Section 8.1.1.

Ledges and Braces

The battens shall be fixed together by 25 mm thick ledges and braces fixed to the inside face of door shutters with screws. The ledge shall be 175 mm wide and brace 125 mm wide unless otherwise specified. The braces shall incline downwards towards the side on which the door is hung. Edges and ends of ledges and braces shall be chamfered. Tee hinges shall be provided for these doors.

Wooden cleats, blocks and fittings shall be as specified.

8.5.2 Paneled, Glazed Or Paneled And Glazed Sashes

Paneling

The following types of paneling shall be used for door/window sashes as specified.

- (a) Plywood
- (b) Hardboard
- (c) Block board
- (d) Sheet glass

These shall conform to the relevant BS.

The panels shall be framed into grooves to the full depth of the groove, leaving an air space of 1.5mm and the faces shall be closely fitted to the sides of the groove. Mouldings to the edges of panel openings shall be scribed at the joints.

8.6 Wooden Floors

Wood floors and landings shall be of specified timber. These shall be 30mm thick unless otherwise specified, with grooved and tongued planks in equal widths not exceeding 150 mm, with well broken and splayed heading joints. They shall be fixed to the joints with 62 mm screws the heads shall be counter sunk and the holes filled with wax, two screws being used for each 150 mm plank wherever it crosses or ends be planed in both directions and made perfectly smooth and even. Where the underside of the floor is exposed the flooring is to be wrot on both side.

8.7 Skirtings, Picture Rails, Mouldings Etc.

All skirtings, picture rails, mouldings, and similar items shall include for all necessary grounds, backings or splayed fillets and for forming all mitres, scribing, fitted ends.

All such features shall be secured by screws driven in to holes fitted with rawl plugs or equivalent.

8.8 Wooden Stairs

- (a) All wood stairs unless otherwise specified shall be framed up in the timber specified and to the design and sizes shown in the drawings.
- (b) All stringers shall be framed and pinned to newels and wall stringers plugged to walls. The feet of newels on a concrete ground floor shall have special cast concrete blocks as described in Sub Section 8.4.3. On upper floors, the newel feet shall be notched to wood joists and /or R.S.J bearers in the concrete floor.
- (c) Where bull nose steps are shown, they shall be properly formed and the riser blocked, screwed, glued and wedged.
- (d) Handrails shall be framed and pinned to newels with all the bends, ramps and wreaths etc. required, and heading joints shall be framed with handrail screws.
- (e) Joinery work shall conform to the requirements of Clause 8.3 and shall be as specified. Handrails shall be French-polished. Other surfaces shall be stained/wax polished/decorated as specified. All finished surfaces shall be protected with rough timber or boarding until completion.

8.9 Shelving

All shelving shall be of the widths and thicknesses specified. Timber shelving shall normally consist of 25 mm thick boarding screwed to 100x50 mm timber brackets fixed to the wall at approximately 1.2 m centre.

Note :- The contractor's rate shall provide for treating both the top and bottom with two coats of approved wood preservative.

8.10 Trellis Work

8.10.1 Plain Trellis

This shall consist of wooden strips or laths 35x10 mm section, unless otherwise specified, planed and nailed together at every alternate crossing. The strips shall be spaced 35mm apart so as to form 35x35 mm openings, or as shown in the drawing. These shall be fixed

with nails to the frame. To cover the ends of strips, 50x12 mm beading shall be fixed to the frame with screws. Finished work with a tolerance of ± 1 mm may be accepted.

8.10.2 Trellis Door and Window Sashes

The sash frame shall consist of two styles and the top, lock and bottom rails, each of section 75x35 mm unless otherwise specified. The styles and rails shall be properly mortised and tenoned. The tenons shall pass through the styles for at least 3/4th of the width of the style. The sash and frame shall be assembled and passed by the Officer-in charge before jointing. The joints shall be pressed and secured by hard wood pins of about 6 mm diameter. To this frame, plain trellis work as described in Clause 8.10.1 shall be fixed as shown in the drawings or as directed by the Officer-in charge. The fittings, wooden cleats and blocks shall be provided as specified.

8.11 Pelmets

The sides, front and top of the pelmets shall be of 12 mm thick planks or boards of specified width unless otherwise stated.

These shall project from the wall face by 150 mm or as specified, and shall be securely fixed to walls with wood screws by means of wooden plugs and 100 mm long dia. 25 x 3 mm mild steel flats bent in the form of an angle or by any other device approved by the Officer in charge. The pelmets shall be provided with curtain rods and brackets or curtain rails with rollers, stop ends and brackets as specified. Intermediate wooden brackets shall be provided if the front length of pelments exceeds 1.5 meters.

8.12 Mild Steel Bars or Grills in Wooden Frames

These shall be of the pattern and details specified.

8.12.1 Fixing of Mild Steel Bars in Wooden Frames

Through holes shall be drilled in one frame, and 50 mm deep in the other frame. The bars shall be passed into the frame from one side and shall be of the correct length to fit in at one end and to end flush with outside of the frame at the other end.

Where there are mild steel flats provided along with the bars, these shall be fixed to the wooden frame with wood screws. Holes for passing M.S. bars shall be punched in the flats at proper positions.

8.12.2 Fixing of Steel Grills

The grills shall be fabricated as per design and fixed to the frame using round headed bolts and nuts in new work, and wood screws in the case of old work.

Appendix - 8A

Timber Species Recommended For Use In The Building Industry

(Issued by the Forest Department)

Brief, descriptions of the headings of the individual columns in the Table are as follows :

Column (1) - Common Name/s
S - Sinhala Name
T - Tamil Name
E - English Name

The Botanical name is given below the common names

Column (2) - Quality (Sup) - Superior quality : Timbers that are naturally durable and where the heartwood does not need preservative treatment.

(Ord) - Ordinary quality : Timbers that are moderately durable or nor-durable and where the heartwood needs preservative treatment.

Column (3) - Density at 12% m.c.
Densities at 12% moisture content (m.c.) are given in both 1bs/ft³ and kg./m³.
The latter units are given in parentheses.

Column (4) - Uses

Uses are denoted by asterisks as follows :-

- * - Suitable
- ** - Highly suitable

Column (18) - Treatability

Treatability with preservatives by pressure impregnation is given by:

- (A) - Easy to treat
- (B) - Moderately difficult to treat
- (C) - Difficult to very difficult to treat

Column (19) - Treatment

This is shown by:

(N) - Preservative treatment necessary

(D) - Preservative treatment desirable

(U) - Could be used without preservative treatment, but any sapwood present must be treated.

Column (20) - Remarks

This column gives the Zonal distribution, availability and suitability other than in the building industry.

Zonal distributions are denoted by :

WZ - Wet Zone, DZ - Dry Zone, IZ - Intermediate Zone, MZ - Montane Zone

Note :- STC stands for State Timber Corporation.

Appendix 8B

Table - B1

Imperial measure sizes most closely corresponding to the recommended Metric sizes of structural timber.

| Component | Standard Metric Sizes (Imperial size in inches) | Standard Metric Sizes (Imperial sizes in inches) |
|-------------------|--|---|
| Ridge Plates | 175 x 25 [7 x 1] | - |
| | 175 x 50 [7 x 2] | - |
| Rafters | 75 x 50 [3 x 2] | - |
| | 100 x 50 [4 x 2] | - |
| Wall plates | 100 x 75 [4 x 2] | - |
| | 100 x 75 [4 x 3] | - |
| | 50 x 50 [2 x 2] | - |
| | 75 x 38 [3 x 1 1/2] | - |
| | 100 x 50 [4 x 2] | - |
| | 125 x 50 [5 x 2] | - |
| | 150 x 50 [6 x 2] | - |
| | 175 x 50 [7 x 2] | - |
| Reepers | 50 x 25 [2 x 1] | - |
| (Battens) | 50 x 13 [2 x 1/2] | 200 x 22(8 x 7/8) |
| Eaves boards | 200 x 25 [8 x 1] | 200 x 19 (8 x 3/4) |
| (Valance Boards) | | - |
| Principal rafters | 125 x 25, 32 , 38 | - |
| | (5 x 1, 1 1/4, 1 1/2) | - |
| | 150 x 25, 32, 38, 50 | - |

| | | |
|-----------------|--------------------------|---|
| Tie beams | (6 x 1, 1 1/4, 1 1/2, 2) | - |
| | 175 x 25, 32, 38, 50 | - |
| | (7 x 1, 1 1/4, 1 1/2, 2) | - |
| | 125 x 25, 32, 38 | - |
| | (6 x 1, 1 1/4, 1 1/2) | - |
| | 175 x 25, 32, 38 | - |
| | (6 x 1, 1 1/4, 1 1/2) | - |
| | 175 x 25, 32, 38 | - |
| Braces | (7 x 1, 1 1/4, 1 1/2) | - |
| | 75 x 50 (3 x 2) | - |
| | 100 x 50 (4 x 2) | - |
| Ceiling bearers | 100 x 50 (4 x 2) | - |
| | 75 x 50 (3 x 2) | - |
| | 50 x 50 (2 x 2) | - |

Table - B2

Imperial measure sizes most closely corresponding to the recommended Metric sizes of non-structural timber.

| Component | Standard Metric Sizes (Imperial size in inches) | Standard Metric Sizes (Imperial sizes in inches) |
|-------------------|--|---|
| Ceiling boards | 115 x 22 [4 1/2 x 7/8] | 100 x 19 (4 x 3/4) |
| | 150 x 16 [6 x 5/8] | 140 x 13 (5 1/2 x 1/2) |
| Ceiling beadings | 38 x 13 [1 1/2 x 1/2] | - |
| | 50 x 13 [2 x 1/2] | - |
| Cornice mouldings | 50 x 50 [2 x 2] | - |
| Window frames | | |
| Jambs & Heads | 100 x 50 [4 x 2] | 95 x 44 (3 3/4 x 1 3/4) |
| | 100 x 63 [4 x 2 1/2] | 95 x 57 (3 3/4 x 2 3/4) |
| Mullions | 100 x 63 [4 x 2 1/2] | 95 x 60 (3 x 2 3/8) |
| Sills | 125 x 50 [5 x 2] | 120 x 44 (4 3/4 x 1 3/4) |
| | 125 x 63 [5 x 2 1/2] | 120 x 57 (4 3/4 x 2 1/4) |
| Stops | 40 x 16 [1 5/8 x 5/8] | 38 x 13 (1 1/2 x 1/2) |
| Window Sashes | 36 [1 x 3/8] thick | 32 x (1 1/4) thick |
| | 44 x [1 3/4] thick | 40 x 1 5/8) thick |

| | | |
|---------------|------------------------|-------------------------|
| Door frames | | |
| Jambs & Heads | 100 x 50 [4 x 2] | 95 x 44 (3 3/4 x 1 3/4) |
| | 100 x 63 [4 x 2 1/2] | 95 x 57 (3 3/4 x 2 1/4) |
| Stops | 40 x 16 [1 5/8 x 5/8] | 38 x 13 (1 1/2 x 1/2) |
| Door Sashes | 36 [1 3/8] thick | 32 (1 1/4) thick |

CHAPTER 09

METAL WORK

9.0 Definitions

Bead

A single run of weld metal deposited on a surface.

Butt Weld

A weld in which the weld metal lies substantially within the extension of the planes of the surfaces of the parts joined or within the extension of the planes of the smaller of the two parts of differing size. The edges of the metal pieces shall be bevelled or chiselled to the required shape at the throat.

Crater

A depression left in weld metal where the arc was broken or the flame was removed.

End Crater

A crater at the end of a weld or at the end of a joint.

Fillet Weld

A weld of approximately triangular cross-section joining two surfaces approximately at right angles to each other in lap joint, tee joint or corner joint. It is of two types (1) Continuous, (2) Intermittent.

Fusion Welding

Any welding process in which the weld is made between metals in a state of fusion without application of pressure.

Fusion Penetration

- (a) In fusion welding - The depth to which the parent metal has been fused.
- (b) In spot, seam or projecting welding. - The distance from the interface to the edge of the weld nugget, measured in each case on a cross-section through the centre of the weld and normal to the surface.

Non Fusion Welding

A term applied to the deposition, by the Oxy-Acetylene process, of filler metal on parent metal without fusion of the latter.

Oxy-Acetylene Pressure Welding - Pressure welding in which an Oxy-Acetylene flame is used to make the surface to be united plastic. No filler metal is used.

Run

The metal deposited during one passage of the electrode or blow pipe in the making of a joint.

Throat Thickness

The minimum thickness of weld metal in a fusion weld measured as follows:

- (a) For a fillet weld or a V.U.J. or a bevel butt weld -
along a line passing through the roof.
- (b) For a close square-butt weld - In the plane of the abutting faces.
- (c) For an open square-butt weld - At the centre of the original gap in a plane parallel to the fusion faces.

Weld

A union between two pieces of metal at faces rendered plastic or liquid by heat or by pressure, or both. Filler metal may be used to effect the union.

Weld Metal

All metal melted and/or made plastic in making a weld and retained in the weld.

9.1 Materials

| Materials | Standards | Remarks |
|--|---------------|--|
| Hot rolled-Mild steel sections excluding angles and hollow sections. | BS 4 Part - 1 | To be hot rolled from weldable steel for structural purposes conforming to BS 4360 |

| | | |
|---------------------------------------|--------------------|--|
| Hot-rolled MS hollow sections. | BS 4848 - Part 2 | To be hot rolled from weldable steel for structural purposes conforming to BS 4360 - do - |
| Hot-rolled MS angles | BS 4848 - Part 4 | |
| M.S. bars | BS 4360 | |
| Steel tubes | BS 1775 | |
| M.S. Plates | BS 4360 | |
| Galvanized steel sheet | BS 2989 | |
| Steel plate & sheet | BS 1449 - Part 1 | |
| Stainless Steel - Tubes | BS 3014 | |
| Stainless Steel (plate, sheet & Strip | BS 1449- Part 2 | |
| Aluminum alloy | BS 1161 or BS 1474 | |
| Extruded section | | |
| Drawn tube | | |
| Plate, Sheet & Strip | BS 1471 | |
| Copper alloy | BS 1470 | |
| Sections | BS 2874 | |

| Materials | Standards | Remarks |
|---------------------|------------------|---------|
| Tubes | BS 2871 : Part 2 | |
| Sheet, Strip & Foil | BS 2870 | |
| Plate | BS 2875 | |
| Fastenings | | |
| Wood screws - Iron | BS 1210 | |
| Wood screws - Brass | BS 1210 | |

| | |
|--------------------------------------|--------------------------------------|
| Bolts, screws & nuts | CS 97 |
| Rivets | BS 641 & VS 4620 or as specified. |
| Expanding bolts & nuts | As specified. |
| Plugs | - do- |
| Adhesives | - do- |
| Electrodes for manual arc welding | BS 639 |

Note 1: If steel supplied has not been manufactured by the Ceylon Steel Corporation, evidence to show that it conforms to the relevant British Standards shall be furnished to the officer-in charge to his satisfaction. For steel conforming to the Specifications for Structural Steel of any other country, the relevant specifications shall be forwarded to the Engineer for prior approval.

9.2 Fabrication and Erection - Shop work

9.2.1 Preliminaries

9.2.1.1 Quality of Work

Metal work shall be fabricated carefully and accurately to ensure compliance with design and performance requirements, using types and grades of metal as specified for the purpose. The finished work must be free from distortion and cracks. Proprietary products shall be used to the recommendations of the manufacturers.

Steel work shall be fabricated and erected by competent, experienced persons and shall generally conform to B.S. 449 - Part 2 - "Specifications for the use of structural steel in buildings".

9.2.1.2 Co-ordination

The work shall be carried out in co-ordination with the work on related building elements and services. The fabrication/installation drawings showing complete details of the work shall be furnished by the contractor well in advance for checking by the Officer-in charge necessary modifications shall be made and sufficient number of corrected copies shall be furnished to the concerned parties.

9.2.1.3 Samples

Where directed, the contractor shall furnish samples of the components and obtain approval for the same before proceeding with the fabrication.

9.2.1.4 Inspection

The officer in charge shall have access at all reasonable times to all places where the work is being carried out, and shall be provided by the contractor with all the necessary facilities for inspection during construction.

9.2.2 Shop Preparation

9.2.2.1 Straightness

All material before and after fabrication, shall be straight unless required to be of curvilinear form, and shall be free from twists.

9.2.2.2 Clearances

Care shall be taken to ensure that the clearances specified are adhered to. The erection clearance for cleared ends of members connecting steel to steel shall be not greater than 2 mm at each end. The erection clearance ends of beams without web cleats shall be not more than 3 mm at each end, but where for practical reasons this clearance has to be increased, the seating shall be suitably designed.

Where black bolts are used the holes may be made not more than 2 mm greater than the diameter of the bolts unless otherwise specified.

9.2.2.3 Cutting

Cutting may be shearing, cropping, sawing or machine flame cutting. Hand flame cutting may be adopted subject to the approval of the Officer in charge. If thermal cutting is permitted for plates which will be subjected to dynamic or fatigue loading, the edges shall be machined. In the case of highly stressed welded joints, thermal cutting shall be controlled to prevent excess hardening. Sheared or cropped edges shall be dressed to a neat workmanlike finish and be free from distortion where parts are to be in metal-to-metal contact.

9.2.2.4 Holing

Holes through more than one thickness of material for members such as compound stanchion and girder flanges shall where possible; be drilled after the members are

assembled and tightly clamped or bolted together. All matching holes for rivets and black bolts shall register with each other so that a gauge 2 mm less than the required diameter of hole will pass freely through the assembled members in a direction at right angles to such members.

Finished holes shall be not more than 2 mm larger in diameter than the diameter of the rivet or black bolt passing through them unless otherwise specified.

When holes are drilled in one operation through two or more separable parts, shall be separated after drilling and the burrs removed.

Punching may be permitted before assembly when the thickness of material punched is less than 15 mm. The holes punched shall be 2 mm less in diameter than the required size and reamed after assembly to the full diameter.

Holes in connecting angles and plates other than splices, as also in roof members and light framing, may be punched full size through material not over 12 mm thick. This shall not be permitted for close tolerance or barrel bolts.

Where a connection is subject to impact or vibration or to reversal of stress (unless such reversal is solely due to wind) or, where for some special reason such as continuity in rigid framing or precision in alignment of machinery, slipping of bolts is not permissible, then rivets, close tolerance bolts, high strength friction grip bolts or welding shall be used. Holes for close tolerance and barrel bolts shall be drilled to a diameter equal to the nominal diameter of the shank or barrel subject to a tolerance of +0.15 mm and -0 mm. Parts to be connected with close tolerance bolts or barrel bolts shall preferably be firmly held together by tacking bolts or clamps, the holes drilled through all the thicknesses in one operation and subsequently reamed to size. All holes not drilled through all thicknesses in one operation shall be drilled to a smaller size and reamed out after assembly. Where this is not practicable the parts shall be drilled and reamed separately through hard bushed steel jigs.

Holes for rivets or bolts shall not be formed by a gas cutting process.

9.2.2.5 Flattened Ends of Tubes

For welded, riveted or bolted connections, the ends of tubes may be flattened or otherwise formed provided the methods adopted are such as not to injure or deface the material. The change of section shall be gradual.

9.2.3 Shop Assembly

The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged, and shall be so prepared that the specified cambers if any are provided.

All tubular members shall be sealed so as to prevent, the access of moisture to the inside of the members. (See also Clause 9.5.2)

9.2.4 Riveting

Rivets shall be heated uniformly throughout their length, without burning or excessive scaling, and shall be of sufficient length to provide a head of standard dimensions. They shall when driven, completely fill the holes and if countersunk, the countersinking shall be fully filled by the rivet, and proudness of the countersunk head being dressed off flush if required.

Riveted members shall have all parts firmly drawn and held together before and during riveting, and special care shall be taken in this respect of all single-riveted connections. For multiple riveted connections, a service bolt shall be provided in every third or fourth hole.

Wherever practicable machine riveting shall be carried out by using machines of the steady pressure type.

All loose, burned or otherwise defective rivets shall be cut out and replaced before the structure is loaded, and special care shall be taken to inspect all single-riveted connections.

Special care shall be taken in heating and driving long rivets.

9.2.5 Bolting

Bolts shall be of sufficient length to have at least one complete thread projecting beyond the outer face of the nut when tightened up.

Washers shall be provided in all cases. Where necessary, washers shall be tapered or otherwise suitably shaped to give the heads and nuts of bolts a satisfactory bearing.

In all cases where the full bearing area of the bolt is to be developed, the bolt shall be provided with a washer of sufficient thickness under the nut to avoid any threaded portion of the bolt being within the thickness of the parts bolted together.

Where a tubular member is drilled to take bolts or studs, provision shall be made to prevent the access of moisture to the interior of the tube. For example, a transverse sleeve can be inserted where a bolt passes through a tube or grommets can be used under the heads and nuts.

9.2.6 Welding

General

Steel shall normally be welded by the metal arc process conforming to B.S. 5135. Other methods shall be subject to the approval of the officer-in charge.

Welding of stainless steel, aluminum alloys, copper alloys, bronze etc. and brazing shall conform to the appropriate British Standard where specified, approval and testing of welders, and welding procedures shall be as per BS. 4870, BS 4871 and BS 4872. Surfaces to be welded shall be dry. When rain is falling off during periods of high wind, necessary precautions shall be taken to protect outdoor welding areas.

Welding shall be so carried out as to ensure that;

- (1) Welds will be of good clean metal deposited by a procedure which will ensure uniformity and continuity of work.
- (2) The surfaces of the weld will have an even contour and regular finish and will indicate proper fusion with the parent metal.

All slag shall be removed after making each run by light hammering followed by wire brushing.

Weld metal shall not be allowed to spatter on surfaces which will be visible in the completed work.

Butt-weld which will be visible in the completed work shall be dressed off smooth and flush with adjacent surfaces.

9.2.6.1 Equipment for Welding of Steel

Equipment

The contractor shall be responsible for ensuring that the capacity of welding plant, instruments, cables and accessories is adequate and suitable for the welding procedure to be used and for maintaining all welding plant and ancillary equipment in good working order. The contractor shall also take all necessary safety precautions in connection with work. All electrical plant in connection with the work shall be adequately earthed. The welding return lead from the work shall be adequate in cross section and shall be correctly connected and earthed.

Adequate means of measuring the current shall be available with the welding plant or a portable ammeter shall be provided.

Electrodes

The Electrodes used for manual metal arc welding shall comply with the requirements of BS 639 or other appropriate standard with the prior approval of the Officer in charge. Electrodes shall be selected having regard to the application i.e. joint design, welding position and the properties required to meet service conditions.

All consumable shall be stored and handled with care and in accordance with the manufacturers' recommendations. Electrodes filler wires, rods and fluxes that show signs of damage or deterioration shall not be used.

Covered electrodes shall be stored in their original packets or cartons in a dry place adequately protected from the effects of the weather. When special protection or other treatment during storage or immediately prior to use is recommended by the manufacturer of the electrodes, they shall be treated accordingly.

9.2.6.2 Butt Welds

The details of the angle between fusion faces gap between parts etc. Shall be as per BS 5135.

The details of the angle V-butt weld (without backing) are given below.

The dimension of the weld preparation may have to be modified for welding in positions other than flat, in which case they should be the subject of arrangement between the contracting parties.

In the as welded condition the weld face shall be proud of the surface of the parent metal the butt weld shall be built up so that the thickness of reinforcement at the centre of the weld shall be not less than 10% of the size of the butt weld nor more than 3mm. Where a flush surface is require, the butt weld shall be first built up as specified above and then dressed flush. When no dressing is to be carried out the permissible weld profile shall either be as specified or as directed.

(a) Full Penetration Butt Welds

Full penetration single V,U,J bevel or square butt welds shall be completed by depositing a sealing run of weld metal on the back of the joint; elsewhere these or other butt welds are to be welded from one side only, backing material may be used except where it is agreed between the officer-in charge and the contractor that, by the adoption of an approved special method of welding, full penetration will be obtained without the use of backing material.

Note :- It should be noted that under fatigue conditions backing material may be undesirable.

Backing material shall consist of another steel part of the structure or of material approved by the officer in charge . Where backing material is employed, the joint shall be arranged in such a way as to ensure that compete fusion of the parts to be joined is readily obtained. In all complete penetration butt welds which are to be welded from both sides, the particular welding procedures which allow this to be done without back gouging shall be adopted; but where complete penetration cannot be achieved, the back of the first run shall be gouged out by suitable means to clean sound metal before welding is started on the gauged outside.

(b) Partial Penetration Butt Welds

Partial penetration butt welds shall not be allowed unless specially designed in which case, the weld shall have a throat thickness not less than that specified.

9.2.6.3 Fillet Welds

A fillet weld as deposited, shall be not less than the specified dimensions clearly indicated as throat thickness and/or leg length as appropriate, taking into account the use of deep penetration processes or partial penetration. The effective length of a fillet weld designed to transmit loading shall be not less than 50 mm nor 6 times its leg length.

For concave fillet welds, the actual throat thickness shall be not less than 0.7 times the specified leg length. For convex fillet welds, the actual throat thickness shall be not more than 0.9 times the actual leg length.

Where the specified leg length of a fillet weld at the edge of a plate or section is such that the parent metal does not project beyond the weld, melting of the outer corner or corners which reduces the throat thickness, shall not be allowed.

9.2.6.4 Preparation of Joint Faces

If preparation or cutting of the material is necessary, this shall be done by shearing, chipping, grinding, machining, thermal cutting, thermal gouging or machine gas cutting, Edges shall be left free of slag. When shearing is used, the effect work hardening shall be taken into account and precautions shall be taken to ensure that there is no cracking of the edges.

Fusion Faces

The preparation of fusion faces, angle of bevel, root radius and root face shall be to the required accuracy.

Fusion faces and adjacent surfaces shall be free from cracks, notches or other irregularities which might be the cause of defects or would interfere with the deposition of the weld.

Fusion faces and the surrounding surfaces for a distance of at least 12 mm shall be free from heavy scale, moisture, oil, paint or any other substance which might affect the quality of the weld or impede the progress of welding. This is particularly important when a controlled hydrogen welding process is used.

9.2.6.5 Assembly for Welding

Parts to be welded shall be assembled such that the joints to be welded are easily accessible and visible to the operator. Welding shall be done in the flat position whenever practicable.

Jigs and manipulators shall be used where practicable so that the welding can be carried out in the most suitable position.

(a) Alignment of Butt Joints

The root edges or root faces of butt joints shall not be out of alignment by more than 25% of the thickness of the thinner material for material up to and including 12mm thick, or by more than 3 mm for thicker material. For certain applications and welding processes, closer tolerances may be necessary.

(b) Fit Up of Parts Joined By Fillet Welds

The edges and surfaces to be joined by fillet welds shall be in as close contact as possible since any gap increases the risk of cracking, but in no case shall the gap exceed 3 mm.

9.2.6.6 Tack Welds

Tack welds shall be not less than the throat thickness or leg length of the root run to be used in the joint and shall be subject to the same welding conditions as those specified for the root run. The length of the tack weld shall not be less than four times the thickness of the thicker part or 50 mm whichever is the smaller.

Where a tack weld is incorporated in a welded joint its shape shall be suitable for incorporation in the finished weld and it shall be cleaned and fused thoroughly with the final weld. Cracked, broken or otherwise defective tack welds shall be removed before final welding.

9.2.6.7 Identification

When specified by the Officer-in charge adequate means of identification, either by an identification mark or other record, shall be provided to enable each weld to be traced to the welder (s) by whom it was made.

9.2.6.8 Inspection and Testing

The Officer-in -charge shall have access to the contractor's work at all reasonable times, and the contractor shall provide him with all facilities necessary for inspection during manufacture and on completion.

Welds showing cavities or in which the weld metal tends to fall over the parent metal without proper fusion shall be cut out and re-welded to the satisfaction of the Officer-in-charge. Care shall be taken to avoid under cutting of the base metal along the weld edges and where serious undercutting occurs the reduction shall be made good to the satisfaction of the Officer-in-charge.

Where specified for important works, radiographic or ultrasonic testing procedures shall be carried out to the satisfaction of the Officer-in charge.

Finished welds and adjacent parts shall be protected with clean boiled linseed oil after all slag has been removed.

Welds shall not be painted or otherwise obscured until they have been accepted by the Officer-in charge.

Quality of Welds

Welds joints shall be free from defects that would impair the service performance of the construction.

9.2.6.9 Correction of Faults Welds

Where welds do not comply with the requirements of the clause above, the defective portions shall be cut out they shall then be rewelded and reinspected in accordance with this standard. Where serious undercutting of the base metal along the weld edges is noticed, the reduction shall be made good to the satisfaction of the Officer-in charge.

9.2.7 Machining of Butts, Caps and Bases

Stanchion splices and butt joints of compression members dependent on contact for the transmission of compressive stresses, shall be accurately prepared to butt so that the permitted stress in bearing is not exceeded nor eccentricity of loading created which would induce secondary bending in the members. Stanchion caps and bases shall be prepared in a similar manner to the above, and where this is obtained by machining, care shall be taken that any attached gussets, connecting angles or channels are fixed with such accuracy that they are not reduced in thickness by more than 2 mm.

9.2.8 Slab Base and Caps

Slab bases and slab caps, except when cut from material with true surfaces, shall be accurately machined over the bearing surfaces and shall be in effective contact with the end of the stanchion. A bearing face which is to be grouted direct to a foundation need not be machined if such face is true and parallel to the upper face.

To facilitate grouting, holes shall be provided where necessary in stanchion bases for the escape of air.

9.2.9 Marking

Each piece of steel work shall be distinctly marked before delivery in accordance with a marking diagram, and shall bear such other marks as will facilitate erection.

9.2.10 Painting

All surfaces which are to be painted, oiled or otherwise treated shall be dry and thoroughly cleaned to remove all loose scale and loose rust; all other steelwork shall be given one coat of red oxide of iron paint at the earliest possible opportunity. During the process of erection and subsequently until the work is completed, these protective coats shall be maintained.

Shop contact surfaces need not be painted unless specified. If so specified, they shall be brought together while the paint is still wet.

Surfaces not in contact, but inaccessible after shop assembly, shall receive the full specified protective treatment before assembly. This does not apply to the interior of sealed hollow sections.

All faces to be riveted or bolted together shall be painted before assembly.

In the case of surfaces to be welded, the steel shall not be painted or metal coated within a suitable distance of any edges to be welded if the paint specified or the metal coating would be harmful to welders or impair the quality of the welds.

Welds and adjacent parent metal shall not be painted prior to de-slagging, inspection and approval.

Parts to be encased in concrete shall not be painted or oiled. See also Clause 18.1

9.3 Erection - Site Work

9.3.1 Plant and Equipment

The suitability and capacity of all plant and equipment shall be decided prior to commencement of erection.

9.3.2 Storing And Handling

All structural steel at the site shall be stored and handled so that members are not subjected to excessive stresses, damage deformation etc.

9.3.3 Permission

The erection of steel work shall be started only after obtaining the permission of the Officer-in charge.

9.3.4 Setting Out

The positioning and leveling of all steelwork, the plumbing of stanchions and the placing of every part of the structure with accuracy shall be in accordance with the approved drawings and to the satisfaction of the Officer-in -charge.

9.3.5 Security During Erection

The work may be erected in suitable units as may be directed by the Officer-in-charge. Fabricated members shall be lifted at such points as will avoid the deformation or excessive stress in members.

The structures or part of it placed in position shall be secured against overturning or collapse by suitable means.

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

9.3.6 Modification to Fabrication

Modification to fabricated steel work which would involve cutting, welding etc. must not be made without the prior approval of the Officer-in -charge.

9.3.7 Painting after Erection

All surfaces to be painted shall be dry and thoroughly cleaned from all loose scale and rust.

The specified protective treatment shall be completed after erection. All rivet and bolt heads and site welds after deslagging shall be cleaned. Damaged or deteriorated paint surfaced shall first be made good with the same type of paint as the shop coat. Where specified, surfaces which will be in contact after site assembly shall receive a coat of paint (in addition to any shop priming) and shall be brought together while the paint is still wet.

Where the steel has received a metal coating in the shop, this coating shall be completed on site so as to be continuous over any welds and site rivets or bolts protection may be completed by painting on site in lieu of metal coating subject to the approval of the Officer-in-charge. Bolts which have been galvanized or similarly treated are exempted from this requirement. Site painting should not be done when humidity is such as to cause condensation on the surface to be painted. Please also see clause 18.8

9.3.8 Bedding of Stanchion Bases and Bearing of Beams and Girders on Stone, Brick or Concrete (Plain or Reinforced)

Bedding shall be carried out with Portland cement grout or mortar or fine concrete.

For multi-storeyed buildings this operation shall not be carried out until a sufficient number or bottom lengths of stanchions have been properly line, leveled and plumbed and sufficient floor beams are in position.

Whatever method is adopted, the operation shall not be carried out until the steel work has been finally leveled and plumbed, the stanchion bases being supported meanwhile by steel

wedges; and immediately before grouting the space under the steel shall be thoroughly cleaned.

The bolt holes and space beneath column base plates shall be filled with grout or mortar of specified below:

- (a) Space not deeper than 25 mm: neat cement slurry to as thick a consistency as possible and poured under a suitable pressure head.
- (b) Spaces between 25 mm and 50 mm deep: A mortar of cement and fine aggregate in the proportion of 1:1, just fluid enough to pour, poured under a suitable head and tamped as filling proceeds.
- (c) Spaces over 50 mm deep: A damp dry mortar of cement fine aggregate 1:2, well tamped against properly fixed forms as filling proceeds.

9.3.9 Encasing of Steel work in Foundations and Filling between Grillage Beams

Grillage beams and all steel in foundations shall be solidly encased in dense concrete of structural Gr. 20 (10 mm) with a minimum cover of 100 mm.

9.3.10 Erection of Trusses

Trusses shall be lifted only at nodes. The trusses above 10 mm in span shall not be signed at the apex, as this will develop compression stresses in the bottom tie member. They shall be lifted by slinging at two mid points of rafters, which shall be temporarily braced by a wooden member of a suitable section. After the trusses are placed in position, purlins and wind bracings shall be fixed as soon as possible.

The end of the truss which faces the prevailing winds shall be fixed with holding down bolts, and the other end kept free to move. In case of trusses of spans upto 10 m the free end of the truss shall be laid on lead sheet or steel plate as per design, and the holes for holding down bolts shall be made in the form of oblong slots, so as to permit the free movement of the truss end. For larger spans, the truss shall be provided with bearing as per design.

9.4 Rolling Shutters

General

Rolling steel shutters shall be the product of an approved and recognized manufacture regularly engaged in the production of the type of shutter required. Standard commercial products, which meet the general requirements of the specifications and vary only in non-essential details shall be accepted subject to the approval of the officer-in charge. These shall include necessary locking arrangements and handles etc. These shall be suitable for fixing in the specified location and position i.e. outside or inside on or below lintel or between jambs of the opening. The doors shall be either push and pull type or operated manually or mechanically with a suitable gear mechanism.

9.4.1 Shutters

These shall consist of mild steel laths 121 mm thick (18 G) and 80 mm wide or as specified. The laths shall be machine rolled from a continuous strips into an easy curve free from crimps or sharp bends and with an effective bridge depth of 16 mm. These shall be interlocked together throughout their entire length and jointed at the ends with end locks designed in such a way as to maintain alignment and protect the slats against abrasion in the guides. All joints shall be completely air and weather tight.

The shutters shall be supported by means of spring barrels which in turn are supported by cast iron or steel brackets. The shutter slats shall coil on the spring barrel. A galvanized steel sheet hood not lighter than 18 G reinforced form the end closure.

The spring shall be preferably of coiled type and shall be manufactured from high tensile spring steel wire or strip of adequate strength to balance the shutters in all positions.

9.4.2 Guide Channels

The guide channel shall be a mild steel deep channel section of rolled, pressed or built up (fabricated) construction. The thickness of the sheet used shall not be less than 3 mm. The minimum depth for guide channels shall be as follows:

| Clear width of shutter | Depth of Guide Channel |
|------------------------|------------------------|
| Under 3.5 m | 60 mm |
| 3.5 m and above | 75 mm |

The gap between the two legs of the guide channel shall be sufficient to allow the free movement of the shutter and at the same time close enough to prevent the rattling of the shutter due to wind.

Each guide channel shall be provided with a minimum of three fixing cleats or supports for attachment to walls or columns by means of bolts or screws. The spacing of cleats shall not exceed 750 mm. Alternatively the guide channels may be provided with suitable dowels, hooks, or pins for embedding in the walls.

9.4.3 Fixing

The installation shall be mounted plumb, square and true on the vertical surface of lintels and/or masonry when completed, the door shall completely fill the opening for which it was designed and shall not obstruct the opening when in the open position. The shutters shall operate easily and smoothly under all conditions.

9.5 Tubular Roofs and Columns

9.5.1 Structural Steel Tubes

These shall conform to B.S. 1775 and shall be one of the following types:

1. Hot finished welded (HFW) type
2. Hot finished seamless (HFS) type
3. Electric resistance welded (ERW) type

The steel shall contain:

not more than 0.06 percent sulphur

not more than 0.06 percent potassium

The steel shall have a yield strength of 209 N/mm² or as specified. The sizes of tubes and wall thickness shall be as specified. Standard sizes of tubes are reproduced from BS 1775 in Appendices 9A to 9D.

Tolerances

These shall be in conformity with BS 1775 for each type of tube. The tubes shall not deviate from straightness by more than 1/600 of any length.

Tubes shall be cleanly finished and reasonably free from scale. They shall be free from cracks, surface flaws, lamination and other defects. The ends shall be cut clean and square

with the axis of the tubes unless otherwise specified. Where Galvanized tubes are specified these shall be hot dip galvanized and in conformity with the requirements of BS 1775.

Minimum Wall Thickness of Tubes

Structural tubes shall have the minimum wall thickness indicated below depending upon the exposure.

| | |
|---|--------|
| Construction not exposed to weather | 3.2 mm |
| Construction exposed to weather | 4.0 mm |
| Structures not readily accessible for maintenance | 5.0 mm |

9.5.2 Fabrication

This shall conform to the requirements of clause 9.2.

Caps and Bases for Column

The ends of all the tubes for columns, transmitting loads through the ends, shall be true and square to the axis of the tube and shall be provided with a cap or base accurately fitted to the end of the tube and screwed, welded or shrunk on. The cap or base plate shall be true and square to the axis of the column.

Sealing of Tubes

When the end of a tube is not automatically sealed by virtue of its connection by welding to another member, the end shall be properly and completely sealed. Before sealing the inside of the tube shall be dry and free from loose scale.

Flattened Ends

In tubular construction the ends of tubes may be flattened or otherwise formed to provide for welded, rivetted or bolted connections provided that the methods adopted for such flattening do not injure the material. The change of sections shall be gradual.

9.5.3 Hoisting And Fixing

Shall conform to 9.3

9.6 Steel Doors, Windows, Ventilators And Composite Units

General

The type, overall sizes and location of steel door window and ventilators shall be either as shown on the drawings or as per details given by the Officer-in-charge. For doors, the provision of the threshold or the tie-bar at the bottom of the door frame shall be as specified or as directed (usually external doors are provided with threshold and the internal doors with tie bars).

The actual sizes of doors, windows and ventilators shall not vary by more than 1.5 mm from the dimensions given in the drawings. Where these are not built into the wall construction, the openings shall allow 12 mm clearance around to facilitate easy installation later on.

9.6.1 Materials

Cold rolled steel sections made from steel sheet conforming to BS 1449: Part I

9.6.2 Protection

Rust proofing and protective finishes shall be as specified.

9.6.3 Workmanship

The fabrication, erection, glazing and finishing shall conform to the following standards.

| | | |
|----------------|---|--|
| BS 1245 | - | Metal door frames (steel) |
| BS 990: Part 2 | - | Steel windows generally for domestic and similar buildings |
| BS 1787 | - | Steel windows for industrial buildings |
| BSCP 152 | - | Glazing and fixing of glass for buildings |

9.7 Aluminum Framed Sliding Glass Doors

These shall be made of extruded Aluminum alloy sections anodized to Grade AA 25 as per BS 1615 or as specified, mechanically jointed and erected and finished conforming in all respects to BS 5286.

9.8 Aluminum Windows

These shall be made of extruded aluminum alloy sections anodized to Grade AA 25 as per BS 1615 or as specified, mechanically jointed, erected and finished conforming in all respects to BS 4873.

Appendix 9.A

Standard Sizes of Steel Tubes Hot Finished Welded Steel Tubes Grade HFW 13

| Approximate outside diameter | Thickness | | | | | | |
|------------------------------------|-----------|----|-------|----|-------|----|-------|
| | in | in | s.w.g | in | s.w.g | in | s.w.g |
| 27/32 | 0.080 | 14 | 0.104 | 12 | 0.128 | 10 | |
| 1 1/16 | 0.092 | 13 | 0.104 | 12 | 0.128 | 10 | |
| 1 11/32 | 0.104 | 12 | 0.128 | 10 | 0.160 | 8 | |
| 1 11/16 | 0.104 | 12 | 0.128 | 10 | 0.160 | 8 | |
| 1 29/32 | 0.116 | 11 | 0.128 | 10 | 0.160 | 8 | |
| 2 3/8 | 0.116 | 11 | 0.144 | 9 | 1.176 | 7 | |
| 3 | 0.128 | 10 | 0.144 | 9 | 1.176 | 7 | |
| 3 1/2 | 0.128 | 10 | 0.160 | 8 | 0.192 | 6 | |
| 4 1/2 | 0.144 | 9 | 0.176 | 7 | 0.212 | 5 | |

Hot Finished Steel Tubes Grade HFW 16 And Hfw 23

| Approximate outside diameter | | | | | Thickness (inches) | | | |
|------------------------------------|-------|-------|-------|-------|-----------------------|-------|-----|-------|
| in | in | s.w.g | in | s.w.g | in | s.w.g | in | in |
| 1 1/16 | 0.128 | 10 | - | - | - | - | - | - |
| 1 11/32 | 0.104 | 12 | 0.128 | 10 | 0.160 | 8 | - | - |
| 1 11/16 | 0.104 | 12 | 0.128 | 10 | 0.160 | 8 | - | - |
| 1 29/32 | 0.128 | 10 | 0.160 | 8 | 0.192 | 6 | - | - |
| 2 3/8 | 0.128 | 10 | 0.160 | 8 | 0.192 | 6 | - | - |
| 3 | 0.128 | 10 | 0.176 | 7 | 0.212 | 5 | - | - |
| 3 1/2 | 0.128 | 10 | 0.160 | 8 | 0.212 | 5 | - | - |
| 4 1/2 | 0.144 | 9 | 0.176 | 7 | 0.212 | 5 | 1/4 | 0.250 |

Appendix 9.B

Hot Finished Seamless Steel Tubes

| Approximate outside diameters (inches) | Thickness (inches) | | | | | | | |
|---|-----------------------|-------|-------|-------|-------|-------|-------|-------|
| 1 11/32 | 0.128 | 0.160 | 0.192 | | | | | |
| 1 11/16 | 0.128 | 0.160 | 0.212 | | | | | |
| 1 29/32 | 0.128 | 0.160 | 0.192 | 0.232 | | | | |
| 2 3/8 | 0.144 | 0.176 | 0.192 | 0.219 | 0.250 | | | |
| 3 | 0.144 | 0.176 | 0.212 | 0.250 | | | | |
| 3 1/2 | 0.160 | 0.192 | 0.212 | 0.250 | | | | |
| 4 | 0.160 | 0.192 | 0.250 | | | | | |
| 4 1/2 | 0.176 | 0.212 | 0.232 | 0.250 | 0.312 | | | |
| 5 1/2 | 0.176 | 0.192 | 0.212 | 0.250 | 0.312 | 0.375 | | |
| 6 1/2 | 0.176 | 0.192 | 0.212 | 0.250 | | | | |
| 6 5/8 | 0.176 | 0.192 | 0.212 | 0.250 | 0.281 | 0.312 | 0.375 | |
| 7 5/8 | 0.192 | 0.212 | 0.250 | 0.281 | 0.312 | 0.375 | | |
| 8 5/8 | 0.192 | 0.212 | 0.250 | 0.281 | 0.312 | 0.375 | 0.438 | 0.500 |
| 8 5/8 | 0.232 | 0.281 | 0.312 | 0.375 | | | | |
| 10 3/4 | 0.232 | 0.250 | 0.281 | 0.312 | 0.375 | 0.438 | 0.500 | |
| 12 3/4 | 0.250 | 0.281 | 0.312 | 0.375 | 0.438 | 0.500 | | |
| 14 | 0.312 | 0.375 | 0.438 | | | | | |
| 16 | 0.312 | 0.375 | 0.438 | 0.500 | | | | |
| 18 | 0.344 | 0.375 | 0.438 | 0.500 | | | | |

Note: Other diameters and thickness can be obtained. Thicker tubes should be in accordance with the following :

1/4 in, 9/32 in, 5/16 in, and then by increments of 1/16 in.

Larger size tubes can be obtained up to 40 inches outside diameter in thicknesses to be agreed between the purchaser and the manufacturer.

Appendix 9.C

Hydraulic Lapwelded Steel Tubes And Electric Fusion Welded Steel Tubes

| Approximate outside diameter (inches) | | | Thickness (inches) |
|--|------|------|-----------------------|
| 16 | 1/4 | 9/32 | 5/16 |
| 18 | 1/4 | 9/32 | 5/16 |
| 20 | 1/4 | 9/32 | 5/16 |
| 22 | 1/4 | 9/32 | 5/16 |
| 24 | 1/4 | 9/32 | 5/16 |
| 26 | 9/32 | 5/16 | 3/8 |
| 28 | 9/32 | 5/16 | 3/8 |
| 30 | 5/16 | 3/8 | 7/16 |
| 32 | 5/16 | 3/8 | 7/16 |
| 34 | 5/16 | 3/8 | 7/16 |
| 36 | 5/16 | 3/8 | 7/16 |
| 40 | 3/8 | 7/16 | 1/2 |

Note : Thicker tubes can be obtained and these should be in increments of 1/16 inch.

Larger size tubes can be obtained up to 73 1/4 inches outside diameter in thicknesses to be agreed between the purchaser and the manufacturer.

Appendix 9.D

Design Properties of Steel Tubes Dimensions and Design Properties of Steel Tubes

| Outside diameter | Thickness | Weight | | Area of cross section | Moment of inertia | Electric modulus of section | Plastic modulus sections | Radius of gyration |
|------------------|-----------|--------|-------|-----------------------|-------------------|-----------------------------|--------------------------|--------------------|
| inches | s.w.g. | inches | Lb/ft | in ² | in ⁴ | in ³ | in ³ | inches |
| 27/32 | 14 | 0.080 | 0.646 | 0.192 | 0.014 | 0.033 | 0.047 | 0.271 |
| | 12 | 0.104 | 0.813 | 0.242 | 0.017 | 0.040 | 0.057 | 0.264 |
| | 10 | 0.128 | 0.968 | 0.288 | 0.019 | 0.015 | 0.066 | 0.257 |
| 1 1/16 | 13 | 0.092 | 0.947 | 0.280 | 0.033 | 0.063 | 0.087 | 0.344 |
| | 12 | 0.104 | 1.05 | 0.313 | 0.036 | 0.068 | 0.096 | 0.340 |
| | 10 | 0.128 | 1.27 | 0.376 | 0.042 | 0.078 | 0.112 | 0.333 |
| 1 11/32 | 12 | 0.104 | 1.35 | 0.405 | 0.078 | 0.116 | 0.160 | 0.440 |
| | 10 | 0.128 | 1.63 | 0.489 | 0.091 | 0.136 | 0.190 | 0.432 |
| | 8 | 0.160 | 1.98 | 0.595 | 0.106 | 1.158 | 0.226 | 0.422 |
| | 6 | 0.192 | 2.33 | 0.695 | 0.118 | 0.176 | 0.257 | 0.413 |
| 1 11/16 | 12 | 0.104 | 1.73 | 0.517 | 0.163 | 0.193 | 0.261 | 0.561 |
| | 10 | 0.128 | 2.09 | 0.627 | 0.192 | 0.227 | 0.312 | 0.553 |
| | 8 | 0.160 | 2.56 | 0.768 | 0.226 | 0.268 | 0.375 | 0.543 |
| | 5 | 0.212 | 3.31 | 0.983 | 0.273 | 0.323 | 0.465 | 0.527 |
| 1 29/32 | 11 | 0.116 | 2.20 | 0.652 | 0.262 | 0.275 | 0.372 | 0.634 |
| | 10 | 0.128 | 2.41 | 0.715 | 0.284 | 0.298 | 0.406 | 0.630 |
| | 8 | 0.160 | 2.96 | 0.878 | 0.337 | 0.354 | 0.489 | 0.620 |
| | 6 | 0.192 | 3.52 | 1.03 | 0.384 | 0.403 | 0.567 | 0.610 |
| | 4 | 0.232 | 4.15 | 1.22 | 0.436 | 0.457 | 0.654 | 0.598 |
| 2 3/8 | 11 | 0.116 | 2.78 | 0.823 | 0.526 | 0.443 | 0.592 | 0.800 |
| | 10 | 0.128 | 3.05 | 0.904 | 0.572 | 0.482 | 0.647 | 0.796 |
| | 9 | 0.144 | 3.41 | 1.01 | 0.630 | 0.531 | 0.718 | 0.790 |

| | | | | | | | | |
|---|------|-------|------|------|-------|-------|-------|-------|
| | 8 | 0.160 | 3.76 | 1.11 | 0.686 | 0.578 | 0.786 | 0.785 |
| | 7 | 0.176 | 4.15 | 1.22 | 0.740 | 0.623 | 0.853 | 0.780 |
| | 6 | 0.192 | 4.48 | 1.32 | 0.790 | 0.666 | 0.917 | 0.775 |
| | 7/32 | 0.219 | 5.06 | 1.48 | 0.870 | 0.733 | 1.02 | 0.766 |
| | 1/4 | 0.250 | 5.66 | 1.67 | 0.955 | 0.804 | 1.13 | 0.756 |
| 3 | 10 | 0.128 | 3.90 | 1.15 | 1.19 | 0.795 | 1.06 | 1.02 |
| | 9 | 0.144 | 4.36 | 1.29 | 1.32 | 0.880 | 1.18 | 1.01 |
| | 7 | 0.176 | 5.32 | 1.56 | 1.56 | 1.04 | 1.41 | 1.00 |
| | 5 | 0.212 | 6.32 | 1.86 | 1.81 | 1.21 | 1.65 | 0.988 |
| | 1/4 | 0.250 | 7.32 | 2.16 | 2.06 | 1.37 | 1.90 | 0.976 |

The weights in lb/ ft are the agreed values in ISO recommendation R 336 “ Plain end steel tubes, welded or seamless; general table of dimensions and masses per unit length”.

CHAPTER 10

DEMOLITION

Demolition work shall be carried out by experience workmen and generally comply with BS 6187. It includes basic consideration and recommended method of demolition of different types of structure , provides a basic for logical approach to safe procedures and offers advice on safety precaution and statutory requirement.

Before any works of demolition are started, a detailed survey and examination of the building or structure and its cartilage should be made, and recommended and kept available for inspection.

All available plans of the building or buildings should be examined, where the nature of the construction is uncertain, a special site investigation should be carried out where there is a doubt concerning the design of structural arrangements, the opinion and advice of an engineer experienced in such work should be sought.

It is also necessary to consider the after and protection of adjoining buildings and other sensitive elements during demolition.

SCAFFOLDING AND SHORING

General

Any scaffolding required should be designed and erected in accordance with the recommendation given in BS 5973 and should be provided by a competent scaffolder.

Where scaffolding is required it should normally be an independent tied scaffold situated on the outside of the building or structure. The demolition contractor should arrange for the scaffolder to visit the site as necessary and make any adjustments required to the scaffolding as the work proceeds, to ensure its stability.

Care should be taken that the load of any debris collecting on a scaffold does not exceed the loading assumed for the design of scaffold. Measures should be taken to prevent debris from being accidentally dislodged from the platform.

Progressive dismantling. Scaffold that are to be dismantled progressively during the demolition of a building should not be left projecting above residual height of the walls more than necessary. Stabilizing ties should be maintained, especially with sheeted scaffolds. Compliance with the statutory regulations.

Scaffolds when completed should be left in a condition suitable to perform the duty for which they were intended, and should comply with the requirement of the statutory regulations and with any Local Authority requirement.

Scaffolds should be inspected by the constructor before being taken into use. The user should inspect them weekly or at more frequent intervals if necessary to see that they remain in compliance with the statutory regulation and should sign the Records of weekly inspections to record his findings.

Shores and shoring . When required, shores and shoring should be designed and erected in accordance with the recommendation given in CP 2004. Shoring should be so designed and constructed that it is adequate for its purpose, and an experienced person should ensure that it is placed in position at the appropriate time. Provision should be made for the erection of adequate shoring before the existing lateral support is disturbed.

The layout of the shores should be designed to enable any new building to be constructed with the least possible interference. The shoring should be checked for effectiveness as the demolition proceeds.

10.1 SAFETY OF PERSONNEL ON SITE

Plant and equipment. Care should be taken to ensure that plant equipment is:

- (a) Of an appropriate type and stranded having regard to the location and type of work involved,
- (b) In the charge of a competent operator, and
- (c) Maintained in good working condition at all times.

The equipment should be fitted to machines and adequate power and stability for the use intended.

The operator should be experienced in the use of the equipment and there should be a high standard of inspection and maintenance .

Where appropriate, plant and equipment should comply with the requirements of the relevant British Standards.

Protection of site personnel. During demolition work all operators should wear adequate protective clothing and, where appropriate, protective equipment such as safety helmets, goggles, ear defenders and respirators.

High levels of noise can cause permanent hearing damage to workers. Attention is drawn to the Health and Safety for reducing the exposure of employed persons to noise, which contains advice on the levels of noise that are a serious hazard and the precautions that can be taken. When noisy machinery is used, ear defenders may be necessary.

For specific operations such as work on building where chemicals have been stored or used or where lead paint, asbestos, dust or fumes may encountered, which may prejudice the health of persons using the site, special precautions should be taken regarding protective clothing, goggles and the use of suitable respirators.

Projecting nails in timber should be removed or hammered flat; they should not be allowed to remain as a source of danger .

Precautions against uncontrolled collapse. The removal of certain parts of the building or structure during demolition can result in other parts becoming unsafe and it is necessary to pre-determine where temporary support will be needed. The advice of a competent engineer may be required .

10.2 Other Precautions

General

Every working place and approach and all openings dangerous to persons employed and others should be properly illuminated and protected .

Overloading of any part of the building by debris or materials should be avoided.

Before carrying out any part of the work the demolition contractor should consider prevailing weather conditions and weather forecast . Particular attention should be paid to the effects of adverse wind.

When materials and debris are lowered , care should be taken to prevent the material from swinging in such a manner that it creates a danger to the safety of either personnel or the surrounding structure .

Prior to and during enter into confined spaces effective steps should be taken to establish and maintain an atmosphere fit for respiration . Standby men may be necessary during such operations as may be the provision, and training in the use, of rescue equipment.

Electrical Hazards

When mechanical plant, especially cranes and pusher arms, is used for demolition purposes, care should be taken to ensure that no part of such machines can come into direct contact or in close proximity to overhead or underground electricity or telephone wires or cables. Where such a possibility exists, the local electricity or telephone authority should be informed in order that they may assess the degree of risk and offer advice accordingly. Precautionary measures may include physical barriers, disconnection, recovery or diversion of the affected wires or cables.

Fire or Explosion Risks

Precaution should be taken to prevent the risk of fire or explosion caused by gas or vapour. When thermal reaction or thermal lancing methods are used, consideration should be given to the prevention of oxygen enrichment and the attendant risk of explosion or ignition of flammable vapour. Containers of oxygen, acetylene or liquefied petroleum gas should be handled with care and stored and used in accordance with good practice.

The use of thermal cutting tools in close proximity to timber and other flammable materials should be avoided unless suitable precautions are taken against the risk of fire or explosion.

Attention is drawn to the increasing use of foam plastics and the like in building construction, including its use as insulation between wall leaves. This material may constitute both a fire hazard and a health risk due to toxic combustion products and methods of demolition likely to cause

ignition should be avoided. Similarly, when burnt, timbers treated with copper /chrome/ arsenic rot preventatives give off poisonous fumes, and where such timbers are known to be present it should be disposed of in a safe manner.

Explosives should be handled and used in accordance with the recommendations given in BS 5607.

Flooding

Care should be taken to guard against the risk of flooding, especially where the method of demolition being used employs water in volume.

Safety and Convenience of Third Parties

A Person carrying on demolition operations should make sure that any building that is partly demolished and its site is, so far as is reasonably practicable, properly secured or closed against entry at all times when demolition operations are not in progress and that the building or structure is left in a safe condition at the close of each day's work. All reasonably practicable steps should also be taken to prevent the exposure of third parties to substances hazardous to health that are or could be present during demolition work.

When a building is to be partially demolished it should be ensured that at no time during the process of demolition is the safety of any occupant of the remaining portion put at risk. If necessary the occupants of the remaining portion should be evacuated.

Where works of demolition are likely to result in the discharge of materials or debris on to the public highway or private property not a part of the demolition site, protective covering or fans should be erected or a temporary closure applied to the highway. Fans should be of adequate strength for the purpose and, if need be, waterproofed and laid to fall so that there is no likelihood of water or drips falling on persons using the highway.

Every effort should be made to minimize any nuisance to the public; the following precautions should be observed.

(a) Dust. The demolition works should be periodically sprayed with water to reduce the amount of dust. It should be borne in mind that some dusts are flammable, particularly if there are residues contained within silos, plant, etc.

(b) Noise. Noise should be minimized as far as possible, in particular by limiting the use of compressors and other plant to stated hours and by the fitting and use of silencing devices wherever practicable.

Where partial demolition or alterations are carried out to an occupied building or to a building structurally linked to an occupied building, the use of non - percussive methods should be considered in order to minimize the structural - borne transmission of noise and vibration.

Fire and Smoke

All fires should be extinguished early enough so that they are out before the personnel leave to site, or an appointed fire - watchman should remain on the site for at least one hour after all fires have been extinguished. Extra care should be taken to ensure that no incipient fires are left when burning equipment (e.g. oxy - propane torches) has been used.

The particular requirements of smoke control areas should be ascertained from the Local Authority.

Gas cylinders and similar containers, whether empty, in use or spare, should be stored in a safe place, in accordance with good practice, since if they become involved in a fire any resulting explosion may cause injury to persons and damage to property.

10.3 Methods of Demolition

General

This clause describes the various method of demolition in use, together with the appropriate precautionary measures that should be taken. While describe separately in this clause, it is common for several method to be used in combination or at such cases the precaution or at different parts of the demolition site. In such cases the precaution relevant to all the methods in use should be taken.

16.3.1 Hand Demolition

Hand demolition involves the progressive demolition of a structure by operatives using hand-held tools; lifting appliances may be used for lifting and lowering members once they are released.

Where work cannot be done safely from a part of a building or structure, a suitable working platform made from standard scaffolding or special purpose scaffolding should be used. Other means of support such as specially designed working platforms or a suitable skip suspended from a crane or aerial platform, or, in some instances, ladders, may also be used.

Buildings and other structures should generally be demolished in the reverse order to that of their construction. The order of demolition for buildings should be progressive, story by story, having regard to the type of construction.

On all sites debris should be allowed to fall freely to the ground internally or externally or externally only where the horizontal distance from the point of fall to a public highway, or adjoining property, is not less than 6 m, or half the height from which the debris is dropped, whichever is the greater. In other cases, chutes or skips should be used.

Where debris from walls, etc. above first floor level is to be dropped to the ground or basement level within a building, sufficient openings, clear of joists or beams, should be formed in the floors to enable the debris to fall without deflection. If it is proposed to remove one or more joists to allow the free passage of debris, care should be taken that such action will not jeopardize the stability of the surrounding structure.

Precautions should be taken against flying or falling debris by sealing off all openings in walls adjacent to the area of fall. To prevent excessive lateral pressure, care should always be taken to avoid a building - up of fallen debris against walls in the lowest stories. This is of particular importance in confined spaces such as lift and tall chimneys.

When material is being dropped, a look-out man should be posted to ensure safety generally. Steel structural members and reinforced concrete structural members should be lowered to the ground or be cut into lengths appropriate to the weight and size of member before being allowed to fall.

Where possible, a crane and lifting gear should be used to support beams and columns whilst they are being cut and lowered to the ground. In framed structures of precast concrete or steelworks, similar support should be given to members while joints are being severed.

When only a portion of a structure is to be demolished, the stability of the part to remain should be checked.

10.3.2 Mechanical Demolition by Pusher Arm

Mechanical demolition by pusher arm involves the progressive demolition of a wall using a machine fitted with a pusher arm exerting horizontal thrust.

The pusher arm should be used only when the equipment is on firm level ground. It should not be overloaded and should generally be used from outside and not from inside the building. No person should be within that distance of the building where debris is liable to fly.

The pusher arm should be made of steel. Pusher arms of other materials should not be used.

The cab of the appliance should be robust enough to withstand impact from flying debris and the cab windows should be of shatter-proof glass.

The height of the building should, in the first instance, be reduced by hand demolition to a height to suit the machine being used; then the height should be reduced progressively by pushing small sections to the ground.

Where this method is adopted for demolition of attached building, the structure to be demolished should first be detached by hand demolition.

The clear space in which the equipment is to operate should be a minimum of 6 m.

The plant should be used only in accordance with the manufacturer's recommendations; On no account should the point where the pusher arm is applied to a wall being demolished be more than 600 mm below the top of the wall. The plant should not be worked from a roadway without the permission of the Local Authority.

10.3.3 Mechanical Demolition by Deliberate Collapse

Mechanical demolition by deliberate collapse involves the removal of key structural members causing complete collapse of the whole or part of the building or structure being demolished.

Expert engineering advice should be sought before this method is used; it should be employed only on detached, isolated, reasonably level sites and where the whole structure is to be demolished. There should be sufficient space to enable equipment and personnel to be removed to a safe distance.

Sections of a structure should not be pulled down by deliberate collapse in separate operation if instability of the remaining structure may result, causing a possible hazard to personnel on the site.

10.3.4 Mechanical Demolition by Demolition Ball

Mechanical demolition by demolition ball involves the progressive demolition of the building by the swinging of a weight suspended from a lifting appliance.

Three techniques may be used :

- (a) . vertical drop;
- (b) . swinging in line with the jib;
- (c) . slewing jib.

The operator should be experienced and skilled in the use of equipment and techniques of demolition and there should be high standard of inspection and maintenance.

Reference should be made to CP 3010. Cranes with telescopic jibs should not normally be used for demolition ball duties.

When high balling is to be carried out, it should be undertaken only by operators and experienced supervisors thoroughly conversant with this technique.

This method should not be used on buildings or parts of building where the angle of the jib would exceed 60° to the horizontal. The use of the demolition ball where attached to a

normal duty mobile crane should be restricted to free fall vertical drop only. The use of a swinging motion to effect demolition by a ball weight, whether by swinging in line with the jib or by slewing, should be restricted to machines designed for arduous or heavy duty such as convertible dragline excavators.

An anti - spin device should always be used on the hoist rope in conjunction with the ball attachment equipment. In all cases, reference should be made to the machine manufacturers for guidance as to the limitation in service, e.g. the lengths of jib and the weight of the drop ball and attachment that may be used. It should be noted that certain manufacturers do not recommend the use of their machines for demolition ball duties or may approve this use only conditionally, with restriction on the techniques to be used or on the maximum jib lengths, etc. The hoist rope, anti - spin device, and the attachment of the demolition ball to the hoist rope should be inspected at least twice daily by a competent person.

It is advisable to reduce progressively the length of the jib as the demolition proceeds. But at no time should the jib head be less than 3 m above the portion of the building being demolished.

Swinging of the ball should be carried out by method that do not overstress the jib or hazard the stability of the machine. The supporting ropes should be of such length or be so restrained that it is not possible for the ball to swing against any structure other than being demolished.

Jib derricking for the purpose of swinging the ball should not be permitted.

Slewing jib techniques can impose excessive stresses on the machine and also on the jib, which should be suitably rated for the purpose. Factors that could impose high operational stresses in the jib are as follows:

- (a) . Angle of slew (which should not exceed a total of 30°);
- (b) . Acceleration of slew;
- (c) . Rate of checking of slew;
- (d) . Weight of ball;
- (e) . Height at point of impact.

Only operators experienced in the use of slewing jib techniques should be employed for this work.

Care should be taken to avoid the ball becoming trapped when drop - balling masonry arches, suspended floor slabs or similar element of structure, as a sudden collapse could result in the machine being overloaded . If the ball is trapped, ttempts should not be made to free it by a dragging or lifting action as this may overload the crane.

The cab of the machine should be robust enough to withstand impact from flying debris and the cab windows should be of shatter - proof glass.

In all cases the machine should be used only when standing on firm level ground. He machine should generally be positioned to operate from outside and not from inside the building.

Where this method of demolition is adopted on attached buildings, the structure to be demolished should first be detached by hand demolition and a clear space of at least 1 meter wide provided between the two buildings to ensure that transmission of vibration is kept to a minimum. At all times the stability and safety of the remaining property should be ensured.

The clear space in which the equipment is to operate should be a minimum of 6 m.

Where it is possible to demolish a building without endangering any adjacent building the whole building may be demolished with a ball, provided that personnel do not have to enter the building once demolition has commenced. If the building has a pitched roof, the roof structure should be removed down to wall plate level by hand demolition before using the ball.

Before walls are demolished, section of the floors should be removed by hand demolition to facilitate the free fall of debris. Generally between 50 % and 75 % of the areas of the floors can be removed but sufficient structure should remain to ensure the stability of the building. The demolition should be carried out progressively story by story, having due regard to the type of construction.

Debris should not be allowed to accumulate above an average height of 2 m from ground level before removal, nor should it be allowed to subject the containing structure to undue lateral pressure.

10.3.5 Mechanical Demolition by Wire Rope Pulling

Wire rope pulling should not be used on masonry structures exceeding 21 m in height. The rope should be of such length that horizontal distance from the demolition work to the winch or pulling vehicle is not less than twice the height of the heights part to be pulled.

Only steel wire ropes should be used for this operation. The size and strength of the rope should be adequate for the purpose for which it is to be used and in no case should the circumference of the rope be less than 38 mm.

The rope should be inspected by a competent person before use and at least twice daily to ensure that its strength has not been impaired by wear or damaged. Damaged ropes should not be used.

The rope should be firmly fixed at both ends and the tension in the pulling rope should be gradually applied; snatch loading should not be permitted.

Any sharp edges round which the rope may be wound should be protected to avoid wear on the rope.

When pulling, no person should be forward of the winch or tracked vehicle and no person on either side of the wire rope within a distance of three quarters of the distance between the winch or tracked vehicle and the structure to be demolished.

If an attempt or several attempts are made to pull a building or structure and the equipment is found to be inadequate to cause collapse it is most probable that weakening of the building or structure will have taken place. Under these circumstances it is dangerous for a person to approach the structure and an alternative method of demolition should be used if at all possible, e.g. pusher arm, demolition ball or any other safe method.

Where it is required to demolish a building or structure by sections and it is not possible or practical to isolate such sections, the wire ropes should be attached to their respective sections prior to the first pull being made and the free ends should be left at a safe distance from the building.

Where sections of the building or structure are progressively completely isolated, such section may be progressively pulled down and the wire ropes re - fixed accordingly, having constant regard to the stability of the building or structure.

A well - anchored winch or a tracked or heavy vehicle should be used for pulling. Care should be taken to ensure that the vehicle does not lift from its tracks or tyres so as to endanger its stability during pulling. The direction of the tracks or tyres should be maintained in line with the line of pull.

Protection from rope breakage and flying debris should be afforded to the drive.

10.3.6 Demolition by Explosive

Reference should be made to the recommendations given in BS 5607 when explosives are to be used for demolition. A specialist experienced in the controlled application of explosives for the purpose of carrying out the demolition of civilian structures should be consulted before deciding whether explosives are to be used for demolition. Account should be taken of the type of structure and its situation. An explosives specialist firm or company should be employed, experienced in this type of work and holding the necessary license from the police to purchase explosives. Before blasting operations commence, the police should be informed and their assistance sought to keep people and livestock away from the area.

Utilities require special consideration, and the proximity of underground and overground services should be carefully considered before blasting operations are carried out. Consultations should be carried out with the necessary authorities who are responsible for concealed underground works (e.g. pipes , cables , etc.).

The explosives specialist should decide the charges to be used and their placing. Adequate storage accommodation should be provided. Precautions should be taken to protect other property from shock and vibration, and flying debris should be controlled by means of blast mats or other baffles. In the event of a misfire the area should remain cleared until the explosives specialist has dealt with the situation. If, after blasting operation, a misfired charge is found during the subsequent removal of debris the area should be cleared and entrance restricted until the explosives specialist has rendered the misfire safe.

Under certain circumstances electrical and radio - transmitting installations can cause detonation of electrical detonators without physical contact; electrical storms may have the same effect.

Guidance on protection against these hazard is given in BS 4992. Demolition by explosives should be supervised by personnel experienced in the controlled application of explosives.

10.3.7 Other Methods of Demolition

General

There are a number of other forms of mechanical, thermal or percussive demolition available. These are generally more limited in application, and in a number of cases are useful for smaller demolition works. As with the previously described methods, they may be used in combination with other techniques. In all cases they should be carried out by persons experienced in the use of the particular equipment involved, and the equipment should be used in accordance with the manufacturer's instruction.

10.3.7.1 Machine - Mounted Impact Hammer

A machine - mounted impact hammer is larger and heavier duty from of the hand - held pneumatic drill , and may be pneumatically or hydraulically operated . As in the case of the lighter equipment, it is useful for breaking up massive construction such as concrete base slabs or the like, and for breaking larger pieces of debris into manageable sizes. It should not normally be used to demolish tall vertical such as walls or columns from the side, because of the risk of debris falling on to the machine or the operatives.

10.3.7.2 Power Grapples and Shears

Power grapples and shears are frequently hydraulically operated . Power shears may be used as an alternative to oxyacetylene cutting or the like to crop and cut through metal such as reinforcing steel or beams, particularly where there might otherwise be a risk of fire or where the more precise cutting possible with a torch is not required. Care should be taken to ensure that any member to be severed is either effectively supported or, if to be allowed to fall, in so doing will endanger neither personnel nor the remaining structures. Power grapples may be used to handle waste material , either to move it about a site or to load other vehicles when disposing of the waste. As some debris resulting from demolition has high density, care should be taken to avoid overloading the equipment both to avoid damage to the equipment itself and to avoid the risk of the machine overturning as a result of instability induced by a heavy load.

10.3.7.3 Purpose -Built Grabs

Purpose - built grabs should generally be used only for moving debris from one location to another. As in the case of power grapples, care should be taken not to overload the equipment, in order to avoid collapse or instability.

10.3.7.4 Drilling and Sawing

Drilling and sawing are used either to remove totally part of a structure or to produce a potential fracture zone (e.g. by stich - drilling , which is drilling a line of overlapping holes) , and are frequently used in conjunction with other methods of demolition, particularly bursting. Diamond or tungsten tipped drills or saws are normally used . These method can be employed in confined spaces, or for work that requires a high degree of accuracy, or where the noise, dust and vibration resulting from some other methods would be unacceptable . They may be used to cut up floors and suspend slabs into manageable sizes, or to cut holes and slots in parts of a structure. Whist this is being done the piece to be removed should be adequately supported . Use of these methods avoids damage to the surrounding area.

In order to flush out the resulting dust , and to cool the equipment during use, it is usual to employ running water in volume as a coolant. This needs to be borne in mind if it is proposed to adopt this method of demolition, and measures should be taken to provide a suitable supply of water, and to collect and safely dispose of the waste water that results. Care should be taken that any sparks produced during sawing do not constitute a health or fire hazard.

10.3.7.5 Bursting

General

The technique of bursting is analogous to the use of explosives in that it makes use of expansion of a mass of gas or a mechanical device in a prepared crack in a mass in order to break it into fragments. It may be possible to use this method where the use of explosives would not be possible as a result of site conditions.

Gas expansion burstings. A Gas expansion burster operates with explosive force and should only be used and operated by persons skilled in its use. The effect of the burster is obtained by inserting it into prepared cavity in the mass to be demolished. Upon being energized by means of an electrically operated device, the resultant increase in pressure of the gas ruptures a diaphragm , releasing the gas into the crevices in the surrounding structure which is thus fractured. Extreme care should be taken to ensure that the burster is effectively restrained within the prepared cavity in order to prevent it from becoming an uncontrolled projectile.

10.3.7.6 Hydraulic Bursters

An hydraulic bursters also uses an expanding device to force apart a mass, but the process is not as rapid as in a gas expansion burster. Pistons or wedges are placed in a prepared cavity and are gradually jacked out under pressure, the resulting increase in size of the device fracturing the surrounding material. During use care should be taken that when the structure or mass collapses it does so without endangering the operatives or equipment.

10.3.7.7 Hydraulic Cannon

An hydraulic cannon projects a single, high - pressure, shot of water into a pre - drilled hole in a structure in order to break it up. It is generally used to break large pieces of rock or rubble into more manageable sizes for easier handling. As in the case of drilling and sawing, measures should be taken to ensure the safe and effective disposal of the water utilized by this equipment.

10.3.7.8 Thermal Reaction and Thermic Lance

General

The thermal reaction and thermic lance methods of demolition are two distinct techniques, but they each use heat as a means of weakening or severing a structure in order to facilitate its removal. As in all methods in which heat is used as the primary agent, care should be taken to prevent the risk of fire or explosion when these methods are used in the proximity of timber and other flammable materials and vapours. In particular consideration should be given to preventing localized oxygen enrichment because of the attendant risk of explosion .

Thermal Reaction

The thermal reaction technique is typically used in conjunction with wire rope pulling to break up structural steel member to be severed is surrounded by a mixture of a metal oxide and a reducing agent that when ignited reacts to liberate a large quantity of heat . After ignition, which may be remotely initiated electrically, the steel becomes plastic and a small unbalancing force applied by means of a pulling rope should normally be sufficient to effect the collapse of the member. Suitable precautions commensurate with the other techniques being used in conjunction with the thermal reaction should be taken .

Thermic Lancing

Thermic lancing is the technique of using a thermic lance to cut through materials, including concrete, that may not be amenable to the use of other forms of cutting equipment. The tip of the

lance is preheated to start an oxygen / iron reaction that produces an intense heat source that is then applied to the material to be cut. Once started the reaction is self - supporting. During thermic lancing the products of combustion typically produce a thick smoke; suitable precautions should therefore be taken, particularly in a confined space.

Fire

The deliberate burning of buildings should not be used as a means of demolition. In addition, fire should not be used for removing temporary timber shoring or the like.

CHAPTER 11

MISCELLANEOUS BUILDINGS WORKS

11.1 Damp Proof Courses

General

Damp proof courses shall be laid for all walls. The damp proof course shall extend for the full thickness and shall be located at a minimum height of 150 mm above finished ground level or as shown in drawings or as directed by the Officer-in Charge.

Note: Consideration shall be given to flooding and site drainage in deciding on the height.

11.1.1 Cement Concrete Layer

This shall consist of cement concrete of specified proportions and thickness, where so specified, water proofing material of approved manufacture shall be added to the concrete mix in accordance with the manufacturer's specifications. The surface of brick work or stone work masonry shall be leveled and prepared before laying the cement concrete. Edges of the damp proof course shall be straight, even and vertical. Side shuttering shall consist of wooden forms and shall be strong and properly fixed so that it does not get disturbed during compaction and the mortar does not leak through. The concrete mix shall be of workable consistency and shall be tamped thoroughly to make a dense mass. When the side formwork is removed, the surface revealed shall be smooth without any honey-combing.

Curing

The concrete shall be adequately cured after which it shall be allowed to dry.

Application of Hot Tar

The surface shall be properly cleaned with brushes and finally with a piece of cloth soaked in kerosene oil. Two coats of hot tar shall be applied at the rate of 0.25 litres per m² per coat.

11.1.2 Cement Mortar Layer

This shall consist of a 20 mm thick layer of cement mortar 1:2 finished with an application of two coats of hot tar applied at the rate of 0.25 litres per m² for each coat.

11.1.3 Vitrified Brick Damp Proof Courses

These shall consist of at least two courses of vitrified bricks set and jointed in cement mortar 1:3 and pointed to match surrounding work. The bricks shall conform to BS 3921 and shall not absorb more water than 3% of their weight when tested in accordance with BS 743.

11.1.4 Damp Proof Courses in Sheets of Bitumen, Polythene, Lead or Chopper

These shall conform to BS 743 as regards materials and workmanship.

11.2 Damp Proofing of Walls/Tanking

This shall conform to BSCP 102.

11.3 Floor Screeds/Roof Screeds

General

Note: Screeds shall be provided over structural bases

- (a) to provide a degree of level and smoothness to suit a particular floor finish where this is not provided by the structural base.
- (b) to raise levels
- (c) to provide slopes for drainage or
- (d) to accommodate services

Unless otherwise specified, the thickness and bay sizes of screeds shall be as per Table 11.1 below:

Table 11.1

| Type | Base | Thickness | Bay size |
|------------|---|-----------------|--|
| Monolithic | Concrete less than 3 hours old. (No preparation for base) | 12 - 25 mm | 15m ² maximum and length not exceeding 1 1/2 times the width. |
| Bonded | Sound, clean concrete more than 3 hours old but not including water-repellent admixture. Base preparation conforming to Sub Sections 11.2.3 | 40 mm (minimum) | |
| Unbonded | | 50 mm (minimum) | |

| | | | |
|--|--|--|--|
| | Damp-proof membrane or concrete which is weak, contaminated or includes water repellent admixtures | | |
|--|--|--|--|

11.3.1 Materials for Screeds

Portland cement conforming to CS 107
 Aggregates conforming to BS 882 and Max. nominal size 10
 Building sands conforming to BS 1199
 Workability additives shall be of approved manufacture.

11.3.2 Mixes

Unless otherwise specified, mix proportions (by weight) shall be as per table 11.2 below or as specified.

Table 11.2

| Thickness of screed (mm) | Cement | Fine aggregate (dry sand or crushed stone graded 5 mm down) | Coarse aggregates (graded 10 mm down) |
|--------------------------|--------|---|---------------------------------------|
| Upto 40 | 1 | 3 - 4 1/2 | |
| 40 to 75 | | | |
| over 75 | 1 | 1 1/2 | 3 |

Note: The cement-aggregate ratio by weight shall not exceed 3. Batching by volume shall conform to Sub Section 4.3.2.1

A mechanical mixer shall be used. Hand mixing shall be adopted with the permission of the Officer in Charge. The driest mix which can be thoroughly compacted with the means available shall be used. A sample squeezed in the hand shall ball together without water being forced out. Workability aids to attain low water cement ratios shall be used to the manufacturer's instructions, if approved by the Officer in Charge.

11.3.3 Laying

Screed concrete shall be laid on bays and thoroughly compacted preferably by means of screed vibrator. Excess of laitance shall not be drawn to the surface while vibrating. The surface shall be leveled with wooden screed boards and wood floated to suit the flooring/roof finish as directed by the Officer-in Charge.

11.3.4 Tolerance for Level

This shall conform to the tolerance for granolithic or other finishes. Please see Sub Section 11.2.10

11.3.5 Curing, Protection etc.

This shall be the same as for granolithic floor finishers.

11.4 Wall Tiling and Mosaic Work

General

Internal wall tiling and mosaic work shall generally conform to BS 5385: part 1, and external wall tiling and mosaic work to BS 5385 part 2.

Where directed, sample areas shall be furnished and approval of the Officer-in charge obtained as regards materials and workmanship. The work on completion shall conform to the sample areas.

11.4.1 Materials

11.4.1.1 Glazed ceramic tiles and specials

These shall be of approved manufacture and for internal work, shall generally conform to BS 1281. For external work and for heavy duty work those recommended by the manufacturers shall be used. The tiles for external use shall be highly vitrified and thicker than internal tiles, and shall be glazed or unglazed as specified. Wall tile sizes shall generally conform to BS 1281.

The following tile sizes are manufactured by the Wall Tiles Corporation:-

| | | |
|--------|---|--------|
| 4 1/4" | x | 4 1/4" |
| 6" | x | 6" |
| 6" | x | 3" |
| 8" | x | 4" |

The tiles shall be flat or round edged, glazed or matt white or other approved color as specified. The tiles shall be sound, hard, well and evenly glazed, free from twist and crazing and true to shape. Tile fittings shall not be less in thickness than the tiles with which they are used. The tiles shall not be damaged or soiled during storage and handling.

11.4.1.2 Mosaics

Mosaic Tessere shall be glazed or unglazed ceramics of sizes supplied by the Ceylon Ceramic Corporation or as specified.

Note:- These are assembled in the form of sheets to approved pattern and color with Nylon nets glued to the back of mosaics or with paper glued to the face of the mosaic.

11.4.1.3 Cement sand mortar

Adhesives where specified, as bedding material for ceramic tiles and mosaics shall conform to BS 5980.

11.4.1.4 Adhesives

Adhesives where specified as bedding material for ceramic tiles and mosaics shall conform to BS 5980.

11.4.2 Fixing

11.4.2.1 Fixing tiles

A rendering or cement mortar 1:3 or 1:4 specified shall be applied over the prepared surface of the wall. The rendering shall be finished with wood floats to give an even texture. The surface shall neither be trowelled nor overworked. No water shall be applied while working and excessive laitance shall not be drawn to the surface. The surface shall be left scratched with wire nail or other pointed tool to provide adequate key for the bedding mortar. The rendering shall be cured for a week and allowed to dry.

The rendering shall be at least two weeks old (or as specified by the manufacturer of the tiles) before tiles are fixed. External tiling shall be started at the top and worked

downwards. Before fixing tiles, the rendering shall be wetted and allowed to dry. Tiles shall be soaked in water for at least half an hour, then drained and stacked. One of the two methods of fixing tiles shall be adopted as approved by the officer-in-charge.

- (a) The buttering method: The back of each tile shall be buttered with cement mortar 1:3 fill all frogs and other indentations filled and bedded solidly over the rendering. The thickness of bedding shall generally be 6 mm and shall in no case exceed 12 mm. The joint widths shall be uniform and normally about 2 mm.
- (b) Floating method: The bedding mortar shall be applied to the rendered surface to a thickness of between 6 and 10 mm, and allowed to stiffen for a short period. A plastic and rich cement mortar 1:2 using fine sand shall be applied to the bedding mortar and evened up. The tiles shall then be pressed on to this surface. Alternatively the tiles could be buttered with the rich fatty mortar and pressed into the stiffened bedding mortar.

A straight edge shall be used to ensure that the surface of the tiling is flat and true. Any adjustment of the tiles shall be made within 10 minutes of fixing.

As the work proceeds, the joints shall be finished off with white (or colored Portland cement to match the color of tiles) and very fine sand mixed in the proportion of 1:1 to paste like consistency; the entire surface shall be cleaned down using a damp cloth before any cement smears and surplus mortar begins to harden on the surface or in the joint spaces, care being taken to avoid any disturbance to the tiles.

If adhesives are used for bedding, specifications of the manufacturer shall be followed.

11.4.2.2 Fixing mosaics

The back ground (of rendering) shall be prepared in a similar manner to tiles as per Sub Section 11.4.2

Before bedding face-papered sheets, the joint cavities on the fixing side of white (or colored) Portland cement and very fine sand in the proportion of 1:1 mixed to a paste like consistency. The backs of mosaics shall be cleaned free of grouting material.

The bedding mix of cement mortar 1:3 shall be floated on to the back ground by trowelling to a thickness not exceeding 10 mm and finishing with a wooden float. A coat of neat cement paste shall be applied and the surface evened up. The bedding shall be allowed to stiffen slightly before the mosaic is applied. The mosaic sheets shall then be hung in position and firmly pressed back at their top edges and the pressure continued downwards until the sheets are firmly bedded.

After a few sheets have been so positioned, this area shall be beaten with a suitable flat implement to ensure good adhesion and a true flat surface. The paper shall be soaked with water, removed, and adjustment of the mosaic done within 10 minutes of fixing. When the work is firm, a grout shall be rubbed over the surfaces to fill any voids remaining in the joints and the work cleaned off with moist cloth. After the grout has hardened sufficiently the surface shall be washed down with water and left clean.

In the case of sheets with nylon backing pre-grouting of joints between mosaics is not necessary. Post grouting of joints shall be done with a grout of cement and fine sand mixed in the proportion of 1:1 to paste like consistency as described before and the work finished off true and flat.

11.5 Asbestos Cement Sheet Ceiling

(Deleted)

11.6 Fibre Board Ceiling

These shall be fixed as described above. Painting shall be as specified in Chapter 18.

11.7 Proprietary Ceiling System

These shall be of approved manufacture and shall be fixed to the manufacturer's specifications.

11.8 Brick Pavements

11.8.1 Bricks

Bricks shall, be good, hard and sound conforming to BS.

11.8.2 Mortar

Mortar used for bedding and jointing shall be lime mortar 1:2 and that used for pointing shall be cement mortar 1:3 all complying with Sections 3:1 and 3.2.

11.8.3 Sub Grade

The brick paving shall be done over a prepared base of consolidated stones, gravel, sand or earth as may be specified. The sub grade shall be provided with the slope required for the flooring itself. Floor - in verandahs, Kitchens, baths, water closets and courtyards shall invariably be provided with suitable sloped to drain off wash and rain water.

11.8.4 Laying

The bricks shall be wetted and shall be laid on edge of flat over a 12 mm thick mortar bed. Each brick shall be properly bedded and set home by gently tapping with the handle of the trowel or wooden mallet. Inside faces shall be buttered with mortar before the next brick is laid and pressed against it.

On completion of a portion of the flooring, the vertical joints shall be grouted with the mortar. The bricks shall be laid to the required slope by constant checking with a 2 m straight edge. The face joints shall be raked with a raking tool to a minimum depth of 12 mm when the mortar is still green and pointed with cement mortar 1:3

Note : If rendering is specified, the mortar for rendering shall generally be cement mortar 1:2. Minimum thickness of rendering shall be 12 mm. The rendering shall be tamped and wood floated to the required surface texture.

The beating shall continue until the concrete is well consolidated and the beater makes no impression and readily rebounds from the surface when struck on it. During the process of beating, the surface shall be kept continuously wet by sprinkling lime water of the sand with bitumen is complete and the mastic well stirred until homogeneous.

Curing and Protection

Shall be as for brick work.

11.9 Plastering for Slab Bearings

Particularly in exposed locations or where specified cement plaster 6 mm thick finished with a floating coat of neat cement and a thick coat of lime wash shall be applied on the top of walls.

11.10 Water Proofing of Reinforced Concrete Roofs

General

Water proofing of flat roofs shall be of the best workmanship executed with utmost care and attention to detail so as to avoid failure. The slopes specified shall be accurately provided.

11.10.1 Reinforced Concrete Slabs Laid Flat

Note: The roof shall be cured for at least 7 days by ponding water to a depth of about 50 mm. (Sub Section 5.4.6.1) After the curing period is over, the roof shall be allowed to dry for another three weeks and attain sufficient strength before laying the water proofing.

11.10.1.1 The screed concrete

A screed of a suitable design shall be laid over the flat slabs and finished to specified slopes. The screed shall be one of the following.

Note: On completion of beating, there shall be no voids and the surface shall be smooth and even. The surface shall be kept moist for a period of 7 days.

11.10.1.2 Water proof cover

The surface shall be finished in one of the following ways:-

(a) Tiling:

Two courses of flat tiles of sound manufacture and 150 x 150 x 10 mm or such other size as specified shall be laid in cement mortar 1:3 with Nonvolatile crude oil at the rate of 10% by weight of cement or Water-proofing admixtures to the specifications of the manufacturers. The tiles shall be laid over a 10 mm thick bed of cement mortar with joints not exceeding 6 mm, and the joints of the 2 courses shall be staggered. Before the work dries up, the joints shall be raked up to about 6 mm and pointed with the same mortar and pressed and rubbed over with thin bar trowels (the excess mortar being scraped off) until the surface of the pointing attains a black polish. The edges of the tile layers shall be finished flush with the finishes for the edges of reinforced concrete slab with a 20 mm thick band of cement mortar 1:3.

(b) Mastic Asphalt

The mastic asphalt shall be of the following:
composition by weight:-

| | | | |
|---------------------------|----|---|-----|
| Sand | 70 | - | 74% |
| Bitumen 20/30 penetration | 15 | - | 13% |
| Filler (Cement, etc.) | 15 | - | 13% |

The sand and bitumen shall be heated separately to about 200° C and bitumen added to the sand and stirred well. The filler shall be added when mixing

- (a) Cement concrete 1:3:6: (20 mm) with a minimum thickness of 25 mm conforming to Clause 4.
- (b) Lime concrete(25 mm) with a minimum thickness of 50 mm composed of one part by volume of slaked lime to 2.5 parts by volume of well burnt broken brick aggregate of maximum size 25 mm. No sand shall be incorporated. The brick aggregate shall be wetted thoroughly and mixed with lime adding just enough water to make it into a stiff paste.

This concrete is laid to a minimum of 50 mm in thickness and well beaten with wooden rammers 40 mm diameter and 1.2 meter long.

The surface of the roof shall be given a priming coat of bitumen, and while still cacky, the hot mastic should be poured on the surface, spread and tamped gently, smoothed out and worked with wooden float or trowels with sufficient pressure until it is free from voids and blow holes and a smooth homogeneous layer 12 mm thick is obtained.

The surface shall be sprinkled with a mixture of fine dry sharp sand containing about 10% of cement and rubbed with floats until a perfectly smooth surface is obtained.

The mastic shall be carried 75 mm up the walls or parapets previously painted with hot bitumen the angle between the wall and roof shall be rounded off and the part carried up the wall beveled.

(c) Bitumastic Emulsion

This treatment shall consist of a priming coat applied to the roof and 230 mm up the parapet walls of Flintkote, Type 1 or equivalent emulsion diluted with about 5% water at the rate of 0.75 litre/ m² a second coat shall be applied when the priming coat is dry, of the same but undiluted emulsion at the rate of 0.75 litre/ m². On this

layer. When still wet, a woven fiber glass membrane or other approved fabric shall be embedded, overlapping all joints by 100 mm. When this is dry, a priming coat of the same emulsion at the rate of 0.5 litre/ m² shall be applied over the membrane. A final waterproofing coat of Flintkote, Type 7 or equivalent emulsion shall be applied by trowel at the rate of 2.5 litre/ m². A thick coat of lime wash shall be applied over the Flintkote to avoid excessive heat absorption.

(d) Plastic Asphalt

The surface shall be cleaned thoroughly and a coat of Bituminous solution PF 4 applied as primer. Care shall be taken that the surface is perfectly dry Plastic Asphalt shall then be applied in two thin layers each 1.5 mm thick, the second coat to dry for four to six days.

(e) Bitumen felt roof covering

This shall conform to BS 747 for roofing felts and BSCP 144 for workmanship.

(f) Proprietary roof covering shall conform to the manufacturer's instructions in all respects.

Note: For b, c & d one coat of clay tiles set in cement mortar 1:3 shall be provided where specified or directed.

11.10.2 Reinforced Concrete Slabs Laid to Slopes

11.10.2.1 The screeds shall be uniform in thickness and one of the following:

- (a) A 12 mm thick layer of cement mortar 1:2 mixed with water proofing admixture to the instructions of the manufacturer.
- (b) A layer of cement mortars 1:3 treated with 2 coats of hot tar 3 mm thick and blinded with sand.
- (c) Cement concrete 1:3:6 (20 mm) 25 mm thick conforming to requirements of Section 4.1
- (d) Lime concrete - 50 mm thick conforming to the requirements of Sub Section 11.10.1

11.10.2.2 The water proofing covering

This shall conform to 11.10.1.2

CHAPTER 12

STRUCTURAL STEEL WORK

12.1 General

Except where otherwise directed by this specification or authorized by the Engineer in writing, the design, detailing, fabrication and erection of structural steelwork shall comply with the edition of BS 5950:Part 1:1990.

The Contractor shall not depart from this Specification except with the permission of the Engineer in writing.

12.2 Supervision of Work

The work shall be supervised throughout by qualified Supervisors who are thoroughly experienced in the fabrication and erection of similar work.

12.3 Materials

12.3.1 New Materials

All materials used throughout the works shall be new unless otherwise specified or agreed by the Engineer in writing.

12.3.2 Miscellaneous Materials

All materials not fully specified herein and which may be offered for use in the works shall comply with the appropriate standards. In the absence of such a standard they shall be to the approval of the Engineer.

12.3.3 Grades of Steel

Unless otherwise specified steel for sections, plates, flats and bars shall comply with grades and standards to be specified.

(a) Rolled Sections and Hollow Sections

Hot rolled structural section and hollow sections shall comply with B.S.4 and BS 4848.
Cold rolled sections shall comply with BS 2994.

(b) Black Bolts

Grade 8.8 bolts shall comply the BS 3692

Black bolts shall have the short thread length and are to be Hot Dip Galvanized to BS 729.
Nuts to be similarly galvanized as blanks and then tapped up to 0.4mm oversize with the threads lightly oiled.

(c) Washers

Flat, circular and square taper washers shall comply with BS 4320 and be Hot Dip Galvanized to BS 729.

(d) Electrodes

Electrodes and fluxes for metal-arc welding shall be in accordance with BS 639 or BS4165 and shall be suitable for the highest grade of parent metal being joined.

12.4 Design and details

12.4.1 Amendments to Details of Design

Should the Contractor wish to propose alternative details to those specified for the design of the works application shall be made in sufficient time to permit the Engineer to give full consideration to the proposals.

12.4.2 Shop Drawings

The Contractor shall prepare and provide detailed shop drawings and schedules for fabrication of the steelwork. These drawings shall be based on the Tender Drawings and on any further drawings or written instructions issued by the Engineer during the Contract.

The Contractor shall provide at the outset two copies of a marking plan locating shop details to facilitate identification for approval.

The shop drawings shall clearly show all details and dimensions of the work, and the materials from which each part is to be made, and the calculated weight of the materials.

Fabrication of the steel work shall not commence until the Engineer has approved the shop drawings, and for this purpose copies of checked shop drawings and copies of checked supporting calculations shall be submitted so that not less than fourteen clear days are available to the Engineer for his consideration from the date of receipt of the drawings.

The Engineer will verify the correct interpretation of his requirements but will not necessarily verify the dimensions, and the Contractor shall be entirely responsible for the accuracy of the drawings, the correctness of design and details of connections and joints. After the Engineer has approved each drawing the Contractor shall provide the Engineer with copies of all final drawings.

The Contractor shall supply to the Engineer 6 copies of all drawings necessary for setting out the foundations to suit the permanent steelwork and to suit any temporary works required for erection of the steelwork and the Contractor shall be responsible for the accuracy of these drawings. Any requirements to suit temporary works shall be given in sufficient time to enable them to be incorporated in the foundations design and construction program.

At the completion of the Contract, the Contractor shall provide 3 copies of all shop drawings to constitute an “as built” set incorporating all amendments and modifications, which have been carried out.

12.4.3 Welded Connections

The length of fillet weld specified on the Drawings shall be the overall length including end craters.

The design shall provide adequate accessibility for welding and inspection during fabrication. The profile of the joints shall enable satisfactory non-destructive testing to be carried out.

No welds apart from the continuous longitudinal web to flange welds shall be made to tension flanges of members without the written permission of the Engineer.

12.4.4 Bolted Connections

Nuts in connections subject to vibration shall be the self-locking type or provided with lock nuts.

Whenever bolted connections are used, the reduced sectional area of members shall be computed and the member strengthened if required.

12.4.5 Camber

Where members are to be cambered, the amount will be specified on the drawings and the means of achieving the correct amount of camber shall be agreed with the Engineer and shown on the shop drawings.

12.4.6 Responsibility

The Engineer's approval of the Contractor's design and drawings shall not in any way relieve the Contractor of responsibility for any error subsequently discovered in the detailing.

12.5 Fabrication

12.5.1 Cutting

Machine flame cutting or shearing of steel to BS 4360 grade 50B and 50C and of steel to BS 4360 grade 43D in tension flanges over 50mm thick is only acceptable if at least 3mm of material is removed from the flame cut or sheared edge by matching.

12.5.2 Straightening

All plates, bars and sections shall be flattened and straightened and made free from twist before any other work is done on them.

The method adopted for this work shall be such as not to injure or mark the material.

12.5.3 Notches

The ends of all beams or girders shall be square where required and flanges neatly cut away or notched where necessary. All notches shall be kept as small as possible and shall be radiused in the inner corner.

12.5.4 Drainage Holes

Drainage holes shall be provided in members where water could collect during and after erection.

12.5.5 Holes

Holes shall be in accordance with BS 5950 except that drilling shall away be used to form holes for friction grip bolts, even if these are in cleats. Holes shall be cleaned up and all burrs and deformed metal removed.

12.5.6 Machining of Joints

The butt ends of compression members which are to be spliced by bolting shall, except where the bolts carry the loads, have their abutting faces machined after fabrication so that they shall be square to the member axes and in tight bearing contact throughout when erected.

The ends of stanchions at intermediate splices and where they bear on bases or caps shall be machined after fabrication so that they shall be in tight bearing contact throughout.

12.5.7 Minimum Thickness

All gusset plates, rolled sections and built-up sections shall be not less than 8mm thick. This does not apply to the webs of rolled steel universal beams and channels.

12.5.8 Accuracy of Measurement

All dimensions shall be made with a steel tape related to a standard tape, which has been certified to be correct at 20⁰ C. The tape and steel to be measured shall be at the same temperature and proper precautions shall be taken to tension the tape correctly to the satisfaction of the Engineer.

12.5.9 Fabrication Tolerances

The maximum acceptable tolerances on fabricated items shall be as follows:

- (a) Length of compression member finished for tight bearing contact: ± 1 mm.
- (b) Length of any other member 9.0m long and/ under: ± 2 mm.
- (c) Length of any other member over 9.0 m long ± 4 mm
- (d) Width of plate girders: ± 3 mm. Depth of plate girders (measured at centre line of web).
 - I. For depths up to 400mm: ± 3 mm
 - II. For depths over 400mm: ± 4 mm
- (e) Deviation from straightness: Length of finished member/1000
- (f) Deviation from straightness of sheeting rails: Length of finished member/500 but not more than 25mm.
- (g) Deviation of centre line of web from centre line of flanges in built-up members at contact surfaces: 3mm.
- (h) Deviation from flatness of plate webs of built up members in a length equal to the depth of the member: Depth/200 or 10mm whichever is greater.
- (i) Tilt of flange of welded plate girders.:

For flanges up to 450mm in width: 2mm

For flanges over 450 mm in width: 3mm

The offset shall be the amount the toe of the flange is out of square with the point of intersection of the web measured at the underside of the flange.

Deviation from squareness of fixed base plates to axes of column: 3mm. This dimension shall be measured parallel to the longitudinal axis of the column at the points where the outer surfaces of the column sections make contact with the base plate.

Deviation from squareness of machined ends of axes of columns: 0.50mm

Deviation from squareness of machine faces of end plates to axes of beam or girder: 0.50mm.

Where a tight bearing contact is specified on the drawings. The abutting parts shall be deemed to be in contact when the following requirements have been fulfilled.

Over at least 60 per cent of the bearing surfaces the gap between the surfaces shall not exceed 0.25mm.

Over the remainder the gap shall not exceed 0.50 mm.

The above acceptable tolerances shall be uniformly distributed over the whole of the abutting parts.

Notwithstanding the above permitted fabrication tolerances, the structure shall be erected to comply with the specified erection tolerances.

12.5.10 Slab Bases and caps

Slab bases and caps shall be accurately machined over the bearing surfaces and shall be in tight bearing contact over the whole area of the machined end of the stanchion or column.

Holes of not less than 40mm diameter shall be provided in all slab bases where indicated to facilitate grouting.

Contact surfaces of connections blast cleaned as part of general surface preparation for works painting shall be masked with adhesive bands before any paint is applied. The masking shall be removed from both contact surfaces of a connection immediately before a connection is made. Masking bands shall not be treated with an adhesive, which adversely affects the slip factor coefficient between the contact surfaces.

Contact Surfaces of Connections on Steelwork Located Externally.

Contact surfaces of non-friction grip bolted connections on steelwork having a paint finish and which is located externally shall be painted with one coat of red lead primer prior to bringing together.

12.5.11 Painting Near Welded Work

No paint other than pre-fabrication primer shall be applied within 50mm of the edges of steelwork, which is to be welded.

12.5.12 Coating of Inaccessible Surfaces of Unpainted Steelwork

Surfaces of member which will be rendered inaccessible when fabrication is completed and are not in close contact with other surfaces shall be protected by filling the cavity between the surfaces with sealing compound or by application of a coating system as shown on the drawings.

The coating system for surfaces of steelwork which are accessible after fabrication but are concealed and not accessible after erection shall be as shown on the drawings or as specified.

12.5.13 Identification of Steel

At all stages of fabrication, structural steel shall be positively identified by grade, either by colour marking or by another marking system.

12.6 Welding

12.6.1 General

Welding of structural steelwork shall be by an electric arc process. The procedure to be followed, plant and equipment to be used and the testing and inspection to be applied shall conform with BS 5135 and this specification.

All non-mandatory clauses and parts of the BS will apply. In particular, the recommendations of Appendix E shall be followed and all weld procedures shall indicate compliance with these requirements.

12.6.2 Terms and Symbols

On all drawings, welding procedure sheets, etc., terms and symbols relating to the welding and cutting of metals shall be in accordance with BS 5950 where applicable, unless otherwise agreed by the Engineer.

12.6.3 Electrodes

Low hydrogen basic coated electrodes to BS 639 shall be used in the following circumstances.

For the welding of steel to BS 4360 grades 50B and 50C.

For butt welds in steel to grades 43C and 43D.

For the root run of but welds in steel to grades 43B in tension flanges 26 mm thick and over.

The impact properties of the parent plate and/or the requirements of the relevant design code shall be considered in the choice of consumables.

12.6.4 Shop and Site Welding

Shop welding shall be carried out in workshops under the specified conditions of temperature, materials, welding procedure, workmanship, welding operations, supervision and inspection.

Site welding shall not be permitted without the special approval of the Engineer and then only if it is carried out in compliance with the conditions specified above.

12.6.5 Welding Procedure and Quality Control

Details of the proposed welding procedures shall be submitted to the Engineer for written approval three months prior to commencement of welding, together with related quality control documentation such as electrode specification, storage, drying and handling requirements.

Testing of welding procedures with accordance BS 5135 and BS 4870: Part 1 or other satisfactory evidence of the Contractor's competence will be called for by the Engineer. No welding shall be carried out unless a procedure has been submitted and approved. This requirement shall include all repair welds, welded attachments, supports and fabrication aids even where these may subsequently be removed.

Welding procedure shall be such that distortion is reduced to a minimum.

Approval of the welding schedules and procedures shall not relieve the Contractor for this responsibility for correct welding and for the minimizing of distortion in the finished structure.

The contractor shall ensure that the design of welds is such that a full volumetric examination of the weldings may be made when ultrasonic or radiographic inspection is required.

12.6.6 Fusion Faces

The forms of weld joint preparation shall be in accordance with BS 5135 as applicable or as may be otherwise approve by the Engineer.

12.6.7 Butt Welded Joints

The ends of butt welds shall have full throat thickness. On rolled sections this shall be achieved by the use of extension pieces, cross runs, or other means approved by the Engineer. On all main plates this shall be obtained by the use of run-on and run-off plates cut from extensions of the main plates and securely clamped to the parent plate.

Such run-on and run-off plates shall have the same joint preparation as the parent plate and arranged so that the direction of rolling is the same as that for the parent plate.

12.6.8 Intermittent Welds

Intermittent Welds shall only be permitted with the approval of the Engineer.

12.6.9 Testing of Welding Operators

The Contractor shall allow in the fabrication and erection rates for the steelwork for the cost of testing his welders and all associated costs including the provision of all labour, material and equipment for the preparation and testing of test specimens and for providing the services of a qualified welding examiner.

Welding operator shall be qualified using the appropriate tests corresponding to the weld positions and parent materials to be employed.

Only welding operators who can produce evidence acceptable to the Engineer of having satisfied the appropriate tests shall be employed on welding.

12.6.10 Acceptance of Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment and absence of undue distortion in the structure, upon satisfactory results from the inspection and testing of the joints and the test specimens, upon the soundness of the welds and upon general good workmanship.

12.6.11 Marking

Every piece of steelwork shall be distinctly marked before dispatch in accordance with the marking plan prepared by the Contractor. It shall also be given other marks and symbols as necessary to assist erection at site, by showing from which works it has come.

Unless otherwise approved by the Engineer members which are to be finished painted at works, metal sprayed or galvanized, shall have all marks hard stamped in addition to being painted. The hard stamping, to such a depth that it will not be obliterated by the metal spraying or galvanizing, shall be done at one end of the member and shall be ringed with a paint mark. Where steel is given anti-corrosion treatment before arrival on site, the marks must be painted with a white paint that can easily be covered with the final site anti-corrosion treatment.

12.6.12 Inspection

Materials and Workmanship

All materials and workmanship shall be subject to inspection by Engineer and this will be at the place of manufacture or fabrication or on the Site or at all any such places. On receipt of copies of orders placed by the Contractor for plant and goods of other manufacturers or suppliers, as called for herein the Engineer will notify the Contractor as follows:

That inspection and/or testing will be carried out at the manufacturer's or the Contractor's workshop, or

That inspection will be carried out at Site by the Engineer, or

That inspection will be waived subject to the Contractor furnishing the Engineer with a Certificate of compliance with the Specification, or

That no inspection or certificate is required.

The Contractor shall notify the Engineer of the dates on which manufacture of items is to commence at his own factory or the dates on which standard items will be available for

inspection. In the case of items, the manufacture of which takes place in stages over a period for which intermediate stages are to be inspected as the work proceeds, the Contractor shall from time to time notify to the Engineer of the dates on which such inspection can be made.

The Contractor shall allow reasonable time (not less than 10 days) for the Engineer to make arrangements for inspection or give permission for dispatch to site. Late notification will not be accepted as a reason for delay in completion of the works.

No items are to be erected until the Engineer has inspected and approved them.

12.7 Site Erection

12.7.1 Plant and Equipment

The Contractor shall provide sufficient plant and equipment to facilitate the efficient erection of the steelwork to meet the program and other requirements. The Contractor shall maintain the plant and equipment in good working order.

The Contractor shall submit to the Engineer for his approval, carnage proposals for erection of steelwork.

The proposals shall be such as to ensure that no damage occurs to the foundations, ground floor slabs or other works.

The carnage proposals which will include track positions and loadings, etc., shall be submitted to the Engineer in sufficient time for a check to be undertaken on the design of concrete works prior to commencement of steelwork erection.

12.7.2 Erection Procedure

Details of proposed erection procedures accompanied by diagrams where necessary shall be submitted to the Engineer for his approval in good time prior to erection. The Engineer may call for other erection procedures should he consider them necessary.

12.7.3 Handling

Damage to any part of the structure either before or during erection shall be immediately brought to the notice of the Engineer. No damaged part shall be assembled in the structure without the approval of the Engineer.

12.7.4 Contractor's Area

The Contractor shall make adequate arrangements within his allocated area for storing and handling all his materials.

12.7.5 Setting out

The Contractor will be supplied with particulars of datums for line and level, which shall be used for setting out the structure.

The contractor shall be responsible for the correct positioning and the correct levels of the structure in relation to the datums given.

The contractor shall give the Engineer not less than 24 hours notice of his intention to set out or give levels for any part of the works.

Errors subsequently found in the alignment or levels of the steelwork shall be corrected by the Contractor at his own cost.

12.7.6 Plumbing of Sections

The maximum permissible deviation from the vertical centre line about both axes shall not exceed 0.1% of the height.

12.7.7 Lining and leveling

The permanent bolting up of connections shall not be carried out until a sufficient portion of the structure has been erected and temporarily connected up to ensure that there shall

be no straining of members during erection, lining up and leveling of the remainder of the structure.

The maximum permissible deviation for horizontal line and level of the steelwork shall be +6mm on any part of the Structure.

Shims shall not be used without the approval of the Engineer.

12.7.8 Temperature Effect

All steelwork shall be level and plumb within the permitted tolerances at mean ambient temperature at the time of issue of the completion certificate.

12.7.9 Foundation Bolts and Anchorage Materials

The Contractor shall supply such drawings and steel templates as may be required for the proper positioning of holding down bolts and bases. The foundation bolts shall be of an approved manufacture and shall be fitted with washer plates or anchor frames and nuts etc. as indicated on the drawings.

12.7.10 Temporary Bracings

Temporary bracings shall be provided by the Contractor to ensure the stability of his work during erection. Details of the Contractor's proposals in this respect shall be submitted for the approval of the Engineer before work is commenced.

12.7.11 Temporary stagings

Stagings of adequate strength and working area together with reasonable access thereto shall be provided by the Contractor to facilitate the work of erection and inspection.

12.8 Painting

In connection with the detailed system, the Contractor and the Paint Supplier may suggest changes in relation to the offer, but such changes shall be approved by the Client before use is allowed.

All systems offers shall comply with the required guarantees whether they are alternative or not.

12.8.1 Quality Surveillance

The paint supplier shall be able to approve, without any reservations whatsoever, the detailed system.

As a minimum, the system shall be specified by the following information being available and agreed upon.

Data sheets for all used products from paint supplier.

Work hygienic data sheets for same products.

Complete system description in the form of:

Cleaning degree and method

Number of layers and thicknesses of each type of paint

Repair procedure for damages occurred during mounting

Total minimum dry film thickness.

Colour sample of finishing coat to be compared with colour requirements.

Extent of documentation for process control carried out.

Extent of documentation for end test carried out

12.8.2 Execution of Paint System

(a) Quality Specification

Before start-up of surface treatment, the paint contractor shall verify that the steel parts are in a satisfactory condition.

All sharp edges shall be ground, radius app. 2mm or 2 x 30 chamfering so that angles between surfaces become 3 angles of each 150 measured externally on the steel.

Degree of rust on the steel may in no place be more than C according to ISO 8501-1

No top rolls ("ash spots") or similar defects may occur in the steel surface.

Surface of welding joints shall be so even that the sandblasting results in a clean rust degree C. If the result obtained corresponds to Sa 2 ½ of rust degree D, the surface is too uneven and has to be ground.

Grinding splatters ("pearls") shall be removed.

Deviations from the above mentioned shall be submitted to the Client and repair shall be made before finishing the cleaning. Possible repairs shall be made by the steel contractor and do not give rise to extra payments.

(b) Pre-Treatment

All steel surfaces shall be effectively free from oil and grease.

Cleaning of rust, iron scales, etc. shall take place by sandblasting (dry) unless otherwise agreed.

Cleaning degree at least Sa 2 ½ according to ISO 8501-1.

Means of blasting is optional but the roughness shall be according to BN9a-BN10 according to RUGOTEST No. 3 (may be adjusted in connection with choice of product).

Grinding is allowed to be locally used if this serves the purpose. The final result shall be according to BN9-BN10 according to RUGOTEST No. 2.

All mechanical cleaning shall, before painting, be finished with efficient removal of sand, dust and other loose material.

In case of doubts, the “tape test” gives the requirements.

(c) Painting

Generally, the paint supplier’s requirements shall be complied with.

Painting may only take place by rolling if so recommended by the paint supplier.

Picking out with a brush shall be used in areas which experiences tell make problems with a full film thickness. This is the case for example with welding joints, edges and re-entrant corners.

Number of layers to be decided upon depending on final choice of type.

There shall be change in colours between each coat.

The final coat shall not be matt.

Runners and possible traces of brush may be accepted to the extent that they do not influence the quality of the corrosion protection of the treatment.

The final coat shall totally cover below colour.

Requirements to film thickness Are stated in the system specification.

All surface treatment, including the above-mentioned pre-treatment and cleaning, is assumed to take place in paint hall/shop.

Repair of Defects, etc.

All repairs of defects, damages, repairs after mounting, etc. shall take place according to the supplier’s indications.

(d) Documentation.

Below requirements to documentation are minimum requirements, which shall always be complied to.

Documentation shall be supplied for number of measurements of total dry film thicknesses both for work carried out in shop and carried out in open air (or outdoor climate)

Documentation shall furthermore be supplied on climatic conditions for works not carried out in workshops including for repairs of mounting damages not carried out in heated building.

The Client reserves the right to make unnoticed inspection and control during the execution of the work to the extent wished, including control of instruments for registration of climatic data.

Thickness of Layer and Measurement of Thickness

The construction to be divided into control areas in which measurements of coat thicknesses are carried out.

Within each control area is placed (possibly marked) a measuring area. This is naturally placed where the smallest thicknesses are found.

10 evenly distributed single measurements are carried out in each measuring area and the results written down.

(e) Acceptance Criterion.

In case the minimum value of the 10 single measurements is greater than specified minimum thickness of coat, the control area is approved and thus the construction part in question.

In case the minimum value of the 10 single measurements is greater than specified minimum (=100%) but greater than 90% of the specified value, another 10 evenly

distributed single measurements are carried out (to be displaced compared to the first ones)

In case a maximum of 5 of the total 20 single measurements are below the specified minimum, but above 90% therefore the area is approved.

If this is not the case, the area, and thus the construction part, is rejected.

In case more than 2 of the first 10 single measurements are below 90% of specified minimum, the control area, and thus the construction part, is rejected.

(g) Adherence

IN case of doubt concerning the adherence, the Client may demand that it be examined. Indications as to the quality of the adherence may be obtained by web cutting, but in case of doubts or uncertainty, the adherence shall be determined by the pulling method according to ISO 4628.

The values measured shall not be below 65% of the mean value of 10 samples carried out on test plates.

(h) Test Plates

The Contractor shall, before start-up of work, supply the Client with two test plates of steel (minimum 200x300mm). The plates shall be treated with the specified surface treatment system as the first app. 3cm shall be untreated, but Sa 2 ½, and each coat shall be scaled down app. 3cm compared to the previous coats. Of the 300 mm plate thus only app. 18cm are painted but sandblast.

(j) Documentation for Film Thickness

A report shall be supplied for results of measurements carried out of total (finished) dry film thicknesses.

(k) Documentation for paint Goods.

Before start-up of work in workshop, the Contractor shall send documentation for all paint goods to be used to the Supervisor.

Guarantee Requirements to Paint System

12.9 Quality Specification

The Contractor will prove that he will carry out the total execution process in a professional and correct manner in all details by guaranteeing the quality of the finished work.

Quality Assurance

12.9.1 Quality Assurance General

The contractor shall be responsible for the Quality Management as stipulated in the ISO Standard. ISO 9001: Quality system- Model for quality assurance in design/development, production, installation and servicing.

The contractor may be at liberty to use his own QA-model if deemed equal to the ISO 9001 by the Employer.

12.9.2 Definitions

In the ISO 9001 Standard the following words shall have the meaning hereby assigned to them.

“The Supplier” means “The Contractor”

“The Purchaser” means “The Employer”

“The Purchasers representative” means “The Engineer”

12.9.3 Organization

The Contractor shall submit to the Employer, for review, his Quality Management Organization. The organization plan shall define all key personnel who manage, perform and verify work affecting quality. The responsibility, authority and interrelation of the personnel shall be clearly defined for the Contractors own personnel as well as for that of his subcontractors.

12.9.4 Quality System

The Contractor shall establish a Quality System as a means of ensuring that all work under his Contract conforms to the specified requirement.

The Contractor shall submit to the Employer, for review, a program which defines the procedures adopted to comply with this requirement as stipulated in ISO 9001.

The program shall comprise all aspects of the Quality System including.

- Design control
- Document control
- Purchasing
- Process control
- Inspection control
- Control of non-conforming products
- Handling storage, packing and delivery
- Erection control

12.9.5 Quality Records

The Contractor shall establish and maintain such records as are stipulated in ISO 9001 and these records shall be copied and submitted to the Employer.

12.9.6 Verification of Purchased Products

The Employer shall be afforded the right to verify at source or upon receipt that purchased products conforms to specified requirements.

12.9.7 Use or repair of non-conforming products.

Proposal to use or repair non-conforming products shall be subject to approval by the Employer.

12.10 Specification for roofing, flashing, fasteners, purlins, surface treatment for structural steel & drain water accessories

12.10.1 Zn/ Al roofing including all necessary flashing, capping, trims, etc. conforms to AS-1397-2001 or an equivalent with the following properties;

- Minimum yield strength - 550 MPa (Grade G550 steel)
- Base metal thickness (BMT) - 0.42mm
- Total coat thickness (TCT) - 0.47mm
- Minimum Zinalume steel resin coat - AZ 150 (coating mass = 150 g/m²)
- Composition of zcalume coating - 55% Aluminum, 43.5% Zinc and 1.5% Silicon

12.10.2 Roofing fasteners with sealing washer conforms to Class 03 of AS 3566 or an equivalent

12.10.3 High tensile pre-galvanized lipped channel purling (roll formed) conforms to AS 1397- 2011 or an equivalent with the following properties;

- Minimum yield strength - 450 MPa (Grade G450 steel)
- Zinc coating - Z350 (coating mass = 350 g/m² on both surfaces)
- Passivation - Chromate passivated

12.10.4 Surface treatment for all structural elements

Durability and surface protection for structural steel shall be comply with the environment category C5M with a durability period of 5-15 years {medium durability} as given in BS EN ISO 12944 and ISO 9223.

12.10.5 Purlins should be manufactured using pre-galvanized mother coils that has exact same width as the girth required to produce the purlins (Purlins manufactured from slitted coils are not acceptable).

12.10.6 Drain water accessories to AS-1397-2001 or an equivalent with the following properties;

- Minimum yield strength - 550 MPa (Grade G550 steel)
- Base metal thickness (BMT) - 0.37mm
- Total coat thickness (TCT) - 0.4mm
- Minimum Zinalume steel resin coat - AZ 150 (coating mass = 150 g/m²)
- Composition of zcalume coating - 55% Aluminum, 43.5% Zinc and 1.5% Silicon

Specification for Coating System - C5-M Marine Corrosivity Category

1. Objective: This specification outlines a comprehensive coating system for structural steel in the C5-M (marine) corrosivity category, as per ISO 12944 standards. This system is designed to withstand harsh marine environments, characterized by high salt and moisture levels.

2. Surface Preparation:

- Clean the surface to remove all contaminants, including salts, oils, and grease.
- Perform abrasive blasting to achieve Sa 2.5 (near-white metal blast cleaning) as per ISO 8501-1.

3. Primer Layer:

- Apply a zinc-rich epoxy or inorganic zinc silicate primer for cathodic protection.
- Dry film thickness (DFT) of 60-80 microns is recommended.

4. Intermediate Layer:

- Use an epoxy mastic coating for additional moisture barrier.
- Typical DFT for this layer: 120-180 microns.

5. Topcoat Layer:

- Apply a polyurethane or polysiloxane topcoat for UV and salt resistance.
- DFT for the topcoat: 50-100 microns.

6. Total Dry Film Thickness:

- Combined DFT: 240-360 microns, depending on environmental exposure and durability requirements.

7. Quality Control:

- Inspection of each layer for application quality, thickness, and curing.
- Address defects per manufacturer's instructions.

8. Environmental Conditions for Application:

- Ensure appropriate conditions, avoiding high humidity and extreme temperatures as guided in the manufacture's guidelines.

9. Manufacturer's Guidelines:

- Adhere to guidelines for mixing, application, and curing times.

10. Warranty Clause:

- **Duration:** 15 years from the date of application.
- **Coverage:** Includes defects in materials and workmanship.

- **Contractor/Supplier Responsibility:** Repair or replace defective coating at no extra cost.
- **Conditions and Limitations:** Warranty void if subjected to mechanical damage, improper maintenance, or unauthorized alterations.

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specifications- Electrical

23553-01-TN-EL-SP-9800

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| 2.0 | URO | Tender Issue | 14.12.2023 |

1.0 GENERAL

1.1. INTRODUCTION

The works described by this specification covers the supply, installation, testing, commissioning of Electrical services installation of the building in accordance with this specification and associated drawings, and without abrogating the more extensive details described elsewhere in the specifications and drawings including the followings.

1.2. SCOPE OF WORK

The scope of work for the electrical installations covered by this specification is described as follows:

- Supply and installation of Earthing and Lightning protection system including equipotential bonding and other accessories.
- Coordinating of the Power Receiving system with the power authority (City Line).
- Supply and installation of Low Voltage Power Distribution System. (Low voltage (LV) Main Switch Board (MSB) with Manual Transfer Switch (MTS), Main Distribution Board (MDB), Floor Distribution Boards (FDBs), Final Distribution Boards (DBs)).
- Supply and installation of cable management system including cable trays, cable ladders, cable trunkings etc., cable ties, cable markers and other accessories.
- Supply and wiring of final circuits for lighting, general power outlets, equipment power supply, etc.
- Supply and installation of lighting fixtures of appropriate type as per the drawings & Small power system.
- Testing commissioning and proper hands-on training of all the above systems.

1.3. APPLICABLE PUBLICATIONS AND STANDARDS

Standards and Publications of the following organizations form part of this Specification to the extent indicated by the references thereto unless superseded by Detailed Technical Specifications.

- | | | |
|----------------------------------|---|---|
| 1. BS 7671 | - | The IEE Wiring Regulations for electrical Installation works (18 th Edition) |
| 2. BS 6004:2012 | - | PVC insulated & PVC sheathed cables, |
| BS 5467 | - | Thermosetting insulated, armoured cables |
| 3. BS 7846 | - | Fire Resistant Cables |
| 4. BS 4678 Part 1 & 2 | - | Cable Trays, Cable Trunking |
| 5. BS 4568 Part 1 & 2 | - | Steel Conduits |
| 6. IEC 61439-1 | - | Low-voltage switchgear and control gear |

| | | |
|-------------------------|---|--|
| | | assemblies |
| 7. BS 5486 Part 12 & 13 | - | Distribution Boards |
| 8. IEC 60947-1 to 7 | - | Low-voltage switchgear and controlgear |
| 9. BS 1363-1 to 5 | - | Switch Socket outlets |
| 10. BS EN 60669-1 | - | Lighting Switches |
| 11. BS IEC 1008-2-2 | - | Residual Current Circuit Breakers |

1.4. CLIMATIC CONDITIONS

All electrical equipment, accessories and fittings to be used in electrical installations shall appropriate for climatic conditions of Kulhudhuffushi Island having the following features:

| | |
|------------------------------|------|
| Maximum ambient temperature: | 35°C |
| Average ambient temperature: | 30°C |
| Maximum relative humidity: | 85% |

All electrical equipment and cables shall be rated for continuous operation at an ambient temperature of 30°C. In plant and machine rooms an ambient temperature of 35°C shall be assumed. Directly buried cables shall be rated for ground temperature of 20°C and soil thermal resistivity of 2° C m/w.

Unless otherwise mentioned, due allowance has been made in the design of the electrical installations described in the specifications and drawings for the prevailing climatic conditions and all equipment, cables, switches, etc., specified shall be satisfactorily selected accordingly.

1.5. SERVICE CONDITIONS

All electrical equipment, apparatus, accessories and fittings shall be so designed and manufactured to operate continuously in the electricity supply system having following characteristics:

| | | |
|-----------|---|-------------------------------------|
| Voltage | : | 400 volts \pm 5%, 3 Phase, 4 Wire |
| Frequency | : | 50 Hz. \pm 2 % |
| Neutral | : | Solidly earthed |

1.6. DRAWINGS

The electrical drawings issued with the specification, indicate general arrangements of electrical equipment, cable trays and cable routes, location of panels, cable schedules, wiring/schematic diagrams. Drawings will also indicate any other relevant details relating to this particular project. The information given on the drawings is indicative and as accurate as surveys and planning can determine. Field conditions should be checked and electrical work shall be properly carried out, for maximum efficiency and to avoid any conflict with structures and any other work. Each item shall be verified for proper action and position before final connections are made.

1.7. SUBMISSION FOR APPROVAL

The Contractor shall submit to the Engineer the required documents to establish compliance with the specification. Submittal shall include at least the following documents.

- Equipment shop drawings.
- Equipment data.
- Test reports.
- Test certificates.
- As-built drawings.
- Operation and maintenance manual.

1.8. EQUIPMENT SHOP DRAWINGS

The Contractor shall submit three (3) prints of the shop drawings of all equipments. The Contractor shall check catalogues and shop drawings for accuracy and contract requirements prior to submittal. Shop drawings shall be stamped with the date checked and a statement indicating that the shop drawings conform to the Specifications and Drawings. This statement shall also list all exceptions to the Specifications and Drawings.

All dimensions shall be field verified at the job site and coordinated with the work of all other trades.

The Shop Drawings shall show the position, dimensions, scheme, arrangement and fixing of all electrical equipment.

Equipment shall not be ordered or shipped until the shop drawings have been approved. No material shall be ordered or installation work started if shop drawings are marked as "APPROVED AS NOTED - CONFIRM", "APPROVED AS NOTED - RESUBMIT"

1.9. WORKING DRAWINGS

In addition to manufacturer's equipment shop drawings, the Contractor shall submit three (3) sets of the following installation working drawings. The Contractor shall prepare the LV installation drawings to a scale agreed on with the Engineer and shall issue them in accordance with the requirements of the Contract having due regard to the time required for approval procedures.

The system installation drawings shall show the position, dimensions, scheme arrangements and fixing of all electrical equipment. The drawings shall comprise, but shall not limit to the following:

1. Dimensioned drawing of raceway systems showing layout of raceways and fittings, spatial relationships to associated equipment and adjoining raceways, if any.
2. Dimensioned drawings of cable routing showing accurately layouts of cables installations and their spatial relationship to associated equipment and details of installation.

3. Dimensioned drawings showing accurately scaled layouts of the location of the equipment and their spatial relationship to associated equipment.
4. Dimensioned drawing of lighting system showing reflected ceiling and lighting layout.
5. Wiring diagram schematic.

1.10. CO-ORDINATION

The LV installation work must be coordinated with the building work and work of other services. The drawings and specifications shall be carefully examined and information regarding building materials and equipment supplied by others obtained from the respective source to determine the extent, type and location of all wiring required. All holes and openings in slabs and walls which may be required for the passage of electrical conduits, trunking and cables must be determined and information regarding them passed on to building contractors so that they may be provided for at the time of pouring of concrete or construction of walls, breaking of concrete, cutting and patching of the structure shall be limited to a minimum and carried out only after securing the consent of the supervising Engineer. All cables and conduits passing holes must be made good by fire resistant incombustible material. Further protection of cables and conduits shall be given as instructed by the Engineer.

1.11. INSTALLATION

Any work not installed according to the Drawings and this Section shall be subject to change as directed by the Engineer. No extra compensation will be allowed for making these changes.

Electrical equipment shall be protected at all times against mechanical damage or damage by water. Electrical equipment shall not be stored outdoors. Electrical equipment shall be stored in dry permanent shelters. Electrical equipment shall not be installed in its permanent location until structures are weather tight. If any apparatus has been subject to possible damage by water, it shall be thoroughly dried out and tested as directed by the Engineer, or shall be replaced at no additional cost at the Engineer's discretion.

Equipment that has been damaged shall be replaced or repaired by the equipment manufacturer, at the Engineer's discretion.

Contractor shall repaint any damage to factory applied paint finish using touch-up paint furnished by the equipment manufacturer.

1.12. TESTING & COMMISSIONING

The Contractor shall be responsible for satisfying himself as to the correctness of the LV System connections to all work supplied and installed by him under the Contract before such work is put into operation.

After the connection of power supply to the installations, the Contractor shall commission all sections of the electrical installations and demonstrate to the Engineer or his Representative that the entire electrical installations are in perfect working order. Where equipment of a

specialized nature is involved, the Contractor shall, if necessary or requested by the Engineer seek and obtain at his own cost the services of specialist and/or commissioning engineers from the suppliers/manufacturers.

1.13. TRAINING

The Contractor shall submit a full proposal of the recommended training necessary for the owner's personnel to attend to routine testing, maintenance service and minor repairs including an indication of the duration of such training.

The number of persons required to be trained shall be determined jointly by the Engineer, and the Contractor.

The scope of training shall include on-site training and such training shall be prior to hand-over of the system. Technical training and system operation instructions to the owner's personnel shall also be provided during the commissioning and performance tests phases of the system.

System operation instructions shall be given by an experienced and competent representative of the Contractor who is thoroughly conversant with the electrical system installed.

1.14. AS BUILT DRAWINGS

All drawings prepared or amended by the Contractor to show the works as constructed shall be known as "As Built" Drawings. All such drawings shall be prepared using S.I. Units and shall have the size of the Contract Drawings. Not more than 4 weeks after the date of the completion of the inspections or such other period of time as may be agreed with the Engineer, the Contractor will submit for the Engineer's approval two paper prints of each of the drawings. After checking the prints of "As Built" Drawings submitted by the Contractor the Engineer will return to the Contractor one copy marked to show his signed approval or comments.

The "As Built" Drawings shall accurately show the installed conditions of,

1. All equipment, conduits, trunkings, lighting fixture, receptacle and switch outlet locations, etc.
2. Circuit lists for each distribution board and such lists shall agree with lists fixed within distribution board doors.
3. Complete electrical circuit details including lighting and power points suitably referenced to indicate type of fittings, manufacturer's name, catalogue number, lamp size and type.
4. Schematic diagrams, single line diagram, control wiring diagram and lighting fixture schedule, distribution board schedules, cable schedules, switchgear and control gear schedules.
5. Indicate all plant room installations in drawings to scale 1:50.
6. Legends which shall detail the symbols used and which shall conform in style and standard to those used in the working drawings.

7. Plan view, sizes and locations of switchgear, motor control centre & mechanical equipments.

1.15. OPERATION AND MAINTENANCE MANUALS

The contractor shall submit comprehensive Operation and Maintenance Manuals of all equipment supplied during the site training. It shall consist of all the detailed diagrams of the equipment, writing of the equipment and arrangements and instructions of the regular maintenance of the equipment. Further, a schedule shall be included which may be in the form of a material list giving all particulars together with ordering references of all replaceable parts for all the equipment which will be supplied.

1.16. GUARANTEES

Contractor shall provide three (3) years guarantees for products furnished under this Contract. However, such guarantees shall be besides and not in lieu of all other liabilities which manufacturers and the Contractor may have by law or by other provisions of the Contract.

All materials, items of equipment and workmanship furnished under this Contract shall carry standard warranty against all defects in materials and workmanship. Any fault due to defective or improper material, equipment, workmanship or Contractor's design that may develop shall be made good, forthwith, by and at the expense of the Contractor, including all other damage done to areas, materials and other systems resulting from this failure.

Guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set forth herein or as indicated.

2.0 ELECTRICAL SYSTEMS

2.1. LOW VOLTAGE DISTRIBUTION SYSTEM

This section specifies the detailed requirements of supply, delivery, installation, testing, commissioning and maintenance during the defects liability period of the low voltage power distribution system.

The extent of work includes basically however not limited to the following,

- (i) Supply and Installation of low voltage power distribution panels.
- (ii) Supply and Installation of low voltage power cables.
- (iii) Supply and Installation of cable management system.

2.1.1. EQUIPMENT SPECIFICATIONS

LOW VOLTAGE POWER DISTRIBUTION PANELS

[A]. MAIN SWITCH BOARD

CONSTRUCTION OF DISTRIBUTION BOARD

- I. MSB shall be of floor-standing, totally enclosed type, built up from enclosed units housing the Moulded case circuit breakers (MCCB), fuses, contactors, relays, bus bars and other items of ancillary equipment as shown on the drawings.
- II. MSB shall fully comply with BS EN 61439 – 5 and the segregation amongst the components of the switchboard shall be of Form 3b for all sections.
- III. The bus bar system of the DB shall be capable to withstand the electrical and mechanical stresses and temperature rise produced by a fault with a magnitude of 35kA for 3 seconds.
- IV. The construction of the indoor type DB shall be designed to have the degree of protection of IP54 or higher in accordance with the standard requirement of IEC 60529.
- V. The construction of the DB shall be modular construction metal enclosure by electro galvanized steel sheets not less than 2mm thick or epoxy power coated to BS 4800 to provide resistance to corrosion. The panel shall be built up on substantial framing with all necessary stiffeners and supports with no cross struts. The entire panel shall be vermin proof.
- VI. Front access doors shall be provided and with hinges and lockable handles to facilitate inspection and maintenance. Removable gland plates shall be provided at the top and at the bottom of the switchboard with knockouts or blanked off openings for incoming and outgoing circuit cables.
- VII. All doors shall have concealed hinges and where necessary, shall be interlocked with the switch mechanism. All doors shall be provided with dust excluding gasket of neoprene or other equal and approved material.
- VIII. Screened ventilating louvers of approved type shall be provided on the sides and rear panels.

MOULDED CASE CIRCUIT BREAKER (MCCB)

- I. Moulded case circuit breakers shall confirm to the latest edition of BS EN 60947-2 and IEC 947-2. The short circuit breaking capacity of MCCB in MSB should not less than 25 kA and Sub and final panels should not less than 15 kA.

- II. MCCB shall be of the heavy duty quick make, break type. Each breaker shall have on each phase a thermal over current release and also instantaneous magnetic trip both of the adjustable type.
- III. Four pole breaker shall have a common trip both with a single operating handle and designed so that any overload in one pole automatically cause all pole to open.
- IV. Breaker shall be trip free and each shall have a trip indication of ON or OFF position. To reset for the trip position the mechanism shall pass first through the OFF position. Tripped indication shall be clearly shown by the breaker handle taking a position between ON and OFF.

NETWORK ANALYSERS & DIGITAL KWH METERS

- I. The microprocessor based network power analyser shall measure the electrical parameters including current, voltage, power factor, active and reactive power and frequency by means of microprocessor based technology.
- II. Both Power Analyzers and Digital meters will be able to communicate with BMS via a common network protocol (such as Modbus/Lonworks via RS323/RS48S/Ethernet communication link) by means of plugging in communication module and without further modification of the basic unit.
- III. Both Power Analyzers and Digital meters shall be permanently installed, record at intervals of one hour or less, and transmit data to a remote location.
- IV. Electricity meters shall record both consumption and demand and Whole-building electricity meters shall record the power factor, if appropriate.
- V. The data collection system shall use a local area network, building automation system, wireless network, or comparable communication infrastructure.
- VI. The system shall be capable of storing all meter data for at least 36 months.
- VII. The data shall be remotely accessible.
- VIII. All power analyzers and digital meters in the system shall be capable of reporting hourly, daily, monthly, and annual energy use.

SURGE PROTECTION

- I. Surge protection device shall be suitable for application in electrical installation operating at 400V, 3-Phase/ 230V 1-phase and at frequency 50Hz.
- II. The operation of surge protection device shall base on the use of metal oxide varistor or other similar technique to effectively limit over voltage under surge conditions and to safely divert the excessive surge energy to ground.
- III. Surge protection device shall be manufactured by a reputable manufacturer which is continuously manufacturing surge protection products preferably for at least 5 years and the manufacturer shall have a local agent to provide full technical support and after sales services.
- IV. Surge protection device shall be shunt or series connected to the concerned electrical installation to achieve maximum protection as recommended by the manufacturer. It shall be installed in strict compliance with manufacturer's installation instruction and relevant safety standards and regulations.
- V. The device shall be able to give protective performance in all modes, including phase and neutral, phase and earth, and neutral and earth.
- VI. Surge protection device shall be able to withstand repeated electrical surges appeared in the electrical system without undue degradation of its surge protection performance under healthy condition.

BUS BARS

- I. Bus bars and bulbar connections shall be constructed in accordance with the requirements of BS 158 and 159.
- II. Bus bars shall be rectangular section, hard drawn high conductivity (HDHC) copper, adequately rated and supported by moulded insulators spaced at suitable intervals. The complete assembly shall be capable of withstanding the maximum mechanical stresses to which it may be subjected under fault conditions.
- III. Full size neutral bars shall be provided.
- IV. Bus bars installed in switchboards shall be so arranged that all conductors can be brought onto the bars without undue bending. Bus bars shall be coloured at strategic locations for phase identification.

- V. Connection to circular section, bus bars shall be made with single bolt split type cable clamps for sizes up to 300amps. Higher rated connections will be made with high conductivity cast brass clamps.
- VI. For rectangular section, bus bar connections shall be made with double split cast brass clamps. Drilling of the bars will not be permitted unless approved by the Engineer.
- VII. Notwithstanding the above, all conductors between the bus bars, circuit breakers and fuse switches shall be high conductivity breakers and fuse switches shall be high conductivity copper bar, having a current rating of not less than that of the fuse switches to which they are connected. The conductors shall be coloured to BS colour code for phase identification.
- VIII. Copper bus bars and connection joints shall be tinned to BS EN 13601.
- IX. A tinned copper earthing strip of dimension not less than 75 mm² shall be provided for the full length of the switchboards and sufficient provisions made for earthing connections of all electrical circuits. It shall be effectively connected to all metal parts other than current carrying conductors.
- X. Neutral bars shall be provided. Main bus bars of cubicle switchboard shall be run in a horizontal chamber over the full length of the switchboard (or the section of) with bolted links at the end.
- XI. Removable bolted links shall be provided as indicated in the drawings for the accommodation of current transformers for metering and protection facilities without affecting the mechanical and electrical properties of the bus bars as a whole.

INTERNAL WIRING

- I. All wiring shall be arranged in a regular manner with bends set at 90° and securely held in position with suitable clips and where convenient shall be installed in the upright and/or backstays.
- II. Meter wiring for the switchboard shall be carried out in PVC insulated cable of not less than 1.5mm². All meter wiring shall be of similar colours to those of the respective bus bars to which connections are made. The cable terminations shall be made with approved lugs.
- III. Wiring shall be carried out in such a manner as to make circuits and connections easily traceable.

DISCRIMINATION

- I. Full discrimination is required within and between switchboards ensuring that short circuits or overload on sub-circuits will not trip the switch board circuit breakers but will effectively isolate the faulty circuit, leaving the healthy circuits unaffected. The contractor shall be responsible for ensuring discrimination is maintained.
- II. Where earth fault detection is provided, discrimination shall be ensured as for overloads above. Sufficient adjustment shall be provided ensuring that spurious tripping due to the inherent earth leakage of long cable runs and other equipment, does not occur, yet ensuring that discrimination is still maintained.
- III. Where circuit protection devices are not provided with earth leakage detection they shall be arranged to trip on earth leakage by means of the over current protection by ensuring a low earth fault impedance in accordance with the IEE wiring regulation.

TESTING

- I. Following tests shall be included, but not limited to, at the manufacturers' workshop during the course of assembly and on completion immediately prior to transport to site.
 - Inspection of the switchboard including wiring, electrical and mechanical connections, external and internal finish, etc.
 - Check all measuring, protection and control circuits and associated components are operative.
 - Functional test of all control circuits.
 - Calibration of all measuring equipments.
 - Mechanical operation tests of all switchgears.
 - Any other tests recommended by the manufacturer.
- II. After transport and erection of switchboard on site, the following tests, but not limited to, shall also be carried out:
 - General inspection of the switchboard.
 - Mechanical tests.
 - Functional tests.
 - Continuity tests.

- Insulation resistance tests.
- III. The following commissioning inspections and tests but not limited to shall be carried out before the switchboard is put into normal operation.
 - Voltage test between any two combination of each phase, neutral and earth.
 - Phase sequence test on each outgoing circuits.
 - Functional test, especially on the control devices.

[B]. SUB AND FINAL SWITCH BOARD

CONSTRUCTION OF THE SWITCHBOARD

- I. The panel board shall be type of wall mounting or floor standing type constructed to Form – 1 requirement. It shall be constructed minimum 1.6 mm thick electro-galvanized steel coated with high solid enamel polyester electrostatic spray and oven baked. The colour shall be RAL 7032 and degree of protection minimum IP 54.
- II. Bus bars shall be HDHC copper and rated for continues operation. The phase bar, neutral bar and earth bar shall be identified by approved colour code. The neutral bar cross section should be same as phase bar. All circuit breakers, metering and bus bar shall be as per the approved load list.

RESIDUAL CURRENT CIRCUIT BREAKER (RCCB)

- I. Residual Current Circuit Breakers (RCCB's) shall comply with IEC 1008. They should be of the inherent current type and be independent of the line voltage.
- II. An integral test device shall be provided on the front of the RCCB to enable the operation of the RCCB to be tested. Operation of this test device shall create out-of-balance conditions simulating an earth fault.
- III. The main distribution board shall have the instruments shown on the drawings.

MINIATURE CIRCUIT BREAKER (MCB)

- I. Single pole or triple pole miniature circuit breakers (MCB) are to be used for sub-circuit protection.

- II. All MCB's shall conform to BS EN 60947-2. The body and base of the units are to be moulded Bakelite or similar material and the units are to be sealed after assembly.
- III. The load handling contacts are to be silver I tungsten, and the contacts and operating mechanism are so designed as to give a wiping action both at make and break.
- IV. The breaker operating mechanism is to be the trip free type. A thermal magnetic time tripping mechanism is to be included for circuit protection against overload and short circuit.
- V. Short circuit level of MCB shall not be less than 6kA.
- VI. On three phase circuits, triple pole circuit breakers shall be used and shall Interlocked so that an over load or fault on anyone phase will trip all phases of the breakers simultaneously. All breakers shall be calibrated at 40 deg C.

[C]. LOW VOLTAGE POWER CABLES

The Power Cables and Conductors scope of work covers all electrical cabling and wiring required for the project. In general the wiring requirements are to the British Standards.

All low voltage feeder and sub-feeder cables will be copper conductor cables, multi-core XLPE/PVC cables laid on cable trays or ladders, or directly clipped to ceilings or walls in electrical shafts, or can be single core, non-armored XLPE / PVC insulated running in heavy gauge uPVC conduits.

In general sub-circuit wiring will be by means of single core PVC insulated copper conductors with earth continuity conductors run in conduits and protected by miniature circuit-breakers.

All circuits for both lighting and power applications will be loaded to not more than 75% of the actual net rated capacity of the protection circuit breaker.

Fire pumps/ Fire lift will be supplied through a separate fire rated feeders directly from the MSB.

XLPE/PVC CABLE

- I. XLPE insulated PVC sheathed copper cables (XLPE/PVC) shall be of single core or multi-core with full neutral and shall be 600/1000V grade complying with BS 5467:2016. The cores of these cables shall be high annealed copper conductors complying with BS EN 60228:2005. Multi core conductors above 16mm² shall be shaped to reduce overall

dimension and to give a smother profile.

- II. The PVC insulated cores shall be colour coded and sheathed with an extruded layer of two or more tapes of PVC bedding. The cables shall be over sheathed with an extruded black PVC layer embossed with the voltage designation and the manufacturer's identification.
- III. The XLPE insulation shall be able to operate continuously at a conductor temperature of 90 C deg.
- IV. The minimum bending radius shall be not less than eight times the overall cable diameter.

PVC/PVC CABLE

- I. PVC insulated PVC sheathed copper cables (PVC & PVC) shall be of single core or multi-core with full neutral and earth cable and shall be 600V/1000V grade complying to BS 6364:1969. The cores of these cables shall be high annealed copper conductors complying with BS EN 60228:2005.
- II. The PVC insulated cores shall be colour coded and shall be sheathed with PVC.
- III. The minimum bending radius shall be not less than eight times the overall cable diameter.
- IV. The cable shall be properly supported on cable trays for horizontal and vertical runs. The exact installation method shall suit the site condition and subject to approve by the Engineer.
- V. Brass cable gland complies with BS 6121 shall be provided for terminating the cables.

PVC INSULATED CABLE

- I. The cables shall consist of copper conductors insulated with PVC complying with BS 6004:2012. Cables for three phase and single phase circuits shall be 450V/750V grade.
- II. The current carrying capacity of each circuit shall be in accordance with I.E.E Regulations and latest amendments and shall be limited to the specified voltage drop.
- III. All wiring shall be carried out by the loop-in system and the wiring shall be enclosed in conduits or in metal trunking. Joints or connectors shall not be allowed in any such cable length, except that connectors may be used in accessible positions within fittings.

- IV. The maximum number of cables that may be accommodated in a given size of conduit is not to exceed the limits given in the I.E.E Wiring Regulations.
- V. For copper cables sizes 6mm² and above, compression type cable connectors/lugs shall be used for all cable terminations. Connections to fixed equipment shall be by means of PVC cables in conduits; with the final connection being made by PVC covered pliable conduit, and suitable adaptor. A separate earth continuity copper earth in accordance with I.E.E. Regulations and BS 6004 of not less than 2.5mm² shall be provided outside the flexible tube and solidly connected at each tube termination.

FLEXIBLE CORDS

- I. Flexible cords shall be PVC insulated; PVC sheathed with copper conductors of 300V/500V grade to B.S. 6500 minimum size of cord shall be 1.5mm².

FIRE RESISTANT CABLES

- I. The fire resistant cable shall be of low smoke halogen free type which, has been approved by the Fire Services Department for the appropriate application.
- II. The fire resistant cable shall have been flame tested by a recognized independent authority to BS 6387 Categories C, W and Z.

[D]. CABLE MANAGEMENT SYSTEM

The cable support & duct systems scope of work covers all electrical installation required for the project. In general the requirements are for installation to British Standards.

Separate PVC conduits and accessories will be used for lighting circuits, power circuits and low current systems wiring.

PVC conduits accessories will be used for concealed and embedded installations. Galvanized steel conduits shall be used for exposed installations in machine rooms and car parks where mechanical damages can occur. Galvanized flexible conduits will be used for terminating all connections to motors and vibrating equipment.

Cable trays will be of powder coated sheet steel supported from ceilings or wall.

All conduits for branch-circuit wiring will be either embedded in concrete, concealed in walls and under floor tiles or exposed under the slab or simply exposed in mechanical and electrical rooms.

[E]. CONDUITING SYSTEM

PVC CONDUITING

- I. PVC conduits shall generally be used for all areas.
- II. The minimum size of conduit used in the electrical & ELV installation shall be 20mm diameter.
- III. Before any work on the installation is started, the Contractor shall prepare drawings of proposed conduit runs showing the number, size and circuit reference of all conductors to the satisfaction of Engineer prior to the commencement of works. The Engineer's endorsement shall not relieve the Contractor from liability in respect to the provision of an adequate number and/or sizes of conduits for the installation.
- IV. Rigid plain PVC conduits and conduit fittings shall comply with BS 4607: Part 1 and B.S. 6099: Section 2-2. Conduits shall be type "a", i.e. they shall be suitable for installation, storage or transport at temperatures not normally below minus 5°C. (Couplers shall be of the slip-type).
- V. Adaptable boxes and boxes for the enclosure of electrical accessories shall be made from insulation materials and shall comply with B.S. 4662. The dimensions of the plastic boxes shall be such that they can be interchangeable with steel boxes. The minimum wall thickness of boxes shall be 2mm.
- VI. Boxes for the suspension of luminaires or other equipment, where considerable heat will be produced, shall be fitted with steel insert clips. Plastic boxes shall not be used in situations where the temperature of the box is likely to exceed 60°C or where the mass suspended from the box exceeds 3-kg.
- VII. Conduit bends shall have an internal radius of at least 4 times the outside diameter of the conduit.
- VIII. The method of carrying out the conduit bends, conduit joints, fixing conduits to boxes without spouts, and the tools and materials to be used shall be as recommended by the manufacturer of the conduits.
- IX. All empty conduits shall be provided with draw wire.

METAL CABLE TRAY

- I. Cable trays are to be of perforated pattern 1.6mm minimum mild steel with returned edges and shall be electroplated with zinc or cadmium to BS3382: Part 1 and 2 with minimum plating thickness of 25µm. The colour of the paint shall be agreed by the Engineer.
- II. Trays shall be supported from the soffit of structural slabs and beams by rods not less than 8mm dia. and/or angle iron brackets fixed on wall. The rods and brackets shall have two layers of primer and enamel paint finish, the bolts and nuts for fixing shall be electroplated with zinc or cadmium to BS3382: Part 1 and 2 with minimum plating thickness of 25µm. The colour of the paint shall be agreed by the Engineer.
- III. Tray supports shall be spaced according to the number and size of cables being carried on the tray, but nowhere shall they be at greater than 1.2m intervals.
- IV. Cables mounted on the trays shall be laid after installation of the tray and spaced in accordance with the I.E.E Regulations to avoid de-rating of the cables. Cables shall be grouped in circuits and individually clipped, cleated or tied at intervals of not less than 2m lengths on horizontal runs and 1 m lengths on vertical runs.
- V. Notwithstanding the minimum gauge of metalwork specified, gauges shall be of sufficient strength to prevent sagging between supports.
- VI. Cables leaving cable trays shall be installed properly without damage to cables by cutting edges of trays and rubber pads shall be inserted to underside of cables.
- VII. Trays shall not be bent for change in direction of run. Proper bends or straight trays meeting at angle shall be employed at change of direction. Cable trays shall be supported at either sides of junction.
- VIII. Where trays are exposed to the weather, they shall be coated with epoxy resin before painting. PVC coating is not acceptable.

METAL TRUNKING

- I. Trunking and fitting shall be compatible to the requirements laid down in BS4678:Part 1 and shall be fabricated with metal enclosure by electro galvanized steel sheet or epoxy powder coated to BS 4800 to provide resistance to corrosion having a nominal thickness indicated hereunder:

| Nominal Size (mm) | | Nominal Thickness (mm) | |
|---------------------|--------------|------------------------|--------------|
| <u>From</u> | <u>Up to</u> | <u>Body</u> | <u>Cover</u> |
| - | 50 x 37.5 | 1.0 | 1.0 |
| 50 x 50 | 100 x 75 | 1.2 | 1.2 |
| 100 x 100 | 150 x 100 | 1.4 | 1.2 |
| 150 x 150 and above | | 1.6 | 1.4 |

- II. Steel trunking shall be of square or rectangular cross section and no projection from screw or other sharp object will be allowed inside.
- III. Manufacturer's standard fittings such as tee or angle pieces, connectors etc. shall be used throughout unless prior endorsement has been obtained from the Engineer.
- IV. Connection between adjacent lengths of trunking, tee or angle pieces, accessories, etc. shall be made by means of butt joints. The two adjacent ends of trunking shall be fixed so that no relative movement can occur between them.
- V. Electrical continuity shall be achieved by means of connecting a tinned copper tape of adequate size across the two adjacent ends of the trunking.
- VI. Trunking and fittings shall have removable covers extending over the entire length. The covers shall be of the same material and finish as those of the trunking body.
- VII. Removable covers shall be held in position on the trunking either by the quick-fix pattern with centre captive screw or spring-on type.
- VIII. Bends, tee junctions, etc. shall also be fitted with removable covers.
- IX. Connection between trunking and apparatus shall be by a screwed coupler and brass male bush, or a standard flange coupling or an adaptor neck, fabricated or casted. Direct attachment of trunking to apparatus will only be permitted if cable entries are provided with smooth bore bushes or grommets and the return edge of the lid of the trunking is left intact.
- X. Where connection is made between trunking and a distribution board, the cable entry or entries shall be sized to accept all cables from all used and 'spare' ways. No cable tray shall be allowed to connect trunking.
- XI. Trunking shall be adequately supported through its length. Trunking support shall be fixed at regular intervals with maximum spacing as follows:

| <u>Trunking Size</u> | <u>Maximum Distance Between Fixings</u> |
|----------------------|---|
| Up to 50mm x 50mm | 900mm |
| Up to 75mm x 75mm | 1200mm |
| Up to 150mm x 150mm | 1500mm |
| Up to 225mm x 150mm | 1800m |

- XII. Overhead trunking shall be suitably supported by means of hangers, brackets or other approved devices, so that no visible sag is observed when loaded with cables. All hangers, brackets or other approved devices shall apply two layers of primer and enamel paint with blot and nuts electroplated with zinc or cadmium, the painting and electroplated standards shall be as described.
- XIII. Cables penetrating through trunking shall be protected by conduits except for PVC insulated and sheathed cables if such cables form part of a surface wiring system. In such case, the holes in the trunking through which such cables penetrate, shall be fitted with suitable rubber grommets to BS 1767 or insulated bushes.
- XIV. Whenever trunking passes through a fire resistant structural element, such as floor and wall, designated as fire barrier, the opening thus formed shall be sealed with approved type of fire resisting material according to the appropriate degree of fire protection required. In addition, suitable internal fire barriers shall also be provided to prevent the spread of fire or smoke through the trunking.
- XV. In vertical trunking installations, internal fire barriers shall be provided between floors or at intervals of 5m apart, whichever is the less.
- XVI. Every entry to the trunking shall be so placed as to prevent and/or to be protected against the ingress of water.
- XVII. Holes in trunking shall be drilled, punched or cut by ring saw. After cutting, burrs and sharp edges on the trunking shall be removed and painted by galvanized paint to prevent abrasion of cables and rusting.
- XVIII. Trunking, which is installed in such a position that the cables would fall out when the cover is removed, shall be fitted with cable retaining bars or other suitable devices to prevent the cables from falling out.
- XIX. Trunking installed in a vertical plane shall contain sufficient supporting devices within the trunking to prevent strain on the cables due to the weight of the cables, and to prevent vertical movement of the cables.

- XX. The number of cables put into a trunking shall be such that no damage is caused to the cables or the trunking. In determining the size of the trunking required for a particular installation, the method recommended by the IEE Wiring Regulations shall be adopted.
- XXI. Where a common trunking is used to accommodate cables for different circuit categories, they shall be effectually segregated by means of partitions or dividers. The partitions or dividers shall be adequately secured to the body of the trunking.

FINAL CIRCUIT WIRING

This section specifies the detailed requirements of the supply, delivery, installation, testing, commissioning and maintenance during the defects liability period of the all related items in final circuit wirings.

The extent of work includes basically however not limited to the following,

- (i) Supply and Installation of wiring system.
- (ii) Supply and Installation of lighting fixtures.
- (iii) Supply and Installation of lighting control system.
- (iv) Supply and Installation of Switches, Socket Outlets and Isolators.
- (v) Supply and Installation of cable management system.

2.1.2. SYSTEM DESCRIPTION

Final circuit wiring consists of switches, socket outlet, lighting fixtures, lighting control system and cable management system for final circuits.

2.1.3. EQUIPMENT SPECIFICATIONS

[A]. WIRING SYSTEM

Concealed conduit wiring system shall be considered where concrete slab or brick wall are present. Within the machine room and services area as indicated in drawing, surface conduit wiring shall be used. The specification of conduit installation is the same as that stipulated in abovementioned relevant clauses of this specification.

In general, lighting circuits shall be wired from 1.5mm² PVC insulated wires with separate protective earth wire of 2.5mm². All circuits will be protected individually by 10A circuit breakers. 30mA sensitive Residual Current Circuit Breakers (RCCB) will also be provided for earth leakage protection.

All the 13A socket outlet circuits shall be Radial or Ring circuit arrangements. Both arrangements shall be wired with 2.5 mm² PVC insulated wires with protective earth of same size. All radial/ring final circuits will be protected individually by 20A circuit breakers while ring circuits. 30mA sensitive Residual Current Circuit Breakers (RCCB) will also be provided for each circuit or group of circuits as appropriate.

[B]. LIGHTING FITTINGS

GENERAL

- I. All the lighting fixtures of the building shall be supplied by the contractor. The Contractor shall supply and install cable and wiring for the fixtures.
- II. Light fittings supplied under this contract by the contractor shall be manufactured by a reputable lighting manufacturer and shall bear the registered trade mark.
- III. Fittings by alternative manufacturers may be considered provided that the performance and quality are the same or higher than the specified ones and shall be subject to the acceptance by the Engineer and shall comply with the following (P.F>0.9, efficacy>100l/w, THD<3%).
- IV. Luminaries shall be well constructed and shall comply with the requirements of BS4533 and be chosen to suit the conditions under which it will operate. They shall be suitable for operation on 230 volts, single phase 50Hz supply.
- V. Outdoor luminaires shall be IP65 or otherwise specified and able to withstand weather. Metal work should be protected against corrosion, and luminaire parts which have to be removed for access to the interior should be properly gasket to restrict the entrance of moisture and dirt. Stir-up mounting and similar parts shall be heavily galvanized, and bolts shall either be made of stainless steel or be galvanized, and bolts shall either be made of stainless steel or be galvanized.
- VI. The adjustment nuts and bolts of the luminaires that will be mounted high on buildings or columns shall be captive to prevent loss or accident during servicing.
- VII. Safety device shall be provided to prevent luminaire mounted at high position dropping, the luminaires installed in such locations that are within hand reach shall be strongly constructed, fitted with an impact resistant transparent or diffusing cover, and shall have secret key fixings

for the cover to the body of the luminaires. Where necessary, wire guards shall be fitted over the cover to give extra protection.

- VIII. The termination of wiring to the outdoor fixture shall be done inside a weather- proof box of IP65.

EMERGENCY, EXIT AND FIRE EXIT LIGHTS

- I. The emergency lights shall be maintained or non maintained type as mention in the drawings and fire exit lights shall be of the surface mounted type. Each unit shall be equipped with the following: All the maintained type emergency lights shall provide with additional fire rated wire from the relevant circuit breaker in order to satisfy the installation requirement.
- Seal-lead acid battery, 12V DC for minimum back-up time of 2 hour.
 - Solid state charger.
 - Low and high voltage cut-off.
 - Overload and short circuit protection.
 - Status indicating lamp for "Power On", "Fully Charged" & "Short Circuit".
 - Corrosive-proof housing.
 - The housing of luminaire shall be steel and diffuser shall be glass diffuser.
 - The low voltage cut-off shall be set at 1.6 volts per cell.

INSTALLATION OF LIGHTING FITTINGS

- I. Installation Method

Luminaries shall be surface mounted, pendant type or recessed type as indicated on the drawings. Outdoor security fixtures shall be pole mounted or wall mounted depend on the final position as approved by the Architect or Engineer.

- II. Cable in Enclosed Luminaries

Cables within an enclosed type luminary shall be properly protected against damage due to the excessive heats generated by the lamp within the luminaries.

- III. Protection shall be by means of sleeving the insulation of the cables with fibre glass or other equivalent heat resistant insulating materials. The sleeves shall be provided for all cables within the luminaire and shall extend to a distance of 150mm outside the luminaire.

- IV. Alternatively protection shall be by means of using heat resisting cables selected in accordance with the IEE Wiring Regulations.
- V. Joints and Connections in Light Fittings

No joint or connection shall be made within a light fitting, except in space incorporated therein for the purpose. Any cables used for wiring within a light fitting shall be of any type suitable for use at the operating temperature within the fitting.

LED LAMP FITTING

1. Each light fitting for interior use shall be design, manufacture and tested in accordance with the appropriate section of BS 4533:102.1/EN 605982.1 and together with all components shall be suitable for service and operation in the local climatic conditions. Louvers shall comply with CIBSE LG3 VDT recommendations. The luminaries shall be class 1 electrical. (European accessories).
- All other accessories shall conform to following specifications.
- | | |
|-------------------|--------|
| Electronic Driver | BS2818 |
| Lamp Holder | BS5042 |
- All lighting fittings shall be earthed.

[C]. SWITCHES, SOCKET OUTLETS AND ISOLATORS.

GENERAL

Electrical accessories other than the switches provided under the lighting control system for office areas shall be generally in white colour, complying with BS. The wiring accessories inside the machine room area shall be metal clad type as approved by the Engineer.

- ## I. Socket Outlet

Socket outlet shall be 3 pin 13A as shown on drawings. All socket outlets shall be switched, shuttered type complying with B.S. 1363 and 546 respectively.

Weatherproof type shall comply with BS 4343 provided with a push on cap and retaining ring or a screw-on cap with rubber gasket.

- ## II. Fuse Connection Unit

Fuse connector unit shall be in comply with BS 1363 and provided with 2A to 13A cartridge fuse link having earthing facilities for connection to the metal work of current appliances being fed.

- ### III. Lighting Switches

Switches for controlling lighting circuits shall be rocker operated to B.S. 3676 and rated at 10 amps.

A.C. circuit load shall not exceed 8 amps for tungsten type lighting fittings and 6 amps for fluorescent type lighting fittings. The switches shall be of polished metallic finish. The switch boxes shall be provided with earthing terminal to connect to the earthing system of the premises.

2.2. LIGHTNING PROTECTION SYSTEM

This section specifies the detailed requirements of the design, manufacture, supply, delivery, installation, testing, commissioning and maintenance during the defects liability period of the lightning protection system.

The Contractor shall supply and install a lightning protection system conforming to the requirements of IEC 62305 for the building.

The system shall include, but not limited to, an air termination network including finials, joints and bonds, test joints, earth termination network, earthing pits and earth electrodes.

The extent of work includes basically however not limited to the following,

- (i) Supply and Installation of Air Termination Network.
- (ii) Supply and Installation of Down Conductors.
- (iii) Supply and Installation of Earth Termination System.

2.2.1. SYSTEM DESCRIPTION

The provided lightning Protection System shall safely convey the lightning current to earth through structural down conductor network. Materials and components of the Lightning Protection System shall be proprietary product that shall have field research, laboratory testing, and reputed name in the lightning protection equipments.

The system includes Cu tapes, finials, connecting accessories, Cu down conductors and earth test point compliance with the requirements of this Specification and shown on the Drawings.

The contractor shall be ensured the Earthing resistance of the complete lightning protection system is less than 1 ohm.

2.2.2. EQUIPMENT SPECIFICATIONS

AIR TERMINATION NETWORK

The air termination network shall comprise of 25mm x 3mm (min) copper tape (solid tape to IEC 62305-3) fixed on to the roof. Air termination network shall be supplemented by taper pointed air terminals (finials) fixed vertically on the roof at the highest level at locations marked in drawings.

All metal components shall be connected to the air termination network. All exposed metalwork on the roof or the structure shall also be securely bonded to the air termination network. A bimetal clamp shall be used to bind different metal.

Air terminal shall be of taper pointed copper rod with multiple points, complete with base for mounting on the roof. The rod shall be 15 mm diameter and 0.5 m length, threaded at one end and secured with a lock-nut after being screwed into the base.

The contractor shall submit fully detailed shop drawings for the air termination network, down conductors, earth termination network and bonding and shall be responsible to provide all the necessary accessories to integrate the system with the architectural finish of the building.

DOWN CONDUCTORS

Adequate size copper down conductors (core) should be straight as possible taking the shortest route and avoiding any sharp bends or upturns. The radius of curvature shall be maintained less than 40cm. The down conductor shall be chosen in such a way as to avoid proximity to or the crossing of electrical wiring.

As far as possible the down conductors should be located away from the doors and access to the buildings.

A terminal (or inspection point) shall be located on the down conductors at a height of 2 meters above the ground means for the measurement of its earth resistance.

Lightning protection system shall be provided with all required test joints for down conductors, fixing clips and clamps for copper tapes and round conductors, earth rod clamps, bonds to metallic items/parts and other accessories.

EARTH TERMINATION SYSTEM

'Type A Earth Termination Arrangement' of IEC 62305-3 shall be provided. A copper tape shall be taken out from each of the down conductors at 2000mm above lowest floor. The contractor shall connect the copper tape to a test joint and earth the system. All the exposed down conductors shall be securely covered by suitable PVC trunking up to 2m from ground level to prevent contact with personnel.

Each earth electrode shall consists of 16mm diameter copper bonded steel earth rods complete with driving stud, coupling dowels and spike. Earth rod shall be made of molecularly bonded 99.9% pure electrolytic copper onto a low carbon steel core. Each earth rod shall be 3m long. (This shall be one 3m length rod or two 1.5m length rods connected by threaded coupling using driving stud.)

The Contractor shall measure the resistance of each earth electrode immediately after it is driven. If the earth resistance is more than the permitted value, the Contractor shall install additional rods which shall be coupled to the rod already installed to obtain acceptable value of resistance. Each earth electrode shall have a factory made, concrete inspection pit and cover provided.

TESTING

Following tests has to be completed, recorded and get the engineers' approval after completing the installation.

- Earth resistance measurement test.
- Continuity test for down conductors.
- Visual inspection on earth pits & termination at earth pits.

2.3. EARTHING SYSTEM

This section specifies the detailed requirements of the supply, delivery, installation, testing, commissioning and maintenance during the defects liability period of the Earthing system.

2.3.1. SYSTEM DESCRIPTION

TT earthing system shall be proposed for the electrical distribution. Separate earthing system shall be proposed for HT transformer as per the power authority requirement. Earth bar of the Main Switch Board, Bodies of the Generators will be taken to an earth panel and panel will be earthed solidly. Testing point shall be provided inside the earth panel. Neutral point of the generators and the transformer will be separately earthed.

All metal works associated with the electrical installation, but not forming part of a live conductor, including exposed conductive parts, shall be solidly and effectively bonded and earthed in accordance with the latest edition of IEE Wiring Regulations.

Clean earthing system will be proposed for the office floors where computer work stations are located.

2.3.2. EQUIPMENT SPECIFICATIONS

- I. A solid copper main Earthing terminal shall be provided at a position near the MSB room for the connection of the circuit protective conductors, the main equipotential bonding conductors and the Earthing conductors to create the equipotential zone. The main Earthing terminal shall be connected to earth via an Earthing conductor to an earth electrode or a group of electrodes.
- II. Earth electrodes shall be in rods of mild steel inner core with a bonded hard drawn copper sleeve of an approved type. The overall diameter of the rod shall not be less than 12.7mm and the thickness of the copper sleeve shall not be less than 2.0mm. The minimum length shall be 2.4m. Additional lengths, whenever required, shall each be of 1.2m, connected together by a coupling. The penetrating end of the rod electrode shall be a hardened steel point. Electrodes shall be driven into the ground within an earth pit. Only approved tools, e.g. electric hammer or pneumatic hammer, shall be used for their installation.

- III. Earth electrode (copper plate 600x600x3mm) shall be installed at a minimum depth of 3m. Copper plate shall be connected to earth lead using cad weld joint or with 3x15mm SS bolts and nuts to the center of the plate. The pit shall be filled up to 1m level a mixture of charcoal and soil. Also the pit shall be covered with soil and compact 1:0.75 ratio; and filled up to finish level.
- IV. In case the Earthing resistance achieved by one rod is not sufficiently low for the purpose required, additional length or additional rods shall be installed.
- V. The connection shall be contained within a concrete earth pit with a substantial removable cover to ensure accessibility and maintainability. Earth Resistance shall be less than 5 ohm for electrical system.

2.4. POWER RECEIVING SYSTEM

This specification covers the coordination of power receiving system with the power authority (City Line) and Supply & installation of underground LV cables from the main electrical room to main switchboard (MSB).

Electrical contractor shall coordinate all the works related to authority power supply to the premise after applying the requirement by the client. LV cable shall be as per the specifications described below and drawing shown. Cable shall be installed as per the details mention in the drawing and the best installation practices.

2.4.1. QUALITY OF ELECTRICAL FITTINGS

| No. | Item | Relevant Standard Specifications | Recommended Brand Names |
|-----|---|---------------------------------------|-------------------------------------|
| 01 | Sunk Switches , 10 A | IEC 60669/ BS EN 60669/ IS 3854 | Clipsal, Orange, Crabtree, Hager |
| 02 | 13A Switched Socket Outlets, Plugs & Adaptors | IEC 60884/ BS 1363/ IS 145 | Clipsal, Orange, Schneider |
| 03 | Ceiling Rose | BS 67 | Polycrome Or Euoropean Make. |
| 04 | R.C.C.B. / R.C.D | B.S. 4293, IEC 1008 BS EN 61008 | Moller, Schneider, Terasaki, Abb |

| | | | |
|----|---|---|--|
| 05 | M.C.B. | IEC 898 or BS EN 60898 or IEC 947 - 2 Or B.S. 3871: Part 1 | Moller, Schneider, Terasaki, Abb. |
| 06 | Consumer Unit | BS 5486 Part 1 & Part 13 I.E.C. 439-1 or BS EN 60439 – 3 IEC 695-2-1 | Emp, Kik, Pubudu, Elsteel, Cubic |
| 07 | M.C.C.B. | BS 4752 IEC 947-2 | Moller, Schneider, Terasaki, Abb |
| 08 | Cu/PVC/SWA/PVC Cables Cu/PVC/PVC Cables | B.S. 6346 B.S. 6004 : 1995 & SLS 733: 1995 | ACL, Kelani |
| 09 | Cu/ XLPE/SWA/PVC Cables Cu/XLPE/PVC Cables | B.S. 5467 B.S. 5467 | ACL, Kelani |
| 10 | Steel Enclosures (Epoxy Powder coated finish) | I.E.C. 529 , BSEN 60529 | Emp, Kik, Pubudu, Elsteel, Cubic |
| 11 | Ceiling Fans | BS 5060 I.E.C. 879 : 1987) | Panasonic, KDK |
| 12 | Switch Box / Junction Box | BS 466 | Polycrome Or Euoropean Make. |
| 13 | PVC Conduits | BS 4607 & BS 6099 | Polycrome, Anton, National |
| 14 | G.I. Conduits | BS 4568 Part I | Marshall Tufflex, Univolt, Aurora |
| 15 | Cable Tray/Trunking | Tray-Iec 61537 Trunking-Ec 61084-1 | Dintek, Elsteel, Cubic,Crabtree, Magline, Kik,Mk, Or Euoropean Make. |

| | | | |
|----|---------------|-------------------|---|
| 16 | Led Or Chip | BS EN 62504 | Philips, Osram, Thron , Eye, Liper, Nvc, Neon |
| 17 | Lamp Fixtures | EN 60598, BS 4533 | Philips, Osram, Thron , Eye, Liper Nvc, Neon |

Table 1

2.4.2. QUALITY OF ELECTRICAL EQUIPMENT & MATERIAL OFFERED

(TO BE COMPLETED BY THE TENDERER)

| No. | Item | Make offered | Country of Origin | Country of Manufacture |
|-----|--|--------------|-------------------|------------------------|
| 01 | Sunk Switches , 10 A | | | |
| 02 | 13A Switched Socket Outlets, Plugs & Adaptors | | | |
| 03 | Ceiling Rose | | | |
| 04 | R.C.C.B. / R.C.D | | | |
| 05 | M.C.B. | | | |
| 06 | Consumer Unit | | | |

| | | | | |
|----|---|--|--|--|
| 07 | M.C.C.B. | | | |
| 08 | Cu/PVC/SWA/PVC Cables Cu/PVC/PVC Cables | | | |
| 09 | Cu/ XLPE/SWA/PVC Cables Cu/XLPE/PVC Cables | | | |
| 10 | Steel Enclosures (Epoxy Powder coated finish) | | | |
| 11 | Ceiling Fans | | | |
| 12 | Switch Box / Junction Box | | | |
| 13 | PVC Conduits | | | |
| 14 | GI Conduits | | | |
| 15 | Cable Tray/Trunking | | | |
| 16 | Led Or Chip | | | |

| | | | | |
|----|---------------|--|--|--|
| 17 | Lamp Fixtures | | | |
|----|---------------|--|--|--|

2.4.3. STANDARD HEIGHTS OF ELECTRICAL WIRING ACCESSORIES

| HEIGHT (FROM FIN. F. L. to Centre) | ELECTRICAL WIRING ACCESSORIES |
|--|---|
| | |
| 300mm | POWER SOCKET OUTLET TELEPHONE SOCKET OUTLETS TV OUTLET AT GENERAL AREAS |
| | |
| 1300mm | POWER SOCKET OUTLET TELEPHONE SOCKET OUTLETS TV OUTLETS |
| | |
| 1450mm | SWITCHES, DIMMER SWITCHES, FAN REGULATOR AT GENERAL AREAS. |
| | |
| 1500mm | MAIN SWITCHES,EARTH LEAKAGE CIRCUIT BREAKERS & MDB's . |
| | |
| 2000mm | MCB DISTRIBUTION BOARD. |
| | |
| 2100-2300mm | WALL LAMP FITTINGS, FUSE DISTRIBUTION BOARD, GEYZER OUTLETS, POWER OUTLET. |
| | |
| 2400mm | PENDANT LAMP FITTINGS. |
| | |
| 2500-3000mm | CEILING FANS,EXHAUST FAN,CABIN FAN. |
| | |

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specifications- ELV System

23553-01-TN-EL-SP-9801

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Version Log

| Version | Issuer | Summary of Changes | Date of Issue |
|---------|--------|--------------------|---------------|
| 1.0 | URO | Initial Issue | 20.09.2023 |
| 2.0 | URO | Tender Issue | 14.12.2023 |

1. TELEPHONE/DATA WIRING SYSTEM

1.1 GENERAL

The Contractor shall supply and install a wiring system for the telephone/data outlet from a central main distribution frame on the ground floor to the telephone/data outlets as indicated in the drawings.

1.2 WIRING SYSTEM

Wiring shall be carried out with Cat 6 cable in PVC conduit and trunking.

Primary distribution shall be carried out from the Main Distribution frame (MDF) using PVC conduit with interlinking junction boxes. Where a suspended ceiling is available the conduit shall be concealed in the void where no suspended ceiling is provided the conduit shall be laid in the floor slab.

Where provided the twin compartment trunking system shall be used and shared with the electrical system for lateral distribution in conjunction with concealed PVC conduits.

The telephone wiring shall be totally segregated from all the other wiring systems.

No conduit shall be less than 20mm (nominal) diameter.

1.3 TELEPHONE/DATA OUTLETS

A telephone/data outlet (BS 5733) comprise a flush conduit box with a fixed telephone terminal block and an overlapping white plaster cover – plate having bushed flex outlets, with cord clamp and suitable for one or two telephone flexible cords as indicated on the drawings.

The terminal block shall be capable of accepting both incoming and outgoing cables.

1.4 JUNCTION BOXES

Junction boxes BS 4662 shall be of the capacity specified in the drawings, comprising of a mounting frame or box with a rigid plastic cover, containing a terminal block with solder terminals on the incoming side and screw – on terminals for the outgoing cable pairs.

The junction box shall be of the flush mounting type when installed in visible position.

1.5 MAIN DISTRIBUTION FRAME

The main distribution frame (MDF) shall be mounted in a wall mounting lightweight metal box with lockable 180 degree opening door containing a document wallet. Capacity shall be as shown on the drawing.

The terminal block shall contain solder terminals on the incoming side and screw – on terminals for the outgoing cables.

1.6 CONTRACTOR'S RESPONSIBILITY

The Contractor would be responsible for the condition of the wiring and equipment of the installation from the time it is completed and handed over to the client.

2. PABX SYSTEM

2.1 GENERAL DESCRIPTION

- i. The make and model of the PABX shall be of a type approved by the Director General, Telecommunications regulatory Commission TRC), Sri Lanka. A copy of the type approval certificate shall be submitted. The Tenderer shall clearly state the lifespan of the equipment offered.
- ii. The system offered shall be of non-blocking which complies with CCITT/ ITU recommendation for A-law PCM, and compatible with legacy line/trunk interfaces to support existing Time Division Multiplexing (TDM) based infrastructure such as analog telephones, Digital telephones, Channel associated Signaling and Common Channel Signaling.
- iii. The system offered shall be compatible with VoIP technologies such as H.323 and SIP.
- iv. The system shall have Universal Port architecture allowing mixed configuration of central office lines, digital, analogue and IP terminals to be added to the same communication system.
- v. The offered equipment shall comply its software lifecycle at least for 5 years to cater any expansion without any software upgrades. In any case if software lifecycle expiration within 5 years' time, the supplier should upgrade the equipment free of charge.

- vi. The basic operational and maintenance characteristics shall be guaranteed by the use of reliable components and system architecture and the PABX shall be also capable of meeting all the requirements of the Sri Lanka national telephone network in numbering, signaling & routing.
- vii. The system offered shall have a high degree of flexibility and shall permit the introduction of new facilities and services with simple additions and/or amendments. The office data shall be alterable by commands from the input devices.

2.2 SYSTEM DIMENSIONS

- The system Expandable up to 16 CO lines & 64 Extensions Universal Port IP PABX System capable of handling ISDN E1 & IP (SIP).
- 5 Central Office lines.
- 18 Extensions.
- 01 Digital Operator console

2.3 POWER SUPPLY AND COMMUNICATION EARTH

- A dedicated power supply circuit should be available for each cabinet with internal regulation, enabling equipment to work satisfactorily when AC input fluctuates between 180 volts and 260 volts.
- The Equipment shall be provided with an emergency battery backup connected to output end of the power supply to supply power to the PABX during mains failure or mains voltage dropping below satisfactory level of operation.
- The batteries shall be of maintenance free sealed type intended for stationary use requiring minimum of 1 hour during mains supply failure. Make, Model, AH capacity and the recommended life period of the batteries shall be stated.

2.4 MANDATORY SYSTEM FEATURES

- All extension instruments (DP/DTMF) shall be connected to the system via 4 wire cable.
- Assignment of Trunk and station numbers and feature codes shall be flexible.
- Discriminate ringing for internal and outside incoming calls shall be available
- Music on hold facility with provision to connect an external music source.
- System shall provide facility to group a number of extensions for group billing.
- Authorization codes for external dialing for individuals.
- Locking facility for extension as and when leaving the station

- System shall support common set of abbreviated dialing numbers for all extensions. The digital display phones should consist of storing facility with name for easy retrieval and dialing. A minimum of 1000 number capacity should be made available.
- System shall provide call return on no answer, call transfer and call conference facilities.
- System shall provide at least one 8 party conference circuit.

2.5 EXTENSION INSTRUMENTS

- Extension instruments offered shall be of a type approved by the Director General of telecommunications, Sri Lanka. A copy of the type approval certificate shall be submitted if necessary.
- The Tenderer shall state the make and model of the offered telephone instrument and indicate the country of manufacture.
- The case and hand shall be constructed of high impact resistant tough thermoplastic or similar material
- Digital Telephone instruments shall be de-assemble and upgradable whenever needed to expand in terms of programmable keys.

2.6 MAINTENANCE

- The Bidder shall agree to enter in to a service contract with the Employer for service and maintenance of the system after the guarantee period.
- The Bidder shall submit a draft service contract, which shall include the facilities and services requested specifications and the rates for **three years** after the guarantee period.
- Following preventive and corrective maintenance work shall be included in the draft service contract to be submitted.
 - a) Preventive maintenance work carried out once in Four month including removal of dust and moisture using suction cleaners.
 - b) Verification of the system performance to be carried out at least once a quarter on pre-programmed features.

2.7 OPERATOR CONSOLE FEATURES

- Each incoming call shall be signaled visually and individually to the operator.
- Number of characteristics that can be read off in the LCD/LED display shall be stated.
- It should be possible to display the following information in the alphanumeric display.
 - a) Date and time

- b) Number of calls to be answered
 - c) Types of call
 - d) Station/ trunk class, Number and status
 - e) Special features
- Warning to the operator
- Operator shall have the facility to intercept an already established internal call. Prior to and during the operator intercepts the conversation tone should be heard by the 2 parties engaged in conversation.
- The operator does not answer within a specified period (which shall be programmable) the call should be diverted to a specified extension.
- Types of night services available in the absence of the operator shall be stated.

3. CCTV SYSTEM

3.1 GENERAL

- i. This specification covers the submittals of shop drawings, sample approvals, setting to work, supply, installation, inspection, testing & commissioning, as built drawings and operation and maintenance manuals and periodic maintenance.
- ii. The Tenderer's shall read this section in conjunction with Tender drawings and Bill of Quantities. They shall clarify any discrepancies between tender drawings and Bill of Quantities.
- iii. The Tenderer shall submit their offer complying with all the conditions of contract, specification, tender drawings and Bill of Quantities.
- iv. Specification, drawings and BOQ are meant to provide sufficient information to the tenderers and it is the contractor's responsibility to supply and install complete systems to working order.

3.2 OPERATION AND MAINTENANCE MANUALS

The Contractor shall submit 3 copies of Operation & maintenance Manuals, which shall contain Product literature, Specific operating instructions and Maintenance instructions.

3.3 TESTING AND COMMISSIONING OF SYSTEMS

The contractor shall submit testing & commissioning procedures, handing over check Lists 1 month before testing and commissioning and shall obtained the approval of the Consulting Engineer. The contractor shall perform all the equipment and devices testing as directed by the Consulting Engineer. The Contractor shall bear the cost for such tests and any items found defective shall be replaced at no extra cost. Such replaced items shall be re- tested for verification.

3.4 EQUIPMENT, MATERIALS AND ACCESSORIES

The equipment, material used, fittings and devices shall comply with the Architectural and design criteria, design concepts and performance requirements.

When selecting products, the contractor shall consider the space limitations, weight limitations, compatibility with other existing devices and systems.

The contractor shall obtain the approval from the consulting engineer for all the equipment, material and accessories before commencing the installation.

All the products supplied under this contract shall be guaranteed for a period of three years from the final handover date.

3.5 PRODUCT BRANDS

All the Materials, Equipment and Devices and Accessories supplied under this contract shall bear the Manufacturer names. The consulting Engineer has the right to accept or reject any Equipment, Material and device brands based on the past performance records.

3.6 DRAWINGS

The contractor shall familiarize himself with the site conditions before preparing shop drawings. He shall verify the dimensions shown in the drawings and notify the consulting engineer any discrepancies.

The contractor shall submit 3 copies of shop drawings for approval. The contractor shall obtain the approval for shop drawings before commencing the installation work.

3.7 PERIOD OF WARRANTY

The contractor shall submit a written warranty for the installation for a period of three years from the date of handing over against the manufacturing defects and poor workmanship.

3.8 IP CLOSED CIRCUIT TELEVISION SYSTEM (CCTV)

This section specifies the detailed requirements of the design, manufacture, supply, delivery, installation, testing, commissioning and maintenance during the defects liability period of the CCTV system.

The extent of work includes basically however not limited to the following,

- (i) Supply and Installation of CCTV cameras.
- (ii) Supply and Installation of Network Video Recorders.
- (iii) Supply and installation of central monitoring station.

3.9 SYSTEM DESCRIPTION

The entire system will be connected on a high speed Ethernet Network. All the cameras & the Digital Disk Recorders should be Network compatible. The Network Cameras will be registered in a Network Video Recorders (NVR). Individual NVR can be accessed using the respective IP address by the authorized network users for accessing the cameras. The NVR shall record the output of all the registered Cameras onto the hard disk of the recorder. Remote Monitoring Software should be able to integrate multiple network digital recorders for operating the recorder by users remotely via LAN or internet connection.

The video and control signals shall be transmitted through the structured cabling system (Fibre back bone). The CCTV network is installed tested and commissioned as per the Specifications.

It shall be possible for up to three remote and one local operator logged into Network digital recorder simultaneously for monitoring the live or recorded video and only the authorized system administrator shall be allowed to perform the control and management of the system. The complete setup, including programming of the unit, start up, shutdown, stop recording, remote controlling and viewing etc., shall be password protected. The operator or user authorization on the system shall be with at least two levels of priority.

It shall be possible to program the contrast, brightness, dwell time, recording modes, video compression, frame rate, motion region etc. of each camera individually or for all cameras together through the menu driven user interface.

3.10 EQUIPMENT SPECIFICATION

CCTV CAMERAS

a). Indoor camera for lift lobby, Staircase lobby & General Area

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| General Requirements | <p>The camera shall be of manufacturer's official product line, designed for commercial/industrial 24/7/365 use.</p> <p>The camera shall be based upon standard components and proven technology using open and published protocols.</p> <p>The camera shall be of manufacturer's official product line, designed for commercial/industrial 24/7/365 use.</p> <p>The camera shall be based upon standard components and proven technology using open and published protocols.</p> |
| Quality Assurance | <p>All camera installation, configuration, setup, program and related work shall be performed by electronic technicians thoroughly trained by the manufacturer in the installation and service of the equipment provided.</p> <p>All equipment provided shall be backed by a minimum of three years manufacturer warranty.</p> <p>The specified unit shall be manufactured in accordance with ISO 9001 / EN 29001.</p> |
| Environmental sustainability | <p>The specified unit shall be manufactured in accordance with ISO 14000.</p> <p>The specified unit shall be compliant with 2002/95/EG RoHS and 2002/96/EG WEEE.</p> |
| Certifications and standards | |
| The camera shall carry the following EMC approvals: | <p>EN55022, EN55024</p> <p>FCC Part 15 - Subpart B</p> <p>VCCI</p> <p>C-tick AS/NZS CISPR22</p> <p>ICES-003</p> |
| <p>The camera shall meet the following product safety standards</p> <p>The camera shall meet the following standards</p> | <p>UL / EN 60950 -1</p> <p>UL / EN 60950 -22</p> <p>MPEG-4:</p> <p>ISO/IEC 14496-10 AVC (H.264)</p> <p>H.265</p> |

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| Networking: | <p>IEEE 802.3af (Power over Ethernet)</p> <p>IEEE 802.1X (Authentication)</p> <p>IPv4 (RFC 791)</p> <p>IPv6 (RFC 2460)</p> <p>QoS – DiffServ (RFC 2475)</p> |
| Network video : | ONVIF Profile S or ONVIF Version 1.01 or higher as defined by the ONVIF organization. |
| Mechanical Environment: | IEC 62262 Class IK10 (Impact resistance) |
| General Features : | The camera shall |
| | <p>Be designed to provide at least two individually configured simultaneous video streams at 30 frames per second in all resolutions up to 4MP pixels in Motion JPEG and H.264, H.265 and shall support a total of 20 simultaneous streams using unicast.</p> <p>Be equipped with Day/Night functionality and remote zoom and focus capabilities.</p> <p>Operate on an open source; Linux-based platform, and including a built-in web server.</p> <p>Be equipped with a slot for SD/SDHC memory card expansion.</p> <p>Be manufactured with an all-metal vandal resistant body.</p> |
| Hardware | <p>The camera shall:</p> <p>Use a high quality IR-sensitive progressive scan sensor.</p> <p>Be equipped with a removable IR-cut filter, providing so-called day/night functionality.</p> <p>Be equipped with a high-quality varifocal lens, provide automated iris functionality with P-Iris control, and provide remote zoom and focus functionality.</p> <p>Provide pictures down to 0.15 lux while in day mode (with IR-filter in use) and down to 0.03 lux while in night mode (with IR-filter removed).</p> <p>Support memory expansion by providing an available SD/SDHC card slot.</p> |
| Video | |
| Resolution | The camera shall be able to deliver at least two individually configurable full resolution full frame rate video streams over IP networks. |

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| Input sources | <p>Built-in microphone</p> <p>External microphone</p> <p>External line device</p> |
| Output sources | <p>External line device</p> |
| Encoding | <p>The camera shall support:</p> <p>AAC LC at 8/16 kHz</p> <p>G.711 PCM at 8 kHz</p> <p>G.726 ADPCM at 8 kHz</p> |
| Functionality | |
| Web server | <p>The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.</p> <p>Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.</p> |
| IP addresses | <p>The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.</p> <p>The camera shall allow for automatic detection of the Camera based on UPnP and Bonjour when using a PC with an operating system supporting this feature.</p> <p>The camera shall provide support for both IPv4 and IPv6.</p> |
| Event functionality | <p>The camera shall be equipped with an integrated event functionality, which can be triggered by:</p> <p>Video Motion Detection</p> <p>Schedule</p> <p>Camera tampering</p> <p>Embedded third party applications</p> <p>External input</p> <p>Audio Detection</p> <p>Edge storage disruption detection</p> <p>Response to triggers shall include:</p> <p>Notification, using TCP, SMTP or HTTP</p> |

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| | <p>Image upload, using FTP, SMTP or HTTP</p> <p>Activating external output</p> <p>The camera shall provide memory for pre & post alarm recordings.</p> <p>Event functions shall be configurable via the web interface.</p> |
| Edge storage | <p>The camera shall support continuous and event controlled recording to:</p> <p>Local memory added to the cameras SD-card slot</p> <p>Network attached storage, located on the local network</p> <p>The camera shall be able to detect and notify Edge storage disruptions</p> |
| Protocol support | <p>The camera shall incorporate support for at least IP, HTTP, HTTPS, SSL/TLS, TCP, ICMP, SNMPv1/v2c/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS, NTP and Bonjour.</p> <p>The SMTP implementation shall include support for SMTP authentication.</p> <p>Text overlay</p> <p>The Camera shall:</p> <p>Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.</p> <p>To ensure accuracy, the camera shall accept external time synchronization from an NTP (Network Time Protocol) server.</p> <p>Provide the ability to apply a privacy mask to the image.</p> <p>Allow for the overlay of a graphical image, such as a logotype, into the image.</p> |
| Security | <p>The camera shall:</p> <p>Support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.</p> <p>Support IEEE 802.1X authentication.</p> <p>Provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.</p> <p>Restrict access to the built-in web server by usernames and passwords at three different levels.</p> |
| API support | <p>The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.</p> |

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| | The camera shall conform to ONVIF Profile S or ONVIF Version 1.01 or higher as defined by the ONVIF organization, and shall be upgradable at any time. |
| Embedded applications | <p>The camera shall provide a platform allowing the upload of third party applications into the camera.</p> <p>The camera vendor shall provide a compatibility tool for the application vendor to verify the stability and performance impact of their uploaded application.</p> |
| Installation and Maintenance | <p>The camera shall:</p> <p>Be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the Cameras' configuration.</p> <p>Support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.</p> <p>Allow updates of the software (firmware) over the network, using FTP or HTTP.</p> <p>Provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.</p> <p>All customer-specific settings shall be stored in a non-volatile memory and shall not be lost during power cuts or soft reset.</p> |
| User logs The camera shall: | <p>Provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.</p> <p>Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.</p> |
| Camera diagnostics The camera shall: | <p>Be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.</p> <p>Be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.</p> |
| Interfaces Network interface | The camera shall be equipped with one 100BASE-TX Fast Ethernet-port, using a standard RJ-45 socket and shall support auto negotiation of network speed (100 MBit/s and 10 MBit/s) and transfer mode (full and half duplex). |
| Audio | The camera shall be equipped with one 3.5 mm jack for line/mic input and one 3.5 mm jack for line output. |
| Inputs/Outputs | The camera shall be equipped with one digital (alarm) input and one digital output, accessible via a removable terminal block. This input shall be configurable to respond to normally open (NO) or normally closed (NC) dry contacts. |

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| Enclosure | <p>The camera enclosure shall include the following:</p> <p>Manufactured with an all-metal vandal resistant body providing encapsulated electronics</p> <p>Vandal-resistant casing with clear transparent cover</p> <p>Impact resistance according to IK10</p> <p>The camera enclosure shall provide the ability to adjust the camera modules angle with at least $\pm 180^\circ$ horizontal, $\pm 85^\circ$ vertical and $\pm 170^\circ$ rotation while maintaining an image that is not interfered with by the camera housing</p> |
| Power requirements | Power over Ethernet according to IEEE 802.3af - Class 2. |
| Environmental | <p>The camera shall:</p> <p>Operate in a temperature range of 0°C to $+50^\circ\text{C}$ (32°F to $+122^\circ\text{F}$).</p> <p>Operate in a humidity range of 10–85% RH (non-condensing).</p> |
| EXECUTION | |
| Installation | <p>The Contractor shall carefully follow instructions in documentation provided by the manufacturer to ensure all steps have been taken to provide a reliable, easy-to-operate system.</p> <p>All equipment shall be tested and configured in accordance with instructions provided by the manufacturer prior to installation.</p> <p>All firmware found in products shall be the latest and most up-to-date provided by the manufacturer, or of a version as specified by the provider of the Video Management Application (VMA) or Network Video Recorder (NVR).</p> <p>All equipment requiring users to log on using a password shall be configured with user/site-specific password/passwords. No system/product default passwords shall be allowed.</p> <p>A proper installation shall meet NEC (National Electrical Code – US only) per the guidelines of that year's revision. When properly installed equipment meets Low Voltage, Class 2 classification of the NEC.</p> |

b). Camera for Lift car

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| GENERAL | |
| General Requirements | <p>The camera shall be of manufacturer's official product line, designed for commercial/industrial 24/7/365 use.</p> <p>The camera shall be based upon standard components and proven technology using open and published protocols.</p> |
| Quality Assurance | <p>All camera installation, configuration, setup, program and related work shall be performed by electronic technicians thoroughly trained by the manufacturer in the installation and service of the equipment provided.</p> <p>All equipment provided shall be backed by a minimum of three-year manufacturer warranty.</p> <p>The specified unit shall be manufactured in accordance with ISO 9001 / EN 29001.</p> |
| Environmental sustainability | <p>The specified unit shall be manufactured in accordance with ISO 14000.</p> <p>The specified unit shall be compliant with 2002/95/EG RoHS and 2002/96/EG WEEE.</p> |
| Certifications and Standards | |
| The camera shall carry the following EMC approvals: | <p>EN55022, EN55024</p> <p>FCC Part 15 - Subpart B</p> <p>VCCI</p> <p>C-tick AS/NZS CISPR22</p> <p>ICES-003</p> |
| The camera shall meet the following standards | <p>MPEG-4:</p> <p>ISO/IEC 14496-10 AVC (H.264)</p> |
| Networking: | <p>IEEE 802.3af (Power over Ethernet)</p> <p>IPv4 (RFC 791)</p> <p>IPv6 (RFC 2460)</p> <p>QoS – DiffServ (RFC 2475)</p> |
| PRODUCTS | |
| General | <p>Be designed to provide at least two simultaneous video streams at 30 frames per second in all resolutions up to 800x600 pixels in Motion JPEG or H.264.</p> |

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| | <p>Be equipped with an electronic shutter and support automatic and manually defined exposure zones operating in the range 1/6 and 1/24.500 second.</p> <p>Provide Back Light Compensation.</p> <p>Allow for rotation of the image in steps of 90°.</p> |
| Functionality | |
| Web server | <p>The camera shall contain a built-in web server making video and configuration available to multiple clients in a standard operating system and browser environment using HTTP, without the need for additional software.</p> <p>Optional components downloaded from the camera for specific tasks, e.g. Active X, shall be signed by an organization providing digital trust services, such as Verisign, Inc.</p> |
| IP addresses | <p>The camera shall support both fixed IP addresses and dynamically assigned IP addresses provided by a Dynamic Host Control Protocol (DHCP) server.</p> <p>The camera shall allow for automatic detection of the Camera based on UPnP and Bonjour when using a PC with an operating system supporting this feature.</p> <p>The camera shall provide support for both IPv4 and IPv6.</p> |
| Event functionality | <p>The camera shall be equipped with an integrated event functionality, which can be triggered by:</p> <p>Video Motion Detection</p> <p>Schedule</p> <p>Camera tampering</p> <p>Response to triggers shall include:</p> <p>Notification, using TCP, SMTP or HTTP</p> <p>Image upload, using FTP, SMTP or HTTP</p> <p>The camera shall provide at least 25 MB memory for pre & post alarm recordings.</p> <p>Event functions shall be configurable via the web interface.</p> |
| Protocol support | <p>The camera shall incorporate support for at least IP, HTTP, HTTPS, SSL/TLS, TCP, ICMP, SNMPv1/v2c/v3 (MIB-II), RTSP, RTP, UDP, IGMP, RTCP, SMTP, FTP, DHCP, UPnP, ARP, DNS, DynDNS, SOCKS, NTP and Bonjour.</p> <p>The SMTP implementation shall include support for SMTP authentication.</p> |
| Text overlay | |
| The Camera shall: | |

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| | <p>Provide embedded on-screen text with support for date & time, and a customer-specific text, camera name, of at least 45 ASCII characters.</p> <p>To ensure accuracy, the camera shall accept external time synchronization from an NTP (Network Time Protocol) server.</p> <p>Provide the ability to apply a privacy mask to the image.</p> <p>Allow for the overlay of a graphical image, such as a logotype, into the image.</p> |
| Security The camera shall: | <p>Support the use of HTTPS and SSL/TLS, providing the ability to upload signed certificates to encrypt and secure authentication and communication of both administration data and video streams.</p> <p>Provide support for restricting access to pre-defined IP addresses only, so-called IP address filtering.</p> <p>Restrict access to the built-in web server by usernames and passwords at three different levels.</p> |
| API support | <p>The camera shall be fully supported by an open and published API (Application Programmers Interface), which shall provide necessary information for integration of functionality into third party applications.</p> <p>The camera shall conform to the network video standard as defined by the ONVIF organization.</p> |
| Embedded application | <p>The camera shall provide a platform allowing the upload of third party applications into the camera.</p> <p>The camera vendor shall provide a compatibility tool for the application vendor to verify the stability and performance impact of their uploaded application.</p> |
| Installation and Maintenance The camera shall: | <p>Be supplied with Windows-based management software which allows the assignment of IP addresses, upgrade of firmware and backup of the Cameras' configuration.</p> <p>Support the use of SNMP-based management tools according to SNMP v1, 2c & 3 / MIB-II.</p> <p>Allow updates of the software (firmware) over the network, using FTP or HTTP.</p> <p>Provide the ability to apply a rectangle of customer-defined number of pixels to the image, which can be used as a pixel counter identifying the size of objects in number of pixels.</p> <p>All customer-specific settings shall be stored in a non-volatile memory and shall not be lost during power cuts or soft reset.</p> |

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| User logs The camera shall: | <p>Provide a log file, containing information about the 250 latest connections and access attempts since the unit's latest restart. The file shall include information about the connecting IP addresses and the time of connecting.</p> <p>Provide a connection list of all currently connected viewers. The file shall include information about connecting IP address, time of connecting and the type of stream accessed.</p> |
| Camera diagnostics The camera shall: | <p>Be equipped with LEDs, capable of providing visible status information. LEDs shall indicate the camera's operational status and provide information about power, communication with receiver, the network status and the camera status.</p> <p>Be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.</p> |
| Interfaces Network interface | <p>The camera shall be equipped with one 100BASE-TX Fast Ethernet-port, using a standard RJ-45 socket and shall support auto negotiation of network speed (100 MBit/s and 10 MBit/s) and transfer mode (full and half duplex).</p> |
| Enclosure The camera enclosure shall include the following: | <p>Manufactured with an all-metal vandal resistant body providing encapsulated electronics</p> <p>Clear transparent cover</p> <p>Impact resistance of 2200lbs / 1000kg</p> <p>The camera enclosure shall provide the ability to adjust the camera modules angle with at least $\pm 180^\circ$ horizontal, $\pm 85^\circ$ vertical and $\pm 170^\circ$ rotation while maintaining an image that is not interfered with by the camera housing.</p> |
| Power requirements | <p>Power over Ethernet according to IEEE 802.3af - Class 2.</p> |
| Environmental The camera shall: | <p>Operate in a temperature range of 0°C to +50°C (32°F to +122°F).</p> <p>Operate in a humidity range of 20–80% RH (non-condensing).</p> |
| EXECUTION Installation | <p>The Contractor shall carefully follow instructions in documentation provided by the manufacturer to insure all steps have been taken to provide a reliable, easy-to-operate system.</p> <p>All equipment shall be tested and configured in accordance with instructions provided by the manufacturer prior to installation.</p> <p>All firmware found in products shall be the latest and most up-to-date provided by the manufacturer, or of a version as specified by the provider of the Video Management Application (VMA) or Network Video Recorder (NVR).</p> <p>All equipment requiring users to log on using a password shall be configured with user/site-specific password/passwords. No system/product default passwords shall be allowed.</p> |
| Event functionality | <p>The camera shall be equipped with an integrated event functionality, which can be triggered by:</p> |

| | |
|------------------------------|--|
| | <ul style="list-style-type: none"> • External input • Video Motion Detection • Audio Detection • Schedule • Camera tampering • Embedded third party applications • Edge storage disruption detection <p>The cameras response to a triggered event shall include:</p> <ul style="list-style-type: none"> • Notification, using TCP, SMTP or HTTP • Image upload, using FTP, SMTP or HTTP • Activating external output • Recording to local storage and/or network attached storage |
| Storage | <p>The camera shall be equipped with a video buffer for saving pre- and post-alarm images and shall have a microSD-card slot to support local storage of video.</p> <p>The camera shall support microSD/microSDHC/microSDXC, memory up to 64 GB.</p> |
| Other functionality | <p>The camera shall be equipped with an ability to perform back focus adjustment remotely from the web interface</p> <p>The camera shall include a customizable pixel counter functionality, identifying the size of objects in number of pixels.</p> <p>The camera shall provide text overlay ability, including date and time.</p> <p>The camera shall have the ability to apply a graphical image as an overlay image in the video stream.</p> <p>The camera shall have the ability to apply privacy masks in the video stream.</p> |
| Network functionality | <p>The camera shall support both static IP addresses and addresses from a DHCP-server.</p> <p>The camera shall support both IPv4 and IPv6.</p> <p>The camera shall incorporate support for Quality of Service (QoS).</p> <p>The camera shall incorporate support for Bonjour.</p> <p>To secure access to the unit as well as provided content, the unit shall support HTTPS, SSL/TLS and IEEE802.1X authentication.</p> <p>The camera shall support IP address filtering and include at least three different levels of password security.</p> <p>The camera shall support time synchronization via NTP server.</p> <p>The camera shall support Power over Ethernet according to IEEE 802.3af.</p> |
| Power | <p>The camera shall accept Power over Ethernet according to IEEE 802.3af, Class 3.</p> |

| | |
|----------------------------------|--|
| Maintenance & service | <p>The camera shall provide a log file, containing information about all users connecting to the unit since last restart. The file shall include information about connecting IP address and the time of connecting.</p> <p>The camera shall be monitored by a Watchdog functionality, which shall automatically re-initiate processes or restart the unit if a malfunction is detected.</p> |
| API & applications | <p>The unit shall contain a built-in web server making video, audio and configuration available in a standard browser environment using HTTP.</p> <p>The camera shall be fully supported by open and published API (Application Programmers Interface) providing necessary information for integration of functionality into third party applications.</p> <p>The camera shall allow for applications developed by third parties to be uploaded into the camera, and the camera vendor shall provide compatibility tools to verify the stability and performance of the applications.</p> <p>The camera shall conform to ONVIF Profile S or ONVIF Version 1.01 or higher as defined by the ONVIF organization and be upgradable at any time.</p> |

c). Network Video Recorder

The server shall make continuous recording of all the cameras for 24 Hrs x 7 days with hardware should have adequate storage @ 25/30 fps with maximum resolution for a period of 30 days. System integrator should provide the exact storage calculation. If necessary, additional storage in form of hard disk drive shall be suggested / provided by the supplier.

- Should be installable on a Windows PC.
- The NVR/NAS should have no limitations on the kind of storage to be used (RAID, NAS ect)
- The NVR/NAS must be capable of recording all system cameras simultaneously
- The NVR/NAS must be providing for a disk management system which will automatically reap old recordings to overwrite with new ones when max disk usage is reached. The recorded data should store at least for 30 days and therefore it is necessary to design the system accordingly.

| NVR | | |
|-------------|--------------------|----------|
| Video/ | IP video input | 32-ch |
| Audio input | Incoming Bandwidth | 256 Mbps |

| | | | |
|---------------------------|------------------------|---|------------------------------------|
| | Outgoing Bandwidth | 160 Mbps | |
| Video/ Audio Output | HDMI Output Resolution | 1-ch, resolution: 4K(3840*2160)/60Hz, 4K(3840*2160)/30Hz, 1920*1080P/60Hz, 1600*1200/60Hz, 1280*1024/60Hz, 1280*720/60Hz, 1024*768/60Hz | |
| | VGA Output | 1920*1080P/60Hz, 1280*1024/60Hz, 1280*720/60Hz, 1024*768/60Hz | |
| | Audio output | 1-ch, RCA (Linear, 1 K Ω) | |
| Decoding | Recording Resolution | 8MP/6MP/5MP/4MP/3MP/1080p/UXGA/720p/ VGA/4CIF/DCIF/2CIF/CIF/QCIF | |
| | Recording format | H.265/ H.265+/H.264/H.264+/MPEG4 | |
| | Synchronous Playback | 16-ch | |
| | Capability | 2-ch @ 4K, or 8-ch @ 1080p | |
| | Network protocols | TCP/IP, DHCP, HIK Cloud P2P, DNS, DDNS, NTP, SADP, SMTP, NFS, iSCSI, UPnP™, HTTPS,IPv4/IPv6 | |
| Recording Storage | | Local HDD, network | |
| External Ports | Video Input | Two-way audio input | 1-ch, RCA (2.0 Vp-p, 1k Ω) |
| | | IP video input | 32-ch |
| | Video Output | 2x VGA+2x HDMI | |
| | Audio Output | 1ch RCA (Linear, 1k Ω) | |
| | Network Port | 1, RJ-45 10/100/1000Mbps self-adaptive Ethernet interfaces | |
| | Serial Interface | 1, RS-232; RS-485 | |
| | USB Port | 1x USB3.0 , 2x USB 2.0 | |
| | Alarm In/Out | 16ch/4ch | |

| | | | |
|------------------------|--------------|--|-----|
| HDD | HDD Port | 4 SATA interfaces for 4HDDs, 1 eSATA interface | |
| | MAX Capacity | Each port supports MAX 6TB HDD | |
| POE Interface | | 16, RJ-45 10/100 Mbps self-adaptive Ethernet interface | |
| POE Supported standard | | IEEE 802.3 af/at | |
| Network | | Remote connection | 128 |
| Working Temperature | | -10°C ~ +55°C | |
| Working Humidity | | 10%-90% | |
| Certifications | | UL,CE,FCC | |

RAID Storage

RAID -5 compliant

LED indications for systems status, power, split mode, activity, drive indicator per drive, fan fault, SAS port Etc.

Configured with RAID 5 support for RAID levels 0, 1, 5, 10, 50

Operating temperature up to 35 Dec Celsius

Video Mounting Wall

43" LED video monitors should be used for the video monitoring wall.

d). Video Management System.

The Video Management System shall be a fully distributed solution, designed for limitless multi-site and multiple server installations requiring 24/7 surveillance with support for devices from different vendors.

The Video Management System shall offer centralized management of all devices, servers and users and must empower a flexible rule-based system driven by schedules and events.

VMS shall already support IP cameras from at least fifty (50) major vendors. Bidders shall clearly list in their proposal the brands and models already integrated into VMS.

To ensure openness, VMS and cameras shall not be from the same manufacturer.

VMS shall support installation and ability to run on virtualized windows servers

VMS manufacturer shall provide their SDK (or any other integration means) libraries and documentation) to ensure a seamless integration with any other system

VMS shall be open to any standard storage technologies integration.

VMS shall be open to any video wall system integration.

VMS shall have the possibility to integrate external Video Analytics systems.

The VMS system shall be a scalable client – server architecture built using well known operating systems

The VMS system shall enable recording to be done at the aggregation sites and shall allow the Command & Control center to import selected videos on demand.

The VMS system shall have three types of aggregation sites. Each aggregation site shall be enabled to record and retain video files for 30 days archived.

To facilitate the VMS system architecture, the BIDDER shall ensure that sufficient capacity is designed into the data communications & telecommunications infrastructure to deliver the required functionality, along with the ability to allocate and reserve resources (including bandwidth).

The Bidder shall ensure that he does not exceed Bandwidth allocation specified by the PSD.

The VMS data communications and telecommunications network shall use a suitable transport medium and associated cabling and data transmission infrastructure that will support real-time video display of cameras at the nominated operations centers. The type of transmission network shall be determined by the BIDDER.

The VMS system shall be compatible to single and multiple processor servers. The server processor & hardware shall be optimized in all cases.

The VMS system shall cluster the processing & memory load across several machines. The failure of any one server in the solution shall not cause a failure in the entire system.

The VMS system device drivers shall be stored separately to the central core application to ensure any instability in 3rd party SDKs do not affect the core application.

The VMS management server shall be able to intelligently scan an IP network for new devices (cameras or servers) along with automatic model detection.

Network infrastructure and installation are the responsibility of the Bidder. Network components both active and required for the successful implementation of the video surveillance detailed in this tender shall be provided by the Bidder. The network infrastructure shall meet the streaming requirement of the project without any bottlenecks. The network infrastructure shall support UDP multicast, UDP unicast and TCP transmission.

The VMS system shall provide an integrated secure, scalable and easily accessible software-based solution for the management of the existing & future physical security infrastructure

The VMS system shall provide a powerful and efficient management interface for all the security systems across all monitored sites.

The Video Management System shall be a fully distributed solution, designed for limitless multi-site and multiple server installations requiring 24/7 surveillance with support for devices from different vendors.

The Video Management System shall offer centralized management of all devices, servers and users and must empower a flexible rule-based system driven by schedules and events.

The Video Management System shall contain recording servers used for recording video feeds and for communicating with cameras and other devices. The recording servers shall process the recordings and playback the video streams.

The Video Management System shall include a federated architecture allowing clients on the host system with the right user rights to view video sources belonging to multiple independent Video Management Systems simultaneously, as if they were on The Video Management System shall contain a management server that shall be the central manager of the system and control recording servers, cameras, devices and users. The management server shall handle the initial client login, system configuration and logging.

The management server shall allow access to a system manager from where the administrator can configure and manage all servers, cameras and users.

The system shall allow the management server to be installed on multiple servers within a cluster of servers ensuring that another server in the cluster automatically takes over in case the first server fails.

The Video Management System shall support installation and ability to run on virtualized Windows[®] servers.

The Video Management System shall allow an unlimited number of cameras to be connected to each recording server and an unlimited number of recording servers to be connected to each management server across multiple sites, if required.

The Video Management System shall support high availability of recording servers. A failover option shall provide standby support for recording servers with automatic synchronization to ensure maximum uptime and minimum risk of lost data.

The Video Management System shall support a versatile rule system including scheduled or event-driven actions with numerous options including support to time profiles.

The Video Management System shall support Microsoft Windows XP Professional, Microsoft Windows Server 2003, Microsoft Windows Server 2008, Microsoft Windows Vista, Microsoft Windows 7, Microsoft Windows 8 and Microsoft Windows 10 with the latest patches and service packs installed.

The system must use DirectX and .NET Framework. The Video Management System software shall include multicast and multi-streaming support.

The Video Management System shall include automatic camera discovery.

The Video Management System shall support archiving for optimizing recorded data storage through unique data storage solutions by combining performance and scalability with cost efficient long-term video storage.

The Video Management System shall incorporate fully integrated matrix functionality for distributed viewing of any camera in the system from any computer with the client viewer.

The Video Management System shall incorporate intuitive map functions allowing for multi-layered map environment. The map functionality shall allow for the interactive control of the complete surveillance system, at-a-glance overview of system integrity, and seamless drag-and-drop integration with video wall module option.

The Video Management System shall support 56-bit encryption of video for export purposes. The 56-bit encryption shall meet the US Government requirements on export limits for encryption.

The Video Management System shall support full two-way audio between clients and remote devices. Two-way audio integration shall support the following features and functions:

The Video Management System software shall provide fast evidence export by exporting in video to various formats, including video from multiple cameras in encrypted native database format with an included viewer.

The Video Management System shall show full awareness of the system through audit logs and shows user activity through comprehensive logs.

The Video Management System shall include support for a frame work data module designed to integrate multiple third party Video Content Analysis (VCA) solutions seamlessly into client viewer environments.

The Video Management System shall include a Software Development Kit (SDK) that offers important capabilities for integrating the Video Management System with third party software and applications.

The Video Management System shall include a stand-alone viewer application to be included with video exported from the client viewer application. The viewer application shall allow recipients of the video to browse and playback the exported video without installing separate software on their computers.

The Video Management System shall include support for Active Directory to allow users to be added to the system. Use of Active Directory requires that a server running Active Directory, acting as a domain controller, to be available on the network.

The Video Management System shall be designed to support each component on the same computer for efficiency in smaller systems, or each component on separate systems for large system deployments. System Monitor shall give actual and historic performance and use reports of server performance, storage availability, network usage and camera performance.

Multi-stream should support two independent streams from a camera to the recording server with different resolutions, encodings and frame rates, dependent on camera capabilities

Multi-live streaming shall define multiple streams for live viewing with different properties.

Multi-Stage storage: The recording shall support multiple storage containers with individual archiving schemes and retention times. Recording capacity is limited only by disk space

The Recording video data grooming shall be supported which enables compression (grooming) of the video by reducing the frame rate of the video data.

EDGE STORAGE

Edge storage shall secure that when a lost or broken connection is back up, the data stored on the camera's internal storage shall be retrieved and stored in the media database.

This feature requires that the used camera must support edge storage and contain a memory card where the recordings can be stored.

After recovery from a malfunction, it shall be possible to retrieve and play back the video and audio recorded by the device, while the malfunction been going on.

The edge storage shall secure that the camera records the video stream directly on its own internal storage, if the connection between the hardware and the recording server is terminated for the following reasons:

Recording server crash.

Power failure on the recording server machine.

Network failure.

Controlled shut down of the recording server. For example, in case of maintenance or upgrade.

Edge storage shall secure that when the recording server is back online, it shall poll the connected hardware for recorded data and retrieve it.

Edge storage shall secure that the recording server specifies the time period from which data shall be retrieved from the camera.

Setting up a rule shall make it possible for the edge storage to serve as a temporary storage which delays the transfer of recorded data until a given date, time or event, for example recordings during working hours that are kept on the edge storage and transferred to the recording server during closing hours.

A system log shall log when data is retrieved from the edge storage.

Time stamps in the retrieved data from edge storage shall be used when inserted into the media database.

The edge storage shall be able to work in a failover server scenario. When the failover server kicks in, it shall retrieve the recorded data on the edge storage.

The edge storage function shall be able to regulate the data transfer rate between the edge storage and the recording server.

Bookmarking

1. A bookmarking feature shall be included in the Video Management System, allowing the client viewer users to mark incidents on live and/or playback video streams.

Optimized Video Archiving

- I. Administrators shall be able to select a storage container for each device and move a device from one storage container to another, or move all recordings inclusive archives to the new storage container, or delete them all.

- II. Administrators shall be provided with an overview of the defined storage containers, their archives with path, and free and used space on the drives for each device, including the used storage space in the recording database, and in archives.

Failover Support

- i. The system shall support automatic failover for recording servers. This functionality must be accomplished by a failover server that shall work as a standby unit, which takes over in the event that one of a group of designated recording servers fails. Recordings shall be synchronized back to the original recording server once it is back online.
- ii. The system shall support multiple failover servers for a group of recording servers.
- iii. The system shall provide monitoring of all failover servers from the graphical alarm management module.
- iv. The system shall provide seamless access to recordings on the failover Server for all clients through the same client views once the services are fully started.

Multicast Support

- I. The system shall support multicasting of video feeds to client workstations in order to conserve network resources. Multicasting should be enabled from the recording servers and not directly from the cameras. Thus the IGMP network would be necessary only for the switches where server and clients are connected.
- II. Multicasting shall send a single stream of video to multiple clients, where the stream may be decoded and displayed on all clients simultaneously. This functionality shall support virtual matrix configurations.
- III. The infrastructure provided for the system shall support Internet Group Management Protocol (IGMP) for each remote network.
- IV. The system shall automatically switch to unicast, if the client fails to connect to the multicast stream.

Multi-streaming Support

- i. The recording server must accept, display and record individual streams of video from each camera that supports it, for example, display a stream in H.264/H.265 format and record another stream in MPEG4 format. The intent of this functionality shall be providing independent streams of video from the camera to the server with different resolution, encoding and frame rate.
- ii. Multi-streaming support shall allow the system to be configured with H.264/H.265 with a high frame rate for live viewing and shall allow the system to be configured with high resolution H.264/H.265 at low frame rates for recording and playback.
- iii. The system shall allow recorded video to be recorded at 8fps.

SNMP Support

- i. The system shall act as an SNMP agent which can generate an SNMP trap as a result of rule activation in addition to other existing rule actions.

- ii. The system shall be able to utilize Microsoft Windows SNMP Service for triggering of SNMP traps.

NAT Firewall Support

- I. The system shall support port forwarding, which must allow clients from outside of a Network Address Translation (NAT) firewall to connect to recording servers without using a VPN.
- II. Each recording server shall be mapped to a specific port and this port must be forwarded through the firewall to the recording server's internal IP address.

Management Server Redundancy

The management server shall provide a resilient system solution based on Windows Server Clustering, to secure maximum uptime.

Alarms Support

- I. The alarm support shall allow for continuous monitoring of the operational status and event-triggered alarms from servers, cameras and other devices.
- II. The alarm support shall provide a real-time overview of alarm status, or technical problems, while allowing for immediate visual verification and troubleshooting.

Matrix Functionality

The system shall include an integrated matrix solution for distributing video to any computer with the client viewer installed. A computer on which the matrix-triggered images can be shown must be known as a matrix recipient.

Client Viewer Functionality:

The client viewer shall provide remote users with a comprehensive suite of features:

It shall be possible to view live video from cameras on the surveillance system from 1 to 100 per view. It shall be possible to playback recordings from cameras on the surveillance system, with a selection of advanced navigation tools, including an intuitive timeline browser. It shall be possible to create and switch between an unlimited number of views, each able to display video from up to 100 cameras from multiple servers at a time. The system shall allow views to be created which are only accessible to the user, or to groups of users based on 37 different layouts optimized for 4:3, 4:3 Portrait, 16:9 and 16:9 Portrait display ratios.

It shall be possible to access views of cameras on any PC with a client viewer application installed. It shall be possible to use multiple screens as well as floating windows for displaying different views simultaneously.

It shall be possible to quickly substituting one, or more of a view's cameras with other cameras.

It shall be possible to view images from several cameras in sequence in a single camera position in a view – a so called carousel.

It shall be possible to view video from selected cameras in greater magnification and/or higher quality in a designated hotspot.

It shall be possible to receive and send video through the matrix functionality.

It shall be possible to include HTML pages and static images (for example, maps, or photos) in views.

It shall be possible to control PTZ cameras.

It shall be possible to use digital zoom on live as well as recorded video.

It shall be possible to activate manually triggered events.

It shall be possible to activate external outputs (e. g. lights and sirens).

It shall be possible to use sound notifications for attracting attention to detected motion.

It shall be possible to get quick overview of sequences with detected motion.

It shall be possible to get quick overviews of alerts.

It shall be possible to quickly search selected areas of video recording for motion.

It shall be possible to skip gaps during playback of recordings.

It shall be possible to configure and use several different joysticks.

It shall be possible to print images, with optional comments.

It shall be possible to copy images for subsequent pasting into word processors, email, etc.

It shall be possible to export recording (for example, for use as evidence) in AVI, JPEG and database formats.

It shall be possible to use pre-configured as well as customizable keyboard shortcuts to speed up common actions.

It shall be possible to insert overlay buttons, for example, for activation of speakers, events, outputs, movement of cameras etc.

It shall be possible to use a sequence function that lists thumbnail images representing recorded sequences from an individual camera or all cameras in a view.

It shall be possible to use a forced playback mode allowing the user to playback recorded video from inside the 'live' mode while viewing 'live' video. The client viewer shall support the use of 3-axis USB joysticks for control of pan, tilt, zoom and auxiliary camera functions. The client viewer shall support the use of multimedia control devices, which are capable of emulating keystrokes, for the efficient review of recorded video. The client viewer shall support the use of keyboard shortcuts for control of standard features. It shall allow the user to program numerical keyboard shortcuts for camera views. The shortcut number shall be displayed with the view description in the live and playback displays. The shortcut shall allow the user to change views with 2 to 3 keyboard entries. The client viewer shall have the capability to receive multicast streams. The client viewer shall have the capability to detect if the network becomes unreliable and to automatically switch to unicast to ensure that the operator is able to receive video. The operator shall have the ability to use digital zoom where the zooming is performed in the image only on any number of cameras simultaneously. This functionality shall be the default for fixed cameras. The use of digital zoom shall have no effect on recording, or other users.

Map Functions

- i. Built-in map function in the client viewer shall provide an intuitive overview of the system and shall offer integrated access to all system components.
- ii. Map function shall be able to use standard graphical file formats including: jpg, gif, png, tiff, etc.
- iii. It shall be possible to use any number of layered maps, and it shall be possible to easily drag-and-drop and point-and-click definition of cameras, servers, microphones, speakers, I/O devices, hot-zones, and PTZ camera presets.

- iv. Hot zones shall be allowed for intuitive navigation between different map levels.
- v. Map function shall support instant camera preview when moving the mouse pointer over a specific camera.
- vi. Map function shall support central overview of the surveillance system via an alarm list containing alarm indicators of high, medium or low prioritized alarms. Furthermore, the alarms shall be categorized by the following states; new, in progress, on hold, or closed. Alarms must be possible to acknowledge by right-clicking elements on maps.

Mobile viewing client

- A. It shall be possible to access and view cameras and views on a smartphone or a tablet (a mobile device).
- B. Access to cameras and views on a mobile device shall be established through three components:
 - 1. A mobile server that shall be able to run as a dedicated server or on a server running a video management system.
 - 2. A mobile plug-in that shall integrate with the video management system to provide the necessary configuration for the mobile server to integrate with the relevant video management system.
 - 3. A mobile client application running on a mobile device that shall connect to the cameras and views in the video management system.
- C. The mobile device shall connect to the same network as the machine running the mobile server.
- D. Mobile client should support Video Push feature any incident can be live captured from the Mobile and can be pushed for live and recording at the centralized monitoring station.

Remote client viewer

The web-based remote client viewer shall offer live view of up to 16 cameras, including PTZ control with joystick, fisheye (360 degrees) cameras and event/output activation. The playback function shall give the user concurrent playback of up to 16 recorded videos with date, alert sequence, or time searching.

The web-based remote client viewer shall offer quick overviews of sequences with detected motion.

The web-based remote client viewer shall be able to generate and export evidence in AVI (movie clip) and JPG (still image) formats.

The system shall support the use of separate networks, VLANs, or switches for connecting the cameras to the recording servers providing physical network separation from the clients, and facilitate the use of static IP addresses for the devices.

The system shall support H.264/H.265, MPEG-4 (Part 2), MPEG-4 ASP, MxPEG, and MJPEG compression formats for all analog cameras connected to encoders, and all IP cameras connected to the system.

The system shall support dual-streaming cameras and shall cover the following compression formats: H.264/H.265, MPEG-4 (Part 2) and MJPEG.

The system shall allow the frame rate, bit rate and resolution of each camera to be configured independently for recording. The system shall allow the user to configure groups of cameras with the same frame rate, bit rate and resolution for efficient set-up of multiple cameras simultaneously.

The recording server(s) shall have the ability to support multiple Network Interface Cards (NIC) and shall support connection to the cameras on a network separate from the client viewer, management server and system manager.

The recording server shall have the ability to accept the full frame rate supplied by the cameras, while recording a lower frame rate yet still shall make the higher frame rate available to the clients for live viewing.

4. PROFESSIONAL SOUND SYSTEM

4.1.PUBLIC ADDRESS AND BACKBROUND MUSIC SYSTEM

This section specifies the detailed requirements of the design, manufacture, supply, delivery, installation, testing, commissioning and maintenance during the defects liability period of the public address and background music system.

The extent of work includes basically however not limited to the following,

- (i) Supply and Installation of main equipment racks complete with system manager, input output controllers, amplifiers etc.
- (ii) Supply and Installation of speaker system.
- (iii) Supply and installation of cabling.

4.2. SYSTEM DESCRIPTION

- I. System shall be capable enough to meet all the requirements on a public address, emergency announcements and background music. The system shall be designed to deliver sound pressure level of 85dB at the 1.5m listening level from the floor. High quality level of audio signal shall be maintained at the

outputs of amplifier to compensate losses in the audio distribution.

- II. The proposed system shall be programmable input / output matrix type with features for playing messages, audio files at pre timed intervals or priority basis, paging or making general announcements and control interfaces to connect with the fire alarm system etc.
- III. Each power amplifier shall have 30% spare loading capacity to drive all speakers during an emergency announcement without overloading the amplifier. Amplifier shall have built in self-restoring protection circuit to guard against hazards of operation such as mis-loading at its input, short circuiting its output and connection mistakes.
- IV. The system shall also have means to cut off the music sources during emergency paging and shall enable the emergency announcement to be heard in these areas. All volume controllers as specified shall be overridden during an emergency announcement.
- V. There shall be background music to selected areas. It shall be possible to pre-program the output music to any of these zones. Sources provided shall be a DVD player, FM tuner and MP3/Disc/Pen drive player.
- VI. All equipment such as central controller and power amplifier shall be housed in 19" equipment rack.

4.3. EQUIPMENT SPECIFICATIONS

- I. The main equipment shall be housed in standard 19" equipment rack and shall be located as shown in the drawings.
- II. The system shall be flexible in design that allows adding and removing of equipment anywhere in the network without affecting the performance of other units to meet the complete tender requirement.
- III. There should be zone selector with main volume controllers for each zone and sub volume controllers for other areas as shown in the drawings.
- IV. A digital message module shall be stored in the central controller for broadcasting of message in case of emergency.
- V. Whatever signal is being transmitted, the emergency and alarm calls shall always have top priority. They shall be broadcasted immediately and at full volume, even in those zones where speakers are currently switched off or set a low volume.
- VI. All equipment shall be housed in standard 19" racks as far as possible; all inter connections shall be by means of standard cables and connectors for ease of serviceability.
- VII. The contractor shall supply install and wire up the proposed speakers. All speakers shall be designed for music and public address application. They shall

have a minimum opening angle of 60 deg at 4000Hz or higher.

- VIII. The uniformity of sound pressure level distribution at 1.5m above the floor level shall not vary beyond +/-4dB for frequency up to 4000Hz and no more than +/-8dB for frequency up to 8000Hz.
- IX. The ceiling speakers so chosen shall have uniform frequency response ranging for 100Hz to 16000Hz within +/- 3dB variations.
- X. Each speaker assembly shall incorporate a flush-mounted baffle, 100V line matching transformer and a high efficiency loudspeaker in order to keep the opening power at a minimum.
- XI. Each loudspeaker shall be capable of generating an on –axis sound pressure level of at least 91dB at a 1m distance, with 1W output.

4.3.1.POWER AMPLIFIERS

Power amplifiers shall meet following minimum requirements;

The main function of the power amplifier is the amplification of audio signals for the speakers. It shall be possible to select the output voltage between 100V, 70V or 50V by changing output. The amplifiers should be protected against overload and short-circuit.

The power amplifiers shall be with the following approvals;

EMC emission EN55103-1

EMC community EN55103-2

Performance

Frequency response 50Hz – 20kHz (+1/-3dB at -10dB ref rated output)

Distortion < 1% at rated output power, 1kHz.

4.3.2. VOLUME CONTROLLERS

Type: Auto-Transformer

Power handling capacity; 6-12W

Total Impedance: 36dB (10W)

Attenuation per step: 3dB

Insertion loss: 0.5dB(6-12W)

4.3.3. CEILING/WALL MOUNTED SPEAKER

Rated Voltage: 100V

Rated impedance: 1667 ohm

Effective frequency range: 70 to 18,000Hz

Opening angle (4kHz) : 100 deg

Power handling capacity: 6W/15W

Sound pressure level at 1kHz, 1W, 1m: 94dB

Maximum sound pressure level: 99dB
Speaker diameter: 200mm

4.3.4.COLUMN ARRAY SPEAKER

Rated Voltage: 100V
Rated impedance: 1667 ohm
Effective frequency range: 70 to 18,000Hz
Opening angle (4kHz) : 110 deg
Power handing capacity: 60W
Sound pressure level at 1kHz, 1W, 1m: 94dB
Maximum sound pressure level: 99dB

4.3.5. PROFESSIONAL LOUDSPEAKER MANAGEMENT SYSTEM

Analogue input / output & digital AES/EBU input
Integrated sample rate - 32 to 96KHz or specified
Built Remote Controller via PC through RS323/RS485
Built-in-switch mode Power Supply (100-240V)
LED illuminates corresponding output

4.3.6. MULTIBAND GRAPHIC EQUALIZER FOR LIVE APPLICATION

31 Band or specified
FBQ Feedback Detection
Limiters with gain reduction system
Illuminated Fader (45mm or above)
Adjustable Crossover Frequency
19" Rack Mounting System

4.3.7. CHANNEL MIXER CONSOLE

24-bit Multi Effects Processor
Adjustable Parameters High low each per effect
Ultra-natural and delay effects
Special effect for live sound
19" Rack Mounting System

4.3.8. DIGITAL TUNER

Fixed and variable outputs
Stereo and mono outputs
Auto scan, auto scans memory
FM stereo indicator, MONO/STEREO function

15 station presets
Automatic mute circuit
Power source: 220~240VAC; 50Hz

4.3.9. GOOSENECK MICROPHONE

Frequency Response : 50 to 17,000 Hz
Output Impedance : Rated at 150 Ohm (180 ohm actual)
Maximum SPL (1 kHz at 1% THD, 1 k Ω load)
Cardioid : 123.0 dB
Dynamic Range : 94.0 dB
Power Requirements : 11 to 52 Vdc Phantom Power

4.3.10. HAND HEALED MICROPHONE

Pick-up pattern : Cardioid
Frequency response : 40 – 16,000 Hz
Sensitivity : 2.7 m V/Pa (free field, no load) (1 kHz)
Nominal impedance : 350 ohm

4.3.11. UHF MICROPHONE SYSTEM (100M RADIUS)

Receivers Frequency : UHF (Adjustable frequency type)
Receiver Type : True Diversity
Antenna inputs : 2 BNC sockets, 50 ohm

4.3.12. HANDHELD TRANSMITTERS

Frequency : UHF
RF output power : typ.30 mW
Power supply : 9V alkaline
Operating time : > 8h

4.3.13. POWER SUPPLY UNITS

The contractor shall make provision for all necessary power supply units, voltage regulators etc., to ensure that the equipment will perform satisfactorily c/w necessary surge arresters and filters. All necessary power supply required for the operation of the sound equipment shall be designed, supply and installed by the contractor.

4.4.TESTING & COMMISSIONING

The contractor shall test the system in the presence of the consulting engineer to show that its performance satisfies the requirement of these specifications. All test equipment shall be professional and supplied by the contractor. A sound pressure meter will be required. No claim is allowed for these testing. The cost shall be deemed to be included in the schedule of rates of the equipment.

4.5.GUARANTEE

The system shall be guaranteed against workmanship, design and manufacturer's defects for the period of 3 years. Any defective material or equipment shall be replaced as with new equipment at no cost to the employer.

5. LAN SYSTEM

5.1 GENERAL

- 1.1.1. This specification covers the submittals of shop drawings, sample approvals, setting to work, supply, installation, inspection, testing & commissioning, as built drawings and operation and maintenance manuals and periodic maintenance.
- 1.1.2. The Tenderer's shall read this section in conjunction with Tender drawings and Bill of Quantities. They shall clarify any discrepancies between tender drawings and Bill of Quantities.
- 1.1.3. The Tenderer shall submit their offer complying with all the conditions of contract, specification, tender drawings and Bill of Quantities.
- 1.1.4. Specification, drawings and BOQ are meant to provide sufficient information to the tenderers and it is the contractor's responsibility to supply and install complete systems to working order

5.1.1 OPERATION AND MAINTENANCE MANUALS

The Contractor shall submit 3 copies of Operation & maintenance Manuals, which shall contain Product literature, Specific operating instructions and Maintenance instructions.

5.1.2 TESTING AND COMMISSIONING OF SYSTEMS

The contractor shall submit testing & commissioning procedures, handing over check Lists 1 month before testing and commissioning and shall obtained approval the Consulting Engineer. The contractor shall perform all the equipment and devices testing as directed by the Consulting Engineer. The Contractor shall bear the cost for such tests and any items found defective shall be replaced at no extra cost. Such replaced items shall be re- tested for verification.

5.1.3 EQUIPMENTS, MATERIALS AND ACCESSORIES

The equipment, material used, fittings and devices shall comply with the Architectural and design criteria, design concepts and performance requirements.

When selecting products, the contractor shall consider the space limitations, weight limitations, compatibility with other existing devices and systems.

Contractor shall obtain approval from consulting engineer for all equipment, material and accessories before commencing installation.

All the products supplied under this contract shall be guaranteed for a period of three years from the final handover date.

5.1.4 PRODUCT BRANDS

All the Materials, Equipment and Devices and Accessories supplied under this contract shall bear the Manufacturer names. The consulting Engineer has the right to accept or reject any Equipment, Material and device brands based on the past performance records

Preferred brands: Active Components CISCO/HP

Passive Components AMP/Molex /3M/Brand-Rex

5.1.5 DRAWINGS

The contractor shall familiarize himself with the site conditions before preparing shop drawings. He shall verify the dimensions shown in the drawings and notify the consulting engineer any discrepancies.

The contractor shall submit 3 copies of shop drawing for approval. Contractor shall obtain approval for shop drawings before commencing installation work.

5.1.6 PERIOD OF WARRANTY

The contractor shall submit a written warranty for the Installation for a period of one year from the date of handing over against manufacturing defects and poor workmanship.

5.1.7 STANDARDS

- ISO 11801
- EN 50173
- TIA/EIA 568-B and 568-C
- TIA/EIA 569 Commercial building standard for telecommunications pathways and spaces
- EN 50174 Information technology – cabling installation
- TIA/EIA-606 Administration standard for the telecommunications infrastructure of commercial buildings
- TIA/EIA-607 Commercial Building Grounding and Bonding Requirements for Telecommunications
- PrEN50303 Application of equip potential bonding and Earthing at premises with information technology equipment
- PrEN50174-2 Information Technology, cabling installation, part 2, Installation, planning and practices inside buildings
- IEC 332-1, IEC 754, IEC 1034: Fire performance standards

IEC 61935 Generic specification for the testing of balanced generic cabling in accordance with ISO/IEC 11801

5.2 DATA SYSTEM

5.2.1 PASSIVE COMPONENTS

5.2.1.1 Patch panel 24 port -Modular, Unshielded Including CAT 6 Keystone modules

- 24 Ports
- 1U rack height
- Provision for labeling
- Satisfy or exceed Category 6 standards
- 19" rack mountable

Bandwidth of 250 MHz or higher for each port
Rear Cable management bar
Each port must accept 4 pairs of solid 23 AWG conductors

5.2.1.2 Fiber patch panel 24 port including SC Fiber connectors with duplex modules, splice tray, cable gland and accessories

Patch panel

Holders for SC connectors
19" rack mountable
Should consist of at least 1 cable gland

Splicing tray

Should manage up to 12 fibers
should consist of a Clear cover to allows viewing or inspection of fiber without having Features to remove cover
Should Accepts up to 12 heats shrink style fibers Splice sleeve
Should accommodates standard heat shrink sleeves in 40 or 60mm lengths
Standard TIA/EIA-568-B and certified by UL

SC Fiber connectors

All connectors should be built on 125µm OFNP rated
Should consist of SC style Connectors and boot
All connectors should have precision pre-radiused zirconia ferrules

5.2.1.3 Patch leads 1m, 2m - CAT 6, Unshielded

Length 1 m, 2 m
Satisfy or exceed Category 6 standards
Bandwidth of 250 MHz or higher
Must accept 4 pairs of solid 23 AWG conductors

5.2.1.4 Patch leads 1m - Multimode Fiber Optic with LC to SC interface

1m length
50/125 Fiber Size
OM3 Fiber Classification
Multi-Mode Fiber Type

5.2.1.5 Supply and installation of single faceplate with CAT 6 Keystone Module (RJ45)

Complete BS type single wall outlet with shutter and Cat 6 (RJ45) tool-less termination Keystone Jack
Compliance with TIA/EIA-568- B.2-1a and ISO/IEC 11801 Category 6 specifications
Gold plated Jack contacts
Labeling

5.2.1.6 Racks

Free Standing and Wall Mounted Enclosures with front lockable glass door, steel side and back doors with louvers Cable Ladder, 230V AC Fan Plates, 1 x Louver Plate, 1 x Cable Gland Plate Plates, 1 x Vertical 4 Way (with 13A sockets) Power Panel, M6 Screws, Washers, M6 Cage Nuts and accessories.
Color black

5.2.1.7 1U Management panels

19" Rack mountable
Color black
Metal with lid

5.2.1.8 UTP cable 4 pair (CAT 6)

4pair, 8 conductors, solid stranding, 23 AWG bare copper, insulated wire
Should support IEEE 802.3:10BASE-T, IEEE 802.3u:100BASE-T, IEEE 802.3ab:1000BASE-T
Minimum operating frequency should be 250 MHz
Meet the requirements of ANSI/TIA/EIA-568-B.2-1a and ISO/IEC 11801 Class E and the product should have a standard certification number
Plenum Rated cable is most preferable

5.2.1.9 Multimode Fibre Optic Cable 6 core OM3

6 core Multimode Laser-Optimized 50-µm Core Diameter/125-µm Cladding Diameter (OM3) Optic Fiber Cable
In conjunction with 850 nm Vertical-Cavity Surface-Emitting Lasers (VCSELS) Water-Blocked (jelly-filled) Loose tube cable with internal strengthening member and a flame retardant (IEC 60332-1), fire retardant (IEC 60332-3) outer sheath
Standard Compliance ISO/IEC 11801, EN 50173-1:2002, IEC 60794-1, TIA/EIA-492AAAC, IEC-60793-2-10 Type A1a.2, ITU-T Rec.G.651.1
Outer Jacket color suits EIA/TIA Standards
Attenuation: less than 3.5dB/km (at 850nm), less than 1 dB/km (at 1300nm)
Minimum modal bandwidth-length product for overfilled launch at 850/1300 nm should be 1500/500 MHz-km

5.2.2 ACTIVE COMPONENTS

All Access Data Switchers shall be CISCO Catalyst Series switchers or equivalent HP Switchers with relevant configurations provided in the BOQ.

Core Data Switcher shall be CISCO Catalyst Series switch or equivalent HP Switch with relevant configurations provided in the BOQ.

5.2.3 POWER SUPPLY UNITS

The contractor shall make provision for all necessary power supply units, voltage regulators etc., to ensure that the equipment will perform satisfactorily c/w necessary surge arresters and filters. All necessary power supply required for the operation of the sound equipment shall be designed, supply and installed by the contractor.

5.2.4 TESTING & COMMISSIONING

The contractor shall test the system in the presence of the consulting engineer to show that its performance satisfies the requirement of these specifications. All test equipment shall be professional and supplied by the contractor. A sound pressure meter will be required. No claim is allowed for these testing. The cost shall be deemed to be included in the schedule of rates of the equipment.

5.2.5 GUARANTEE

The system shall be guaranteed against workmanship, design and manufacturer's defects for the period of 3 years. Any defective material or equipment shall be replaced as with new equipment at no cost to the employer.

QUALITY OF ELV ACCESSORIES

| No. | Item | Relevant Standard Specifications | Recommended Brand Names |
|-----|---------------------------------|----------------------------------|----------------------------------|
| 01 | Telephone Outlets, Data Outlets | BS 5733 | Clipsal, Orange, Crabtree, hager |
| 02 | PABX and accessories | TRC approval | Nec, Panasonic or equivalent |
| 03 | Telephones | TRC approval | Nec, Panasonic or equivalent |

| | | | |
|----|---------------------------------------|----------------------------------|--|
| 04 | CCTV Camera, NVR and Accessories | BS EN 62676 | Hikvision, Panasonic or equivalent |
| 05 | PA System and accessories | BS EN 60268 BS EN 61305 | Inter -M, DAS, JBL, Sennheiser, Behringer, TOA |
| 06 | PVC/PVC/Cu Cables | B.S. 6004 : 1995 & SLS 733: 1995 | KELANI, ACL OR equivalent |
| 07 | Cat 6 Cables/ OM3 Multi Mode 6C Fiber | ISO/IEC 11801 | Corning, 3M, D link or equivalent |
| 08 | Data switches and accessories | IEEE 802.3, IEEE 802.11 | Cisco, Hp |

QUALITY OF ELV EQUIPMENT & MATERIAL OFFERED

(TO BE COMPLETED BY THE TENDERER)

| No. | Item | Make offered | Country of Origin | Country of Manufacture |
|------------|---------------------------------|---------------------|--------------------------|-------------------------------|
| 01 | Telephone Outlets, Data Outlets | | | |

| | | | | |
|----|---------------------------------------|--|--|--|
| 02 | PABX and accessories | | | |
| 03 | Telephones | | | |
| 04 | CCTV Camera, NVR and Accessories | | | |
| 05 | PA System and accessories | | | |
| 06 | PVC/PVC/Cu Cables | | | |
| 07 | Cat 6 Cables/ OM3 Multi Mode 6C Fiber | | | |
| 08 | Data switches and accessories | | | |

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specifications- Solar System

23553-01-TN-EL-SP-9802

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Version Log

| Version | Issuer | Summary of Changes | Date of Issue |
|---------|--------|--------------------|---------------|
| 1.0 | URO | Initial Issue | 20.09.2023 |
| 2.0 | URO | Second Issue | 27.11.2023 |
| 3.0 | URO | Tender Issue | 14.12.2023 |

1.0 GENERAL

1.1. DESCRIPTION

Supply, install, test at works, deliver to site, install and commission of solar PV system. The solar power system shall operate on the principle of direct conversion of sunlight to electrical energy by employing photovoltaic technology. The given Photovoltaic design is a guide line only. Contractor may alter the design according to given specifications.

1.2. APPLICABLE PUBLICATIONS AND STANDARDS

Standards and Publications of the following organizations form part of this Specification to the extent indicated by the references thereto unless superseded by Detailed Technical Specifications.

| | |
|---------------------------------|---|
| IEC 60364: 2017 | Electrical installations of buildings – Part 7-712: Requirements for special installations or locations – PV power supply systems Electrical installations of buildings – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems |
| IEC 61727, 2nd Ed. (2004) | Photovoltaic (PV) systems - Characteristics of the utility interface |
| IEC 62116, 2nd Ed. (2014-02), | Utility-interconnected photovoltaic inverters – Test procedure for islanding prevention measures |
| IEC 62109-1, 1st Ed. (2010-04), | Safety of power converters for use in photovoltaic power systems – Part 1: General requirements |
| IEC 62109-2, 1st Ed. (2011-06), | Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters |
| IEC 62109-3:2020 | Safety of power converters for use in photovoltaic power systems - Part 3: Requirements for electronic devices in combination with photovoltaic elements. |
| IEC 61730-1:2016 | Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction. |

| | |
|--------------------------|--|
| IEC 61557 | Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring, or monitoring of protective measures |
| IEC 60755: 2017 | General safety requirements for residual current operated protective devices |
| IEC 62423:2009 | Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses |
| IEC 60947 | Low-voltage switchgear and control gear |
| IEC 62305 | Protection against lightning |
| DIN EN 63027 | DC arc detection and interruption in photovoltaic power systems |
| IEEE 519 (2014), | Recommended practice and requirements for harmonic control in electric power systems |
| IEC 61000 | Electromagnetic Compatibility |
| BS 7671 – 18th Ed (2018) | Section 712 – Solar Photovoltaic (PV) power supply systems |
| IEC 61427-1:2013 | Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 1: Photovoltaic off-grid application |
| IEC 61427-2:2015 | Secondary cells and batteries for renewable energy storage - General requirements and methods of test - Part 2: On-grid applications |

| | |
|----------------|--|
| IEC 62619:2022 | Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications |
|----------------|--|

1.3. SCOPE OF WORK

The Scope of Work shall include the following:

- To supply, deliver & install a complete set of solar panels with accordance to technical requirements in this tender.
- To supply, deliver & install a complete set of matched multiple inverters for the solar panel with accordance to technical requirements in this tender.
- To supply, deliver & install a complete set of DC power line surge protector and AC power line surge protector to have a complete surge protection with accordance to technical requirements in this tender.
- To design, supply, deliver & install lightweight frames to mount the solar panels together with Professional Engineer endorsed calculation & drawing.
- To supply, deliver & install complete solar system earth & installation earth in accordance to BS7430, IEEE Wiring 18th Edition and IEC62305 standard recommendations.
- To provide detail drawings and work method statement on lightning protection system bonding with accordance to IEC62305 standard recommendations.

1.4. SUBMITTALS

1 Tender Stage

- Technical data and product catalogues.
- Detail drawing of proposed system bonding of lightning protection system.
- Proposed Project Schedule
- Proposed Project Team Structure

2 Construction Stage

- Shop drawings/construction drawings.
- PE endorsed calculation & structure drawing
- Catalogues and samples of solar panel, mounting structure, surge protector, DC & AC cable, trunking /conduit & fixing accessories.

3 Inspection and Commissioning Test

- Commissioning test reports after testing
- O&M manuals
- As-built AutoCAD drawings

1.5. CLIMATIC CONDITIONS

Climate Change and Irradiance - Maldives

Irradiances

Climate data and irradiance

Irradiance chart

Sun paths

Maldives

Maldives

Source of climatic data

NASA-SSE

Latitude

4.31 °

Longitude

73.42 °

Altitude

0.0 m

T Max

28.6 °C

T Min

26.0 °C

Time zone

5

Total annual irradiance

Direct

1438.1 kWh/m²

Diffuse

689.85 kWh/m²

Global

2127.95 kWh/m²

Monthly average irradiance on horizontal plane

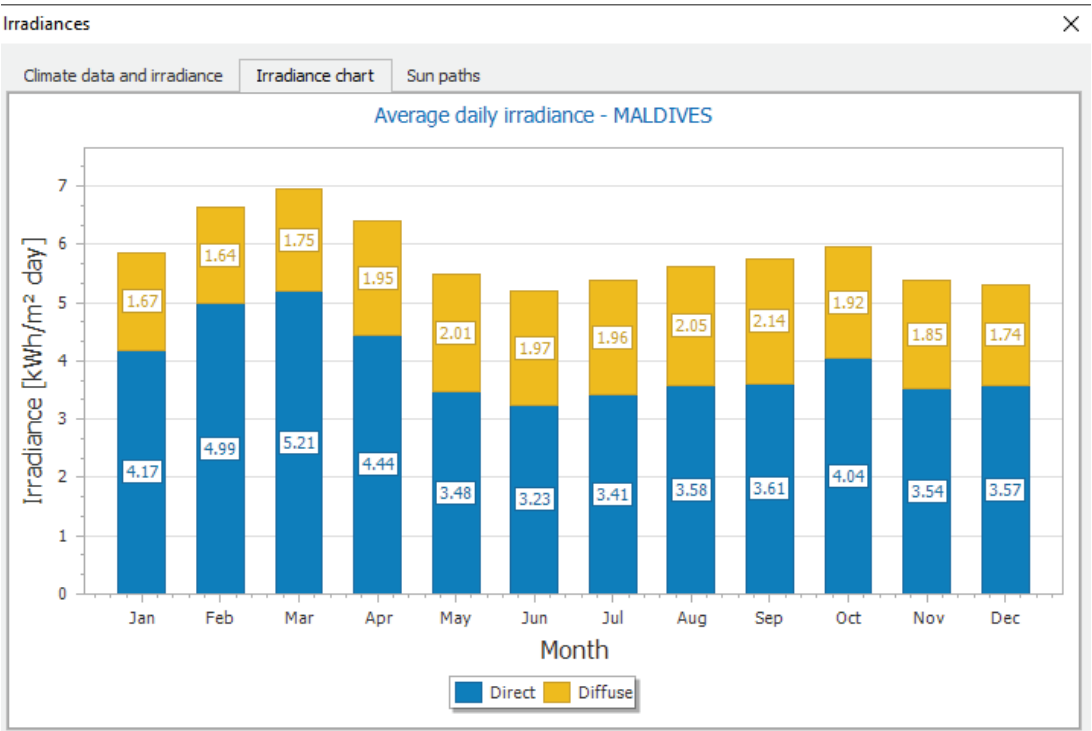
| Month | Global [kWh/m ²] | Diffuse [kWh/m ²] |
|-----------|------------------------------|-------------------------------|
| January | 5.84 | 1.67 |
| February | 6.63 | 1.64 |
| March | 6.96 | 1.75 |
| April | 6.39 | 1.95 |
| May | 5.49 | 2.01 |
| June | 5.2 | 1.97 |
| July | 5.37 | 1.96 |
| August | 5.63 | 2.05 |
| September | 5.75 | 2.14 |
| October | 5.96 | 1.92 |
| November | 5.39 | 1.85 |
| December | 5.31 | 1.74 |

Units of measurement

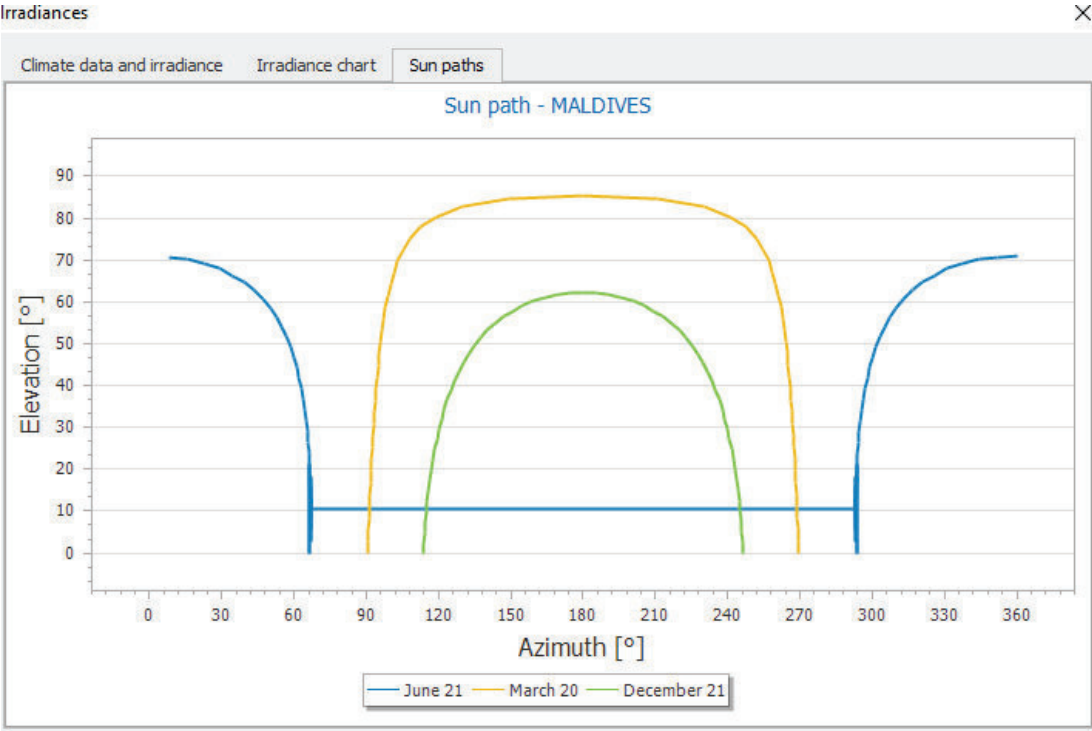
☒ kWh/m² day

☐ kWh/m² month

Average Daily Irradiance - Maldives



Sun Path - Maldives



1.6.CO-ORDINATION

The LV installation work must be coordinated with the building work and work of other services. The drawings and specifications shall be carefully examined and information regarding building materials and equipment supplied by others obtained from the respective source to determine the extent, type and location of all wiring required. All holes and openings in slabs and walls which may be required for the passage of electrical conduits, trunking and cables must be determined and information regarding them passed on to building contractors so that they may be provided for at the time of pouring of concrete or construction of walls, breaking of concrete, cutting and patching of the structure shall be limited to a minimum and carried out only after securing the consent of the supervising Engineer. All cables and conduits passing holes must be made good by fire resistant incombustible material. Further protection of cables and conduits shall be given as instructed by the Engineer.

1.7.INSTALLATION

The solar PV system provider shall carefully evaluate the potential hazards and systematically devise methods to minimize the risks. The service provider shall consider both mitigating potential hazards present during and after the installation phase.

The service provider shall be knowledgeable of the supply from PV modules cannot be switched off. Thus, special precautions should be made to ensure that live parts are either not accessible or cannot be touched during installation, use and maintenance. The standard practice needs to be followed at all the time when designing protection system to the PV system.

PV systems include DC wiring, generally competency of electrical installers in DC systems are lower. Other important point is that the installation of PV systems presents a unique combination of hazards – due to risk of electric shock, falling and simultaneous manual handling difficulty. All these hazards are encountered as a matter of course on a building site, but rarely all at once. While roofer may be accustomed to minimizing risks of falling or injury due to manual handling problems, they may not be used to dealing with the risk of electric shock. Similarly, Electricians should be able to handle large object at heights.

The PV service provider shall thoroughly study the potential risk and prepare a detailed mitigation plan. The developed risk mitigation plan shall be strictly followed by all the personal involved in system design, installation and operation and maintenance.

It is then important to ensure that the long-term safety of the system is not compromised by a poor installation or subsequent poor maintenance. Much of this comes down to the quality of the installation and system inspection and testing.

Therefore, to ensure the safety of solar PV systems, all involved parties should ensure the following:

- Selection of the correct system components that conform to the appropriate international standards as provided in this guideline. (i.e. Modules, Inverters, cables, connectors, junction boxes, isolators etc.);
- Correct Design and Installation of the solar PV system; and
- Correct operation and maintenance of the solar PV system.

All key safety issues affecting the design and installation process must be addressed including following typical issues.

- The supply from PV modules cannot be switched off, so special precautions should be made to ensure that live parts are either not accessible or cannot be touched during installation, use and maintenance.
- PV modules are current-limiting devices, which require a non-standard approach when designing fault protection systems, as fuses are not likely to operate under short-circuit conditions.
- PV systems include DC wiring. DC wiring has few differences than AC wiring.
- The installation of PV systems presents a unique combination of hazards – due to risk of electric shock, falling and simultaneous manual handling difficulty. All of these hazards are encountered as a matter of course on a building site, but rarely all at once.

The following is a summary of some of the main hazards that may be encountered during the construction, operation, and maintenance of a Solar PV Systems:

- PV Modules produce electricity during daylight and cannot be turned off. Therefore, it is expected that during installation work, installers will be working on live modules and a risk of direct or indirect contact with electricity will be high. Measures should be taken to inform installers of such risks and use of proper insulating materials (e.g. gloves, insulated shoes, proper harness, and etc.) to minimize the risk of electric shock.
- PV Modules are current limiting devices with the short circuit current being not much higher than the operating current which in turn may not be detected by the overcurrent protection used as such minor faults may remain undetected for a long period of time which can develop into a fire hazard.
- PV Modules installed on roofs, affected by high wind may increase the risk of flying objects. As such, the mounting structure holding the PV Modules should take into consideration such risks during the design and installation phases.
- The majority of Solar PV systems would be installed at premises rooftops, the risk of falling becomes very high, as such measures should be taken to reduce such risks by using the appropriate scaffolding, suitable access provisions, safe lifting procedures, and suitable labelling and warning signs.
- Electric shock from PV Modules, cables, combiner boxes, and termination points. As indicated above Modules will produce electricity when subjected to sunlight, as such measures should be taken to eliminate the risk of exposed/damaged wires, cables, and connections.

Most likely cause of a fire on a grid connected solar PV system is the development of a DC arc because of poor connections (module connectors, combiner boxes, Batteries) creating high resistance junctions or faulty DC disconnecter switches or damaged cables resulting in a short circuit.

The design and installation of solar PV system should aim to minimize the risk of the system being the source of fire and minimize the risk to occupants or emergency services. The following are some measures for consideration:

- Specifying and installing the proper DC overcurrent protection.
- Properly securing DC cables in containments.
- Use of enclosures made from insulating materials with self-extinguishing properties.
- Ensuring the correct ratings are used for the DC cables, combiner boxes and switch disconnectors etc.
- Ensuring all connections are tightened and torqued in accordance with manufacturer specifications.
- Ensuring that used inverters have a built in DC arc detection capabilities. Otherwise, standalone detectors should be considered for PV systems operating 80V or greater.
- Ensuring that double insulated cables are used throughout the DC circuit to greatly minimize the risk of parallel arcs between conductors, or via an earth path.
- Minimize as much as possible the length of the DC cables from the inverters and avoid installing DC cables in walls or hidden in the building structure.

1.8. TESTING & COMMISSIONING

The Contractor shall be responsible for satisfying himself as to the correctness of the Solar Power System connections to all work supplied and installed by him under the Contract before such work is put into operation.

After the connection of power supply to the installations, the Contractor shall commission all sections of the electrical installations and demonstrate to the Engineer or his Representative that the entire electrical installations are in perfect working order. Where equipment of a specialized nature is involved, the Contractor shall, if necessary or requested by the Engineer seek and obtain at his own cost the services of specialist and/or commissioning engineers from the suppliers/manufacturers.

1.9. TRAINING

The Contractor shall submit a full proposal of the recommended training necessary for the owner's personnel to attend to routine testing, maintenance service and minor repairs including an indication of the duration of such training.

The number of persons required to be trained shall be determined jointly by the Engineer, and the Contractor.

The scope of training shall include on-site training and such training shall be prior to hand-over of the system. Technical training and system operation instructions to the owner's personnel shall also be provided during the commissioning and performance tests phases of the system.

System operation instructions shall be given by an experienced and competent representative of the Contractor who is thoroughly conversant with the electrical system installed.

1.10. OPERATION AND MAINTENANCE MANUALS

The contractor shall submit comprehensive Operation and Maintenance Manuals of all equipment supplied during the site training. It shall consist of all the detailed diagrams of the equipment, writing of the equipment and arrangements and instructions of the regular maintenance of the equipment. Further, a schedule shall be included which may be in the form of a material list giving all particulars together with ordering references of all replaceable parts for all the equipment which will be supplied.

1.11. GUARANTEES

Contractor shall provide ten (10) years guarantees for the solar power system furnished under this Contract. However, such guarantees shall be besides and not in lieu of all other liabilities which manufacturers and the Contractor may have by law or by other provisions of the Contract.

All materials, items of equipment and workmanship furnished under this Contract shall carry standard warranty against all defects in materials and workmanship. Any fault due to defective or improper material, equipment, workmanship or Contractor's design that may develop shall be made good, forthwith, by and at the expense of the Contractor, including all other damage done to areas, materials and other systems resulting from this failure.

Guarantee that all elements of the systems are of sufficient capacity to meet the specified performance requirements as set forth herein or as indicated.

2.0 SOLAR POWER SYSTEM

2.1. PROPOSED SYSTEM

| PROPOSED SYTEM INFORMATION SHEET | | |
|----------------------------------|--|--|
| PARAMETER | QUANTITY/ COMPONENT | REMARKS |
| SYSTEM CAPACITY(KWP) | 123.2 KW | |
| SOLAR PANEL | 224 NOS/ 550Wp SOLAR PANEL | AE SOLAR, JA SOLAR, JINKO SOLAR, CANADIAN SOLAR OR EQUIVALENT |
| INVERTER | 3 NOS/ 40kW ONGRID INVERTER | GROWATT, SOLIS, HUWAI OR EQUIVALENT |
| REQUIRED ROOF AREA | APPROX. 784 SQ. M | |
| FRAMES | ANODIZED ALL MOUNTING ACCESSORIES | MANUFACTURED IN SRI LANKA |
| CABLES | ARMORED/NON-ARMORED CABLES | - AC – KELANI/ACL/SIERRA CABLES - DC - PRYSMIAN/LAPP OR EQUIVALEANT |
| SWITCHGEAR | AC AND DC PROTECTION AND ISOLATORS | SCHNEIDER, ABB OR EQUIVALENT |
| SURGE PROTECTION | AC AND DC SURGE PROTECTION | SCHNEIDER, ABB OR EQUIVALENT |
| EARTHING SYSTEM | SEPARATE EARTHING SYSTEM FOR SOLAR PV SYSTEM AND STRUCTURE | |
| WARRANTY | - PANEL – 25 YEARS POWER DEGRATION / 12 YEARS PRODUCT WARRANTY - INVERTER - 10 YEARS PRODUCT WARRANTY - SERVICE – 5 YEARS' SERVICE WARRANTY - OTHER ELECTRICAL ACCESSORIES - 5 YEARS PRODUCT WARRANTY | |

2.2. DC SYSTEM

DC system of a solar PV system shall include DC cables, isolators / disconnectors, surge protective devices switches, connectors etc. All DC component ratings of the system shall be derived from the maximum voltage and current of the relevant part of the PV array adjusted in accordance with the safety factors. The system voltage/currents of the series/parallel connected modules making up the array and maximum output of the individual modules shall be taken into account when calculating the component ratings.

The rating of all DC components of Solar PV system must be rated in consideration of the highest DC voltage and highest DC current the circuit will be subject to. This will include but not limited to all cables, switch disconnectors, and connectors used on the DC side of the Solar PV System.

An assessment of the highest DC voltage and highest DC current need to be made based on the PV Modules Open-Circuit-Voltage (Voc) and Short-Circuit-Current (Isc). This information is typically provided by the PV Module manufacturer under Standard Test Conditions (STC).

Standard test conditions (STC) refer to the following testing conditions:

Irradiance of 1000 W/m²
25°C cell temperature

Air mass of 1.5

The temperature rise due to solar gain must be calculated for the relevant equipment (typically 10°C above ambient temperature), and this will have an impact on the output voltage and output current of PV Modules. Therefore, it is critical perform system design calculation taking into consideration the minimum/maximum temperatures that can occur where the system is being installed. Typically, module manufactures provide the required technical data sheets that will include temperature coefficients for Voc and Isc respectively and may include other information on the operation of modules during the first week of exposure to sunlight these must be taken into consideration.

The DC components shall be rated for following minimum voltage and current when operating with PV modules. For other PV module types, the ratings shall be calculated case by case basis.

Voltage 1.15 Voc

Current 1.25 Isc

In a general system, PV array and string voltages exceed 120 VDC. Such DC voltage will exceed levels that are considered to reduce the risk to a minimum. Thus, double insulation shall be applied as the method of shock protection. In this instance the use of suitably rated cables, connectors, and enclosures along with controlled installation techniques becomes fundamentally important to providing this protective measure as defined in BS 7671- Section 412. Similarly, double insulation of the DC circuit greatly minimizes the risk of creating accidental shock current paths and the risk of fire.

Therefore, Double insulation (insulation comprising both basic & supplementary insulation) or reinforced insulation, appropriate barriers and separation of parts must be applied to all parts of the DC circuit to facilitate a level of protection equivalent to the protective measure “double or reinforced insulation” as defined in BS 7671- Section 412.

DC CABLE SYSTEM

The installer shall use following type of cables or cable installations for DC system.

- Single conductor “double insulated” cable which complies with IEC 62930:2017,
- Single conductor cable suitably mechanically protected conduit/trunking. Alternatively, a single core Steel Wire Armoured cable shall be considered as a mechanically robust solution,
- Multi core Steel Wire Armoured cables. Typically, only suitable for main DC cable between a PV array junction box and inverter position, due to termination difficulties.

Cables should be sized in accordance with BS 7671. Guidance on a method of cable sizing including any de-rating factor requiring to be applied and typical current carrying capacities for common cable types are provided in Appendix 4 of BS 7671.

Cables should be designed such that the overall voltage drop, at array maximum operating power (STC), between the array and the inverter is <3%.

For a system of N parallel connected strings, with each formed of M series connected modules:

The main DC cables must be rated as a minimum as follows:

$$\text{Voltage} > \text{Voc}(\text{STC}) \times M \times 1.15$$

$$\text{Current} > \text{Isc}(\text{STC}) \times N \times 1.25$$

The string cables must be rated as a minimum as follows:

$$\text{Voltage} > \text{Voc}(\text{STC}) \times M \times 1.15$$

$$\text{Current} > \text{Isc}(\text{STC}) \times (N-1) \times 1.25$$

DC OVERLOAD PROTECTION

The short circuit current of a module is little more than the operating current, so in a single string system, a circuit fuse would simply not detect or operate to clear a short circuit fault.

In systems with multiple strings some fault scenarios can result in the current from several adjacent strings flowing through a single string and the prospective fault current may be such that overcurrent protective devices are required.

Therefore, PV system shall be protected from overcurrent from the PV modules by means of fuses at the string combiner box. Since PV modules are connected in series in a string, the short-circuit current of the string is equal to the short circuit current of the PV module. Both the positive terminal and negative terminal of a string shall be protected with a fuse. The fuses shall be rated for minimum 1,000 VDC.

For a system of N parallel connected strings, with each formed of M series connected modules:

- String fuses must be provided for all arrays where: $(N - 1) \times \text{Isc} > \text{module maximum series fuse rating}$,
- Where fitted, fuses must be installed in both positive and negative string cables for all strings,
- The string fuse must be of a type gPV, according to IEC60269-6
- The string fuse must be rated for operation at $\text{Voc}(\text{STC}) \times M \times 1.15$
- The string fuse must be selected with an operating current I_n such that:

$$I_n > 1.5 \times \text{Isc}(\text{STC})$$

$$I_n \leq 2.4 \times \text{Isc}(\text{STC})$$

$$I_n \leq \text{Maximum series fuse value}$$

DC ISOLATION AND SWITCHING

Isolation is a function intended to cut off for reasons of safety the supply from all, or a discrete section, of the installation by separating the installation or section from every source of electrical energy (from BS 7671). Isolation shall be provided in both positive and negative cables and all isolation measures shall be readily accessible.

The following table describes the requirements for both isolation and switching in the DC side of the PV array circuit:

| DC Circuit | Switching | Isolation |
|------------|--|---|
| String | Not required | Readily accessible means of string isolation |
| Sub array | Optional | Readily accessible means of sub array isolation |
| Array | Readily accessible load break switch disconnecter on DC side of inverter | |

Note: An additional DC switch or isolating device may be used for systems with long DC cable runs (typically at the point of cable entry into the building), so as to provide a means of isolating the cable for safety reasons or maintenance works.

A switch disconnecter installed on the DC side shall have the following features:

- The switch must isolate all live conductors (typically double pole to isolate PV array positive and negative conductors)
- The switch must be rated for DC operation at the system voltage maximum as calculated.
- The switch must be rated for DC operation at the system current maximum as calculated.
- The switch must be labelled as '**PV array DC isolator**', with the ON and OFF positions clearly marked. Switch enclosures should also be labelled with '***Danger-contains live parts during daylight***'. All labels must be clear, easily visible, constructed and affixed to last and remain legible for as long as the enclosure.
- Shall comply with the requirements of IEC 60947 (series).
- Have a utilization category at least DC-21B of IEC 60947-3.
- Voltage ratings of both poles together of the isolator/switch disconnecter shall be at least the PV array maximum voltage.
- All equipment exposed to the outdoor environment shall be of an appropriate IP rating in accordance with SLS 963 and shall be UV resistant.

2.3.AC SYSTEM

Each solar PV system connected to the Distribution network must be designed, installed, and tested to be compatible with distribution network performance requirements with respect to frequency, voltage, control capabilities, protection coordination requirements, and phase voltage unbalance.

The PV system inverter(s) should be installed on a dedicated final circuit to the requirements of BS 7671 in which:

- No current-using equipment is connected to the circuit, and
- No provision is made for the connection of current-using equipment, and
- No socket-outlets are permitted.

Note: For the purposes of this guide a data logger is not considered current-using equipment and can be connected into the same final circuit as the PV system.

An inverter must not be connected by means of a plug with contacts which may be live when exposed and AC cables are to be specified and installed in accordance with BS 7671.

The AC cable connecting the inverter(s) to the consumer unit should be sized to minimize voltage drop less than 3%.

RESIDUAL CURRENT (RCD) PROTECTION

Where an electrical installation includes a PV power supply system that cannot prevent DC fault currents from entering the AC side of the installation, and where an RCD is needed to satisfy the general requirements of the electrical installation in accordance with BS 7671, then the selected RCD should be a **Type B RCCB** as defined in IEC 62423.

If the inverter manufacturer has provided written statement claiming that a Type B RCCB as defined in IEC 62423 is integrated into the inverter, shall be exempted from having additional Type B RCCB in the installation.

If the inverter manufacturer has provided written confirmation that no smooth DC residual current can occur because of the use of his PV inverter, a Type A RCCB may also be sufficient.

AC ISOLATION AND SWITCHING

Isolation and Switching of the AC side of the installation shall also comply with the requirements of BS 7671. This is to include the provision of an isolator adjacent to the inverter to disconnect the inverter from the source of supply (AC).

The PV system shall be connected to an isolation switch that fulfils the following conditions:

- Isolate phase(s) and neutral conductors
- Be securable in the OFF position
- Located in an accessible location

This switch shall clearly show the ON and OFF positions and be labelled as 'PV system – Main AC isolator'

AC CABLE PROTECTION

Protection for the cable from the inverter(s) must be provided at the distribution board. This protective measure shall be specified and installed in accordance with the requirements of BS 7671.

In very many cases the current limiting nature of the PV array and inverter(s) omits the requirements for overload protection and therefore the designer only need to consider fault current protection.

The protection afforded at the origin of the circuit (the distribution board) in accordance with BS 7671, means there is no requirement for additional overcurrent protection to be installed at the inverter end of the AC installation.

2.4. EARTHING SYSTEM

Earthing shall be required for all exposed conductive parts PV module frames, array structures, power, communication and protective equipment and enclosures for protection. Earthing systems of AC side and DC side shall be connected at the earth electrode. It is to be noted that DC system is considered to be energized even when the system is disconnected from the grid side.

All the frames in a row shall be connected to one continuous earthing conductor when earthing PV modules. Bare copper conductor or copper tape shall be used for this purpose. Use of small pieces of jumper cables to connect frames of consecutive modules shall be avoided. A separate continuous earthing conductor shall be laid to connect the individual earth cables of each row and that shall be connected to grounding conductor. Further, star-type washers shall be recommended when bolting the lugs of earthing cable with the module frame that can scratch the anodization of the module frame to contact its aluminium.

The earthing conductor shall be rated considering safety factor of 25 % and albedo factor of 25% to protect from any unaccounted external reflection onto the PV modules increasing its current. Thus, the conductor shall be rated for 1.56 times the maximum short circuit current of the PV array. However, bare copper earthing conductor size shall not be less than 6mm². Resistance between any point of the PV system and earth should be as smaller as possible and it is recommended to have a value less than 10Ω at any time.

Equipotential bonding is a protective measure used where the connection of Extraneous-Conductive-Parts within Premises using designated conductors such that potential touch voltages are kept to safe value during the passage of earth fault current.

The first safeguard to put in place is a medium that ensures equipotential bonding between all the exposed conductive parts of a PV installation. The aim is to bond all grounded conductors and metal parts and so create equal potential at all points in the installed system.

A connection to earth of any of the current-carrying DC conductors is not recommended. However, earthing of one of the live conductors of the DC side is permitted if there is at least simple separation between the AC and the DC side.

Where a functional earth is required, it is preferable that where possible this be done through high impedance (rather than directly). The PV installation designer must confirm whether the inverter is suitable for earthing of a DC conductor. Transformer less inverters will not be suitable, and an earthed conductor may interfere with the inverter's built-in DC insulation monitoring. Hence, if an earthed DC conductor is required, it should be done in accordance with guidance from the inverter manufacturer.

SURGE PROTECTION

Overvoltage may occur in electrical installations for various reasons. It may be caused by:

- The distribution network as a result of lightning or any work carried out.
- Lightning strikes (nearby or on buildings and PV installations, or on lightning conductors).
- Variations in the electrical field due to lightning.

Like all outdoor structures, PV installations are exposed to the risk of lightning which varies from region to region. Preventive and arrest systems and devices should be in place. SPDs are particularly important to protect sensitive electrical equipment like AC/DC Inverter, monitoring devices and PV modules, but also other sensitive equipment powered by the 230 VAC electrical distribution network.

The requirement of surge protection is evaluated by the risk assessment as per the IEC 62305-2.

DC side of the inverter shall be protected with surge protective device (SPD) of IEC 61643-1 Type 2 "Low Voltage Surge Protective Devices".

It is recommended that a specialist entity in lightning protection be consulted to determine the appropriateness of installing a surge protection and Lightning Protection system.

Simplified selection guide is given below;

| Location | | PV Module or Array A | | Inverter DC Side B | Inverter AC Side C | | Main DB D |
|--------------|--|--|------------------------|--------------------------|---|------------------------|---------------------|
| Criteria | | $L_{DC} < 10\text{ m}$ and $U_p < 0.8 U_w$ | $L_{DC} > 10\text{ m}$ | | $L_{AC} < 10\text{ m}$ | $L_{AC} > 10\text{ m}$ | |
| External LPS | No | No need | Class II | Class II | No need | Class II | Class I or Class II |
| | Yes –Isolated/ with sufficient separation | No need | Class II | Class II | No need | Class II | Class I |
| | Yes –Non Isolated/ with sufficient separation | Class I | Class I | Class I | Class I, except inverter is located inside the main DB | Class I | Class I |

3.0 EQUIPMENT SPECIFICATIONS

The Solar PV Power System shall be according to the given design or accepted by consultant. The contractor shall take account of the site location, roof pitch, and ground condition when installing the system.

3.1. Solar Module

- Solar Module shall be made by **mono-crystalline** comply with IEC 61215 and IEC 61701 Ed.2.
- The Module shall be tested & certified for PID free.
- The module shall be Class A
- 10 Years power output warranty – min 90% of initial rated power output
- 12 Years product warranty, 25 Years power output warranty – min 80% of initial rated power output.
- The rated peak power of solar module shall be typical 550Wp.
- The tolerance rated peak power of solar module shall be maximum $\pm 3\%$
- The normal operating cell temperature shall be rated at $45 \pm 2^\circ\text{C}$
- Shall be provided with high quality plug and socket connection (suitable for PV application).
- The panel efficiency shall be minimum 20.0%.

3.2. Solar Module Mounting Structures and Frames

- The PV array mounting structures and frames shall be able to withstand the loading imposed by the PV modules and the wind and are properly connected to the existing building.
- The back of the PV modules shall have a sufficient clearance from any surface to allow for proper air flow/ventilation.
- The mounting structures and brackets used shall be of anodized aluminum or stainless steel 316 grade or hot dipped galvanized. Nuts, bolts and washers shall be of hot dipped galvanized or stainless steel 316 grade.
- The PV mounting structure system shall be installed so as to cause as little alternation to the building design as possible. All penetrations shall be made waterproof to prevent leaks in accordance with standard industry practice.
- The PV mounting structure system shall be able to withstand wind speed up to 100km/hr.
- The PV mounting structure shall be comes with minimum 5 years product warranty.
- All details of design work, wind load calculations for the PV system on the mounting structure and the brackets to the building, drawings, choice of material, etc shall be endorsed by the professional engineer and submitted for approval before commencement of work.
- Approval of drawings prepared by the contractor does not relieve the contractor of the responsibility for accuracy of detail dimensions or drawings, nor the general fit-out of parts to be assembled on site.

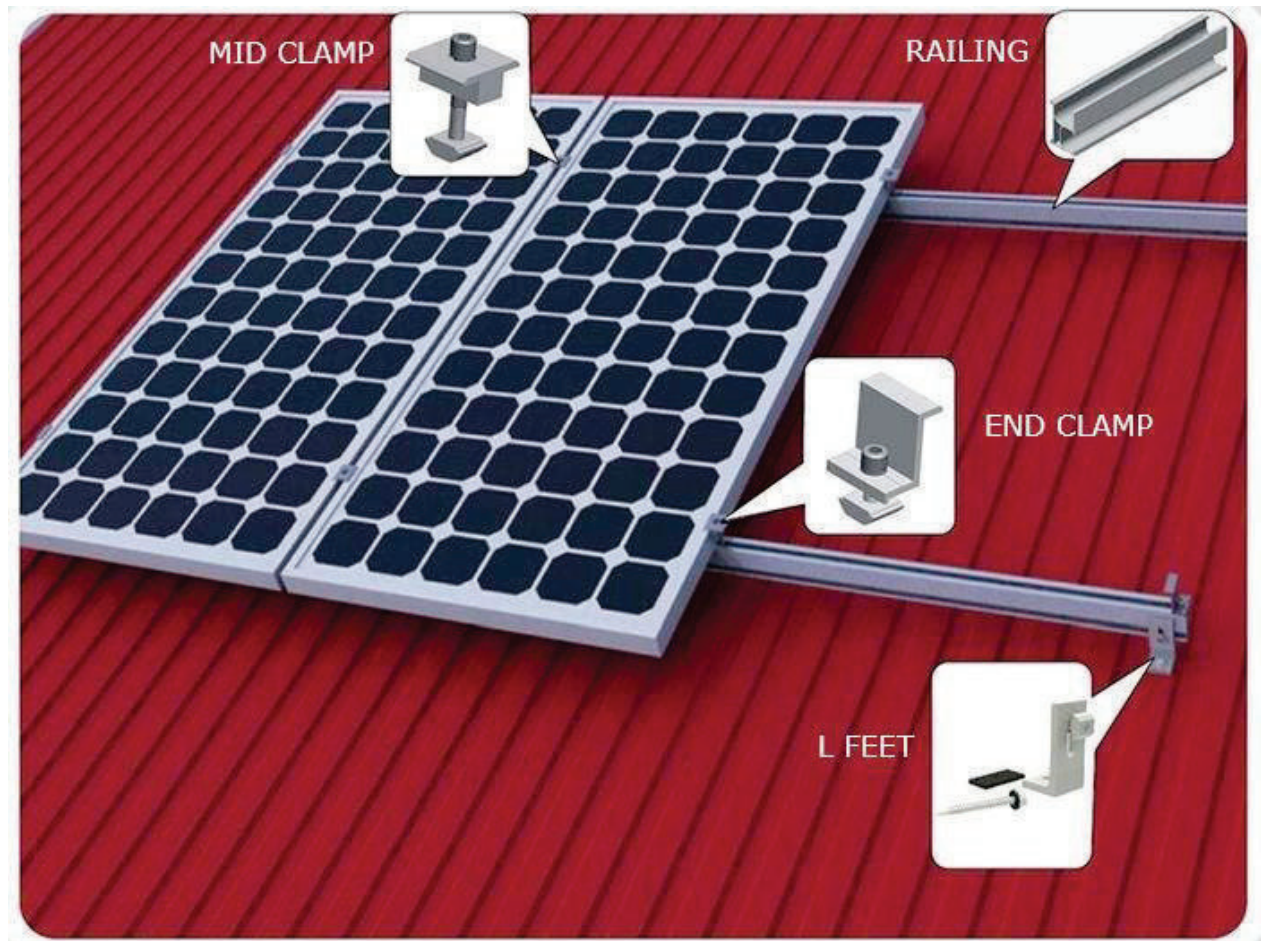


Figure 1 – Solar Panel Mounting Structure Detail

3.3. Grid Tie Inverter

- The offered inverter shall be of matched multiple string inverters. Single inverter or centralized inverter is not acceptable. In the event of any inverter failure the entire system will not be shutdown but only the affected inverter only.
- The offered string inverters efficiency must be minimum 98.5%.
- The offered inverter must be transformerless, with no galvanic isolation.
- The offered inverter must be integrated with DC isolation switch and ground fault protection.
- The offered inverter must be comply to IP65 degree of protection.
- The offered string inverter should have an input voltage range of 200V to 1000V.
- The total harmonics distortion for the output power from the inverter shall be less than 3% of the maximum power.
- The inverters shall be self-synchronizing to the mains supply. The inverter shall monitor the power quality of the system and shutdown if the parameters deviate from the specified range. The inverters shall also prevent reversal of system current.
- The inverter shall have a minimum warranty of 10 years.
- The inverter shall have Certificate of compliance as per DIN VDE 0126-1-1/ IEEE 1547 characteristics.

- The inverter shall be compatible with local utility and shall have all disconnection parameters changeable on site through software or passcodes. All relevant configuration tools shall be provided to the purchaser.
- Transformer less inverters shall be installed with necessary secondary RCCB protection stipulated by the inverter manufacture and all such details shall be forwarded with the proposal.
- The offered Inverter shall be equipped with communication device to be connected with central monitoring system.

3.4. DC Surge Protector for grid connected system DC

- The offered surge protector shall be DC rated and the maximum working voltage of the surge protector
- The offered surge protector shall be able to withstand the total voltage from the solar modules arrangement.
- The nominal discharge current shall be 20kA tested at 8/20us surge wave pattern
- The maximum discharge current shall be 40kA tested at 8/20us surge wave pattern
- The surge protector shall comply to IEC 61643 – 1, IEC 61643 -11.

3.5. AC Surge Protector

- The surge protector shall have a Maximum Continuous Operating Voltage (Uc) (L-N) 50Hz of 230Vac.
- The surge protector shall have Maximum Discharge Current (Imax) of 150kA ratings.
- The surge protector shall have a nominal discharge current (In) of 100kA
- The surge protector shall have enclosure material and class of resistance against fire.
- The surge protector shall comply to IEC 61643-1, Class II

3.6. Electrical Connections, Cables and System Wiring

- The electrical system is 230V AC 50Hz, 400V 3phase in TTsystem of protective earthing system.
- Electrical connections shall be verified for tightness and correct polarity during installation to reduce the risk and possibility of arcs during commissioning and operations.
- All DC and AC cables shall be sized to allow for a maximum of 3% voltage drop. All external cables shall be double insulation and UV resistant suitable for PV applications and inspection.
- Any penetrations for wiring shall be made watertight to prevent leaks in accordance with the standard industry practice.

3.7. Lightning Protection and Earthing System

DATA SHEET OF SOLAR POWER SYSTEM

Note: Bidders shall provide all necessary information of their proposed product under the column 'As Offered' under this returnable schedule. Bids with incomplete returnable schedule will be rejected.

1. Solar Panel

| | Feature | | Requirement |
|----|---|--|-----------------------------------|
| 1 | Make | | |
| 2 | Model | | |
| 3 | Country of Origin | | |
| 4 | Country of Manufacturer | | |
| 5 | Module Output | | 550W |
| 6 | Type of panel | | Mono crystalline half-cut cell |
| 7 | Module Grade | | Class "A" |
| 8 | Cell Technology | | Mono Crystalline |
| 9 | Module Efficiency | | More than 20% |
| 10 | Number of Cells | | 144 |
| 11 | Number of Bypass diodes | | 3 |
| 12 | Number of Busbars | | 6 |
| 13 | Performance Guarantee | | 30Years 0.45% Annual Degradation. |
| 14 | Product Warranty | | 12 Years |
| 15 | Module Sorting | | Class "A" |
| 16 | STC Maximum Power Voltage | | 550W |
| 17 | STC Sort Circuit Current | | 14.00A |
| 18 | NOCT (Nominal operating Cell Temperature) | | 45±2°C |
| 19 | NOCT Maximum power voltage | | 41.95±3 V |
| 20 | NOCT Short circuit current | | 14.98± A |
| 21 | Maximum system voltage | | 1500V |
| 22 | Temperature coefficient of PMpp | | -0.350%/°C |
| 23 | Temperature coefficient of Isc | | +0.045%/°C |
| 24 | Temperature coefficient of Voc | | -0.275%/°C |
| 25 | Dimensions | Length | 22200±200mm |
| | | Width | 1150±200mm |
| | | Height(Thickness) | 35±10mm |
| 26 | Frame Material | | Anodized Aluminum |
| 27 | Weight | | 31.6kg±3% |
| 28 | Standards to comply | IEC 61215 (Terrestrial photovoltaic (PV) modules - Design qualification and type approval) | |
| a. | | IEC 61730 (Photovoltaic (PV) module safety qualification) | |
| b. | | IEC 61701 (Photovoltaic (PV) modules - Salt mist corrosion testing) | |
| c. | | IEC 62716 (Photovoltaic (PV) modules - Ammonia corrosion testing) | |
| d. | | IEC 60068 (Environmental testing) | |
| e. | | UL 1703 (Standard for Flat-Plate Photovoltaic Modules and Panels) | |
| f. | | | |

| | | |
|----|--|---|
| g. | | IEC 62804-1-1 (Photovoltaic (PV) modules - Test methods for the detection of potential-induced degradation) |
|----|--|---|

2. Inverter/s

| | Feature | Requirement |
|-------|--|---|
| 1 | Make | SMA, ABB, Fronius, KACO or equivalent |
| 2 | Model | |
| 3 | Country of Origin | |
| 4 | Country of Manufacturer | |
| 5 | Capacity of Inverter (kVA @ $\Phi=1$) | 40kVA |
| 6 | Inverter type | String Inverter |
| 7 | No of Inverters | 3 |
| 8 | European Efficiency | Minimum 98.5% |
| 9 | No of MPPTs per inverter | 4 |
| 10 | Night time consumption | <2W |
| 11 | Dimension | 580/435/230mm |
| 12 | Weight | 29.5kg |
| 13 | Heat dissipation method | Convection/Smart air cooling |
| 14 | Maximum working ambient temperature | +60°C |
| 15 | Minimum working ambient temperature | -25°C |
| 16 | Operating Relative Humidity | 5-95% RH non-condensing |
| 17 | Online/LAN monitoring and control applications and web portal, with full history data analysis, weather predictions, fault recording, and network/Wifi connectivity. RS485 Communication | Available |
| 18 | Protection against Over current, residual current leakage, arc fault, over voltage, under voltage, grid frequency level, reverse power flow, grid availability, feeder line status. | Available |
| 19 a. | Standards to comply | IEC 62477 (Safety requirements for power electronic converter systems and equipment) |
| b. | | IEC 60664-1 (Insulation coordination for equipment within low-voltage supply systems) |
| c. | | IEC 62109-1 & 2 (Safety of power converters for use in photovoltaic power systems) |
| d. | | IEEE 1547 (Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces) |
| e. | | CE Standard |

3. DC Cables

| | Feature | Requirement |
|----|-------------------------|---|
| 1 | Make | |
| 2 | Model | 6 sq mm |
| 3 | Country of Origin | |
| 4 | Country of Manufacturer | |
| 5 | Colours | Red & Black |
| 6 | Cores | Single core |
| 7 | Insulation | Crosslinked special Polyolefin |
| 8 | Sheathing | Crosslinked special Polyolefin |
| 9 | Designed Voltage | 1500V _{DC} |
| 10 | UV stability | Yes |
| 11 | Standards to comply | IEC 62930 (Electric cables for photovoltaic systems with a voltage rating of 1,5 kV DC) |
| a. | | UL 44 or EN 60216 (Electrical insulating materials - Thermal endurance properties) |
| c. | | EN 50618 (Electric cables for photovoltaic systems) |
| d. | | EN 60332-1-2 (Test for vertical flame propagation on complete cable) |
| e. | | |

4. AC Cables

| | Feature | Requirement |
|---------|-------------------------|---|
| 1 | Make | |
| 2 | Model | 16-240sqmm |
| 3 | Country of Origin | |
| 4 | Country of Manufacturer | |
| 5 | Colours | Brown, Black, Grey and Blue |
| 6 | Number of cores | 4 core |
| 7 | Conductor Material | Copper with 99.99% purity |
| 8 | Insulation | XLPE/PVC |
| 9 a. | Standards to comply | BS 6346 (Electric cables - PVC insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V) and BS 5467 (Electric cables. Thermosetting insulated, armoured cables of rated voltages of 600/1000 V and 1 900/3300 V for fixed installations. Specification) |
| b. | | IEC 60502-1 (Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)) |

5. Warranty

| Item | Warranty details |
|------------------------------|---|
| PV Panel | 12 years Product Warranty and 30Years performance warranty. |
| Inverters | 10 Years product warranty, |
| AC/DC Cables | 25 Years warranty |
| Aluminium mounting structure | 10 years warranty |
| Distribution boards | 2 Years Warranty |
| | |

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specification - Air Conditioning

23553-01-TN-AC-SP-9800

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Version Log

| Version | Issuer | Summary of Changes | Date of Issue |
|---------|--------|--------------------|---------------|
| 1.0 | URO | Initial Issue | 20.09.2023 |
| 2.0 | URO | Second Issue | 27.11.2023 |
| 3.0 | URO | Tender Issue | 14.12.2023 |

GENERAL TECHNICAL SPECIFICATION FOR VRV/VRF TYPE AIR CONDITIONING SYSTEM

1.0 INTRODUCTION

VRV/VRF type Air Conditioning System shall be provided for proposed emergency construction of patient wards at Kulhudhuffushi island in Maldives according to the following specifications.

This section consists of the general rules that apply to the design, manufacture, shop testing, delivery to site, erecting, commissioning, site testing, maintaining and handing over the material, equipment plant and services required for the air conditioning system of the building.

- **The manufacturer of the VRV/VRF air conditioning equipment shall have at least ten (10) years of experience in the design, manufacture, installation and commissioning and maintenance of HVAC equipment.**
- **Bidder should submit previous VRV/VRF installations references details for offered VRV/VRF make**

Bidder must submit documenting proof for the same with the bid documents. Bids without above documents will be rejected.

All equipment being supplied shall be suitable for operation under tropical conditions with ambient temperature up to 36°C and relative humidity up to 90%. All the outdoor units' components must be panel, brackets, nut & bolts, base pan, motor, heat exchanger and all the components of the outdoor unit's corrosion resistant coating & weather resistant coating.

1.1 LOCATION OF SITE

The site is located at Kulhudhuffushi island in Maldives.

1.2 SCOPE OF WORK

The scope of work consists of supply and installation of an air-cooled Variable Refrigeration Volume / Variable Refrigeration Flow (VRV/VRF) & Split type air conditioning system. The building will be air conditioned as indicated in the detailed technical specification and drawings. The system shall include ceiling suspended / Wall Mounted type indoor units. All components permanent and of temporary nature to successfully supply, install, test and commission the project shall be provided by the contractor.

1.3 STANDARD OF WORKS

1. ASHRAE : American Society of Heating, Refrigeration and Air conditioning Engineer.

Standard for the Installation of Air conditioning and Ventilation Systems ; ANSI/NFPA 90A-2015
Ventilation of Health Care Facilities ; ANSI/ASHRAE/ASHE Standard 170-2013

Safety Code for Mechanical Refrigeration Method of Testing General
Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size ; ANSI/ASHRAE Standard 15-2013 52.2-2012

Design, Construction, and Operation of Sustainable, High-Performance Health Care Facilities interactions Affecting the Achievement of Acceptable Indoor Environments; ASHRAE Standard 189.3 Guideline 10-2011

2. IHVE : The Institute of Heating and Ventilation Engineers (UK)
3. ASME : American Society of Mechanical Engineers
4. ARI : Air conditioning Refrigeration Institute (USA)
5. ASTM : American Society of Testing and Materials
6. AWS : American Welding Society
7. DW142 : Specification for Sheet metal ductwork
8. SMACNA: Sheet Metal and Air-conditioning Contractor's National Association, Vienna
9. IEC/IEEE regulations for electrical system installation

1.4 AIR CONDITIONING SYSTEM

System Description:

Air Conditioning system consist of VRV/VRF System. Proposed system shall be having adequate capacity to meet building AC load.

All indoor units capacities will be rated at air on coil temperature of 27C DB,19C WB. Condensing unit capacities shall be rated at 35 C DB temperature.

VRV/VRF AIR CONDITIONING SYSTEM:

Each unit is equipped with modular condensing unit connected to several Indoor units. Condensing unit consist with DC Inverter type compressors and note that inverter driven high pressure chamber type Scroll type reputed brand compressors are preferable. Refrigerant shall be R410A or an equivalent environment friendly refrigerant. Compressors must have internal oil separator and external oil balancing lines between modules shall be avoided. Indoor unit must be consist with Electronic type expansion valve which also acts as a pilot valve.

All bidders must provide soft ware generated VRV unit selection data sheet along with the tender.

COP at full load – Shall fully comply with latest ASHRAE 90.1 energy minimum efficiency requirements(COP) and units with higher COP(Above 4.0) is preferred.

All selected units must suitable for tropical climate operation and special condensing protective hydrophilic/herasite coating shall be applied to the condenser fins for durability. Also there must be protective covering for condensers. Noise level of Condensing unit must be below 60dB(A) at 3m distance.

Condensing unit Refrigerant circuit designs with hard copper piping and brazed joints.

Crankcase heater, manual reset high low pressure cutout switch, to guard against compressor damage due to high discharge head and system leakages must be provided. Compressor motor winding

shall be provided with Thermistor protection in addition to Thermal overload protection provided with contactor.

The air cooled condenser coils are of 3/8" OD seamless copper tubes arranged in staggered rows, mechanically expanded into die formed coated aluminum fins. The condenser fan is of high ESP (85Pa), high efficiency propeller type, direct driven by 3 phase IP 55, class F insulation condenser motor, suitable for outdoor application.

The cabinet is constructed of heavy gauge galvanized steel, which provides a rigid structure. All outdoor units external exposed surface are coated with silk grey backed polyester based paint, providing high corrosion resistant. Outdoor noise level at 1m distance shall be less than 60dB(A).

Power supply of the unit will be 380-415 V, 3Ph, 50 Hz.

Unit shall be capable of Continuous capacity controlling(10%-100%) and must also include Internal motor protector to protect winding from over heating, as mentioned earlier. Mechanism must be in built to facilitate oil return especially at low load conditions. Also condensing units must be protected from over current, power surges, Phase failure and Phase sequence failure.

Installation:

AC Units & piping:

Piping layout and sizes given in the design drawings are for reference only and piping layout must be submitted with equipment manufacturer recommendations(Software generated piping layout is accepted).

All indoor units shall be fixed on to the concrete slab with 10mm Drop Anchor bolt ,vibration isolators for high capacity units and thread bars. Refrigerant piping will be properly anchored to the slab using hanger bars and hanging space shall be not more than 2m and where bends are to be installed must anchor from both end. Refrigerant gas line to be insulated with Closed cell Nitrile Rubber insulation(Armaflex or Aerofoam-NBR) and all the joints must apply adhesive tape.

All refrigerant piping shall be of Hard copper(Must be a reputed brand) and soldering shall be done with an inert gas(Nitrogen) to avoid oxidization. Refnet joints supplied by the manufacturer shall be used for pipe connections and no locally manufactured joints are allowed. Once soldering is completed system must be thoroughly flushed to remove impurities in piping. Pipe work shall be leak tested at a elevated pressure (1.5 times operating pressure) for a period of 12 hours before Vacuuming. System must be vacuumed as per Supplier's installation instructions.

Additional Refrigerant charge required for pipe work must be obtained from Supplier by submitting shop drawings of the installation. Refrigerant pipe sizes shall be based on each manufacturers specifications and only piping route is shown in the design drawings.

Drain piping shall be properly installed using hanger bands and must maintain adequate slope with U trap where necessary. Where ever drain lines are to connected to floor drains air gap must be maintained.

Since all condensing units shall be fixed on Roof slab adequate oil traps shall be installed in the compressor suction lines especially in Split Units.

1.5 DUCT WORK

The contractor shall provide and erect all ductwork including controls, isolating/balancing dampers, grilles, diffusers to form a complete air distribution system as indicated on the tender drawings. The contractor shall balance, test and commission all installations prior to the engineer issuing a completion certificate. Shop drawings shall be submitted to the engineer prior to the commencement of works.

G.I Steel Duct

The Contractor shall provide and erect all ductwork including controls, isolating/balancing dampers, grilles, diffusers and vapour proof insulation to form a complete air distribution system as indicated on the tender drawings. The Contractor shall balance, test and commission all installations prior to the Engineer issuing a Completion Certificate. Shop drawings shall be submitted to the Engineer prior to the commencement of works.

All sheet metal ductwork shown on the drawings, specified or required for exhaust air systems shall be fabricated and finished from best quality, cold rolled annealed galvanized mild steel sheets of soft bending quality especially suitable for air conditioning works. Materials used for ductwork, shall be free from blisters, pits and imperfections in coating.

Ductwork shall be so constructed that when erected, it shall be made airtight by tightly sealing after fabrication and free from movement, sagging or drumming under all operating conditions. It shall be true to size and accurately lined-up.

While the tender drawings shall be adhered to as closely as possible, runs and sizes of ductwork may be varied only by the Engineer, at no extra cost to the Employer, when deemed necessary for co-ordination purpose with other works.

All duct elbows having an inside radius smaller than the width of the elbow shall be equipped with approved vanes tightly riveted to the duct and in general as shown on the details of the tender drawings.

Approved duct-turn shall be installed in all cases where 90-degree square elbows are used and short take-offs are used on large ducts. Guide splitter vanes shall not be spaced more than 15 cm apart.

Take-offs from main ducts shall be conical. All take-offs and connections shall be constructed to minimise pressure loss. All raw edges of ductwork seams, rivets and areas where galvanizing has been destroyed shall be cleaned, prepared and painted with zinc rich paint at works and a further coat shall be applied after erection.

Allowances shall be made in ductwork construction for instruments and control connections and adequate local stiffening shall be incorporated to provide rigid mountings.

The fabrication of ductwork shall be carried out in accordance with HVAC/DW/142, ASHRAE or SMACNA standards.

Material

Galvanized Sheet

Hot dip galvanized steel shall be to ASTM-A527-87 standard, steel shall be of lock forming quality, zinc coating designation Z-27 or equivalent approved standard.

Duct Sealant Duct sealant shall be non hardening, non migrating mastic or liquid sealant as compounded and recommended by the manufacturer especially for sealing joint and seams in the duct.

Duct Hangers and Supports

Ductwork shall be supported by means of pre-galvanized fully threaded drop rods and also preferably galvanized mild steel angle/channel sections, with spacing between supports not exceeding 2.4 m and projecting 100 mm on either side to allow for proper insulation.

Rectangular Duct

All channels and angles shall be preferably galvanized or mild steel, painted with one coat of zinc chromate paint prior to erection and a further two coats of gray paint on exposed metal parts after erection. Ductwork supports shall preferably be positioned close to dampers, diffusers and all similar equipment. Ductwork supports shall in general conform to HVAC/DW/142 or SMACNA standards. Galvanized serrated band with insulating band type supports shall also be acceptable up to duct size of 600 mm except in the Plant room.

Contractor to submit complete details for approval before fixing.

1.6 DAMPERS

Damper Quadrants

All dampers other than dampers behind registers shall be fitted with substantial locking cast metal quadrants. Quadrants shall be mounted outside the duct in an accessible position. On insulated ducts, the quadrants shall be fastened to bearing plates flush with the outside finish of the insulation.

Volume Control Dampers

Manual volume control dampers shall be provided as shown on the drawings or as required additionally for balancing purposes. The dampers shall have sturdy corrosion resistant construction. All dampers shall have multi-leaf double skin aerofoil section opposed blades. Individual blades should not exceed 1200 mm in length or 175 mm in width. Double skin blades shall be made out of minimum 22 gauge galvanized steel sheet. Damper frames shall be galvanized made out of 16 gauge steel sheet.

Single blade dampers with single skin blade section may be used for damper sizes up to 300 x 150 mm. Single skin blades shall be fabricated from 18 gauge galvanized steel sheet. The blades shall be securely bolted to plated steel spindles, the ends of which shall be extended to the outside of the duct with a groove in line with the blade. Spindles shall be carried in brass or nylon bearings.

The control linkage shall be outside the air stream. Clear airflow area equal to the duct size shall be maintained within the damper frame. Maximum clearance between the blades and between the blades and the frame shall be limited to 3 mm. It should be noted that the dampers should be separate and independent from the dampers, hereafter specified to be set behind registers and diffusers.

1.7 FRESH AIR INTAKE LOUVRES

Fresh air inlet shall be fitted with insect wire meshes and filters.

Fresh air inlets shall be fitted with SS mesh bird screens and louvers in addition to 50 mm thick washable synthetic fibre filters. Filter media thickness shall not be less than 45 mm, having 60% efficiency .

1.8 FLEXIBLE CONNECTIONS

Flame-proof flexible connections shall be fitted on all intake and discharge connections of fans for preventing the transmission of vibration through the ducts to occupied spaces.

Flexible connections shall also be provided where ductwork passes across building expansion joints.

Flexible connections shall be factory fabricated from chemically impregnated canvas. Connections shall fit closely and be secured in airtight fashion to connections to ductwork, fans and apparatus.

The material shall have a penetration time of at least fifteen minutes when tested in accordance with BS 476 and shall remain flexible and without strain or distortion. Flexible connections shall be 150 mm minimum and 250 mm maximum in length.

1.9 GRILLES:

Grilles shall be of the type and shape indicated on the drawings, a sample of which must be approved by the engineer prior to ordering.

1.10 EXHAUST/SUPPLY FANS

General

Fans shall be supplied and installed by the Contractor as shown on the drawings. Capacity, type and rating of the fans shall be as indicated in the schedule. The fan motors and switches shall be in accordance with this specification regarding electrical works. Fixing details shall be in accordance with manufacturer's recommendations.

1.11 SITE TESTING AND COMMISSIONING

On completion of the works all systems installed shall be tested in the presence of Engineer's representatives and other officials of the client. The contractor shall give adequate notice to the Engineer of the proposed dates for testing and shall provide all facilities required such as personal, instruments and equipment, access ladders for this purpose. The contractor shall rectify all works not conforming to the required specifications and tests be repeated after remedial measures at his cost.

The contractor shall commission and test the installation for a minimum period of seven (7) days to indicate to the engineer that the equipment installed achieves the minimum room conditions specified above. The tests shall be carried out during periods of maximum ambient temperature and loading. All conditioned areas shall be tested together.

1.12 Electrical Installation

The contractor shall undertake all the electrical work connected to the A/C system. The electrical work will conform to those set out in the BS 7671:1989.

The system electrical power supply 3 phase, 4 wire, 50Hz, 400V will be terminated on isolators closed to outdoor units. It will be the responsibility of the contractor, to provide all the distribution and motor control equipment, as pertaining to the A/C system, and make all connections downstream from this point. The motor control panel shall be of the modular type incorporation short circuit over load and phase failure protection along with the contactors, timers as required to meet industry standard.

Timers shall be incorporate, as directed by the engineer to control the operating periods of the motors, fans etc.

The controls will have the same specifications as set out in the electrical specifications. All equipment's used shall be from a single manufacturer to ease future maintenance. All cable entrances to the main control panel and all other panels will be fitted with standard cable bushing to render the transition of the cable into the panel both dust and water proof.

Samples of all electrical equipment to be used shall be submitted to the engineer, for approval prior to their incorporation in the works.

1.13 Additional Information

All drawings are indicative of the system required. The contractor shall ascertain for himself that the equipment offered by him can be installed in the locations indicated.

The contractor shall make certain that the equipment offered by him will operate as indicated in the attached schematic.

The contractor shall obtain the engineer's approval for the indicated ranges of all instruments to be incorporated in the project, prior to their use in the works. This is applicable to all thermometers, pressure gauges, ammeters, etc.

1.14 Testing and Commissioning

The contractor shall commission and test the installation for a minimum period of seven (7) days to indicate to the engineer that the equipment installed achieves the minimum room conditions specified above. The tests shall be carried out during periods of maximum ambient temperature and loading. All conditioned areas shall be tested together.

A chart indicating the temperatures, humidity and the air flow at all supply air diffusers, against the time of day, shall be prepared for each area, and submitted to the engineer on completion of the tests, prior to the application for the practical completion certificate for the system.

All controllers and thermostats shall be adjusted so that they operate correctly.

1.15 Makes of equipment offered

Makes of equipment offered shall have been commonly used in Maldives and have workshop facilities, experienced technical personnel operating in Maldives. Prior approval of the Engineer shall be obtained before placing orders for the supply of equipment.

1.16 Free Maintenance & Guarantees

The contractor shall maintain the complete system for a period of 12 months from the date of takeover of the system for beneficial use.

Any equipment which may prove defective during this period shall be replaced or repaired free of charge during this period.

Items of equipment repaired or replaced, during this period, shall be guaranteed for a further period of one (1) year from the date of repair or replacement.

PART 2 - DETAILED TECHNICAL SPECIFICATION

1.0 SCOPE

This section specifies the detailed requirements of the design, manufacture, supply, delivery, installation, testing, commissioning and maintenance during the defects liability period of the Air Conditioning System for the proposed patient wards at Kulhudhuffushi island in Maldives. The system shall consist of the marine treated Variable Refrigerant Volume/ Flow (VRV/VRF) type air conditioners in combination 4-Way ceiling mounted cassette type & ceiling concealed ducted type indoor units and accessories suitable for coastal area.

VRV/VRV Air Conditioners

- Supply and installation of following indoor units, with grouping outdoor units:

Outdoor Unit VRV–OU-01

| Indoor Unit Type | Cooling Capacity/ (TR) | Quantity |
|-------------------|------------------------|----------|
| Fan coil unit | 0.8 | 1 |
| Fan coil unit | 1.1 | 1 |
| Fan coil unit | 1.5 | 2 |
| Fan coil unit | 2 | 2 |
| Fan coil unit | 2.2 | 12 |
| Fan coil unit | 2.3 | 1 |
| Fan coil unit | 2.4 | 1 |
| Ceiling Cassettes | 0.8 | 4 |
| Ceiling Cassettes | 1.1 | 2 |
| Ceiling Cassettes | 1.5 | 3 |

Total Cooling Capacity for Specified Area = 50 TR

Outdoor Unit VRV–OU-02

| Indoor Unit Type | Cooling Capacity/ (TR) | Quantity |
|-------------------|------------------------|----------|
| AHU | 35 | 2 |
| Ceiling Cassettes | 1.5 | 3 |
| Ceiling Cassettes | 2.5 | 2 |

Total Cooling Capacity for Specified Area = 80 TR

- Supply and installation of condensate drainage pipe work with all the insulations and accessories.
- Supply and installation of all the required sensors, thermostats and controls for indoor units.
- Supply and installation all the electrical power cables (indoor units & outdoor units) and supply from the main air conditioning distribution board.

2.0 BASIS OF DESIGN

- 2.1 It is required to maintain condition of comfort in the given specific areas under normal load conditions and average lighting limits.

The outside conditions are assumed as follows:

| | | |
|----------------------|---|------|
| Dry bulb temperature | - | 33°C |
| Relative humidity | - | 80%. |

Inside conditions to be maintained:

| | | |
|---------------------------|---|--------------------------|
| Dry bulb temperature | - | 24 °C - 25 °C |
| Relative Humidity | - | 55%-60% |
| Sound level | - | 40 dBA |
| System Minimum Efficiency | - | Comply ASHRAE 90.1- 2019 |

3.0 SYSTEM DESCRIPTION

The entire building areas to be air conditioned with VRV/VRF air conditioners. Three phase electrical power supply to air conditioners shall be obtained from the dedicated MCCBs & Socket outlets. The air conditioning contractor shall carry out all wiring of outdoor units from the MCCBs & indoor units from socket outlets.

Condensing water pipe lines from indoor units shall be installed to the nearest drain point as recommended by the manufacturer, taking care not to allow air to enter the lines. Refrigerant pipes & Condensing water piping where exposed outside the building shall be vapor sealed and clad using Al sheet. Insulated pipe system complete with all accessories of suitable diameter to meet the requirement of the proposed units with lengths to suit the locations of the units as shown in the drawings shall be designed and supplied by the contractor.

4.0 SELECTION OF AIR CONDITIONING UNITS

The minimum capacities of the units shall be as per the schedules given in the drawings.

The air conditioning units should be capable of achieving following functional requirements with specified equipment.

- Air cooled outdoor units designed for variable refrigerant flow systems.
- Broad outdoor temperature operating range with 43°C DB maximum.
- Cooling capacity control capability ranging from 10% - 100% to suit the demand
- Use of high efficient inverter controlled permanent magnet scroll compressors
- Inverter frequency control range from 30Hz – 100Hz in 1Hz incremental steps
- Refrigerant circuit with super coolers and sub coolers to improve performance
- System reliability achieved by emergency operation of compressors and outdoor units
- Computer controlled network system integrated with outdoor units and indoor units.
- Fine control of indoor temperature achieved through electronically controlled expansion valves which control refrigerant flow to suit the demand
- Simultaneous operation of 100% loaded compressors with capacity controlled compressors to suit the demand.

Both Indoor & Outdoor units shall be mounted in an anticorrosive rust resistant and Marine treated casing.

5.0 REFRIGERANT PIPING

- Long refrigerant piping lengths should be possible with these Variable Refrigerant Flow Air Conditioning units, reducing restrictions during installation.
- Maximum pipe length shall be as per equipment manufacturer recommendations
- Pipework Class and material

The types and quality of all pipework used shall comply with the following schedule unless otherwise shown on the Drawings or specified elsewhere in the Specification: -

Refrigerant pipework shall be of Copper to B.S. 2871.

- All pipe works shall be so installed and supported so that it is free from excessive stressing due to its own weight and its contents, equipment vibration or movement, and thermal movement.
- Care shall be taken to achieve a neat installed appearance. All pipes and fittings shall be cleaned before erection and free from scales, burrs, sand and other foreign matters.
- Sufficient unions or flange joints shall be allowed for satisfactory removal and reassembly of equipment, valves fittings for inspection or repair.

Joints - Copper

- For refrigerant use may be of compression type of ASA B16- 26-1958 and brazed type to ASA B9-1 code for size up to 40mm diameter. Only brazing rod containing 45% silver may be used and shall be thoroughly cleaned and washed to remove all traces of flux before installation.
- Copper pipework 50mm diameter and above shall be joined by means of brazing connections. At terminals joints to equipment, flanged joint shall be used to facilitate maintenance, dismantling and repair for water service and drains shall be joined by solder, using special capillary fittings.

Fittings - Copper

- For refrigerant circuit, fittings to be of copper or brass specially manufactured for refrigerant use, no fabricated fittings shall be accepted.
- Small size may be joined by compression fittings to ASA B16.26. Larger size fitting to be of brazed type to ASA B9.1. Flanges to be used in equipment locations.

Anchors, Expansion Joints and Welding

- a. Wherever possible, advantage shall be taken of changes in direction of pipes to take up expansion and contraction due to temperature changes of the pipe and its contents.
- b. All anchors shall be securely mounted to structure with suitable neoprene pads or approved equal. All pipes shall be anchored to control the movement of pipes due to thermal movement. Anchors shall be fitted to resist the attempted movement due to expansion and the weights of pipe and contents.
- c. All oxy-acetylene welding shall be in accordance with B.S. 2640:1982.

Pressure Test

Refrigerant piping shall be tested by filling the system with dry nitrogen to the required pressure and all joints inspected with a halide torch to check for leaks. A test pressure of 1.5 times the maximum service pressure shall be maintained for 24-hours. Pressure drop of more than 2% over the 24-hours shall not be accepted.

Insulation and Painting

Thermal Insulation

All insulation work shall be carried out by skilled and experience craftsmen and special attention paid to the final coating of insulation that will be on view; all plane surfaces shall be trowelled to a truly smooth surface and all pipe insulation shall be finished using purpose made metal former as necessary for a clean, smooth unlined surfaced to the approval of the Engineer.

All cold valves, strainers, flanges, pump volutes and other fittings shall be insulated as necessary as detailed for the pipe insulation and securely held in position by purpose made galvanised sheet steel or aluminium split case boxes with non-corrodible screws. A sample of one of these boxes shall be submitted to the Engineer for approval before final manufacture is commenced.

All insulation shall be applied as whole continuous pieces to the approval of the Engineer. The Engineer reserves the right to order the partial or complete replacement of any section of insulation or call for further skin-finishing coats where in his opinion the work is of sub-standard nature. This work shall be carried out by the Contractor at no extra cost.

All insulation work shall be carried out after the particular section or run of the pipework has been successfully tested and the Tenderers attention is called to the correct choice of Flintcote materials, its adaptability and correct method of usage when combined with other materials. Samples of the typical finished insulation on sheets of 300 mm x 300 mm x 2 mm steel plate shall be submitted to the Engineer for approval before insulation work is carried out. All internal insulation to ductwork shall be fabricated off site, unless otherwise approved.

The following items shall be insulated as specified later.

- a. Factory Assembled Plant.
- b. Refrigerant and Condensate Pipework.
- c. Air-Conditioning Supply and Return Ductwork.
- d. MV duct passing through air-conditioned area.

All refrigerant suction lines shall be insulated using vapour sealed closed cell elastomeric foam type insulation having a K factor not higher than 0.038 W/m/°C @ 0°C, and an average water absorption of not more than 0.9% by volume over 28 days. Insulate all fittings in the pipework.

Insulation shall be fire and flame propagation tested to BS 476 Pt 7:1990 and exhibit Class O performance, and BS 476 Pt 6:1989 and exhibit a Total Index of Performance of less than 12. Insulation thickness shall be in accordance with the following table depending on the installation practice:

| Description of Installation | Minimum Thickness of Insulation Required |
|--|--|
| Concealed in brickwork with plaster | n (Insulation to be protected against deformation prior to plastering) |
| Running through aircon space | 13mm |
| Running through non-aircon space | 19mm |
| Running through bathroom ceiling space | 25mm |

Jointing of lengths of preformed insulation shall not be by means of adhesive tapes which deforms the insulation. Such joints shall be by proper gluing of mating faces of each length using glue and method recommended by the manufacturer.

Factory Assembled Plant

The factory assembled plant shall be insulated as recommended by the manufacturers and as specified earlier. This insulation shall be applied at the manufacturer's factory, and only as necessary on site during or after installation. Should this insulation appear inadequate in the opinion of the Engineer, he reserves the right to call for its partial or complete removal and repair or replacement by the Contractor at no extra cost to the Employer.

Refrigerant and condensate Pipework

The whole of the condensate and refrigeration pipe lines including gas suction line, all fittings, valve and strainer bodies, flanges, etc., on the refrigeration equipment shall be insulated with 25mm thick thermal insulation. Thermal conductivity shall not exceed 0.0039 W/M degrees C for a mean temperature of 24 degrees C.

All surfaces over which the insulation is to be applied shall be dry and grease free.

Exposed pipe work will be provided with two layers of 25mm thick insulation. Suitable weather proof paint as per manufacturer's recommendation shall be applied.

6.0 ELECTRICAL WORKS

The system electrical power rating is 3 phase, 50Hz, 400 V. 3 phase, 50Hz, 400V electrical power supply for outdoor units shall be obtained from the isolator provided within each floor level near to outdoor location. Control panel for air conditioning equipment, switch gear, all electrical & control wiring for indoor units shall be provided by the air conditioning contractor. All necessary control wiring in-between indoor and outdoor units have to be carried out by AC contractor.

The Contractor shall supply and install electrical distribution and control panels, switchgear including circuit breakers, other electrical equipment and wiring necessary for the operation of the air conditioning equipment as specified. All equipment supplied and install by the contractor shall suit the above power rating of 400 / 230 V, 50 Hz.

This work shall be carried out by a Contractor who has specialized in this type of work and shall meet the requirements of the 17th edition of IEE regulations latest amendment, local supply authority's requirements and conform to best trade practices.

All signals of indication and faults displayed in the local control panels of equipment shall be duplicated on this Main Control Panel.

7.0 MATERIALS

Test reports on materials used tested according to the relevant standards shall be provided if called for by the Engineer.

8.0 TEST EQUIPMENT, SPECIAL TOOLS AND RECOMMENDED SPARES

Bidder shall submit with the Bid a complete itemized list of test equipment, special tools and recommended spares needed to enable the user to carry out maintenance work. All test equipment, special tools and recommended spares shall be on site when the commissioning work is completed and shall be handed over with the system to the Engineer.

9.0 SUBMISSIONS

The Contractor shall submit for approval the following documents and samples in quantities as indicated.

9.1 Shop Drawings

Shop drawings of all piping systems, electrical circuit and wiring diagram and any other drawings necessary for fabrication and installation of the system.

9.2 Technical Literature of Equipment

Technical literature of all equipment proposed to be used in the system inclusive of dimensional drawings, capacity, tables, test reports and other relevant information shall be supplied in triplicate for the Engineer or determine the adequacy and suitability of the equipment for the proposed air-conditioning system.

9.3 Operation and Maintenance Manuals

The Contractor shall furnish three (03) copies of an operation and maintenance manual which shall contain complete instructions for overall operation of the facility and its component parts. The manual shall also include the operation and maintenance charts specified above. Drawings to be photo-reduced for incorporation into the Manuals to facilitate reference and reduction in volume. Manuals shall be complete, detailed guides for the maintenance and operation of equipment and systems and shall include complete information necessary for start-up, adjustments, maintaining continuous operation for long periods of time and dismantling and re-assembling of the complete units and sub-assembly.

9.4 Samples

Samples of all materials to be supplied under the contract such as pipes, insulating materials and multiple fittings such as valves, strainers, electric components shall be supplied to the Engineer for approval. Such samples shall be kept with the Engineer until completion of the Works and same will be released to the Contractor on completion of work. The items of supplies used for the project shall be at least equal in quality to the approved sample.

9.5 As-built drawings

On completion of the installation, the Contractor shall prepare a set of As-built drawings incorporating all changes made to the original design and drawings, which drawings shall represent an accurate description of the installed systems. These drawings shall be bound with covers in to an album and handed over to the Engineer.

9.6 Handing over documents

The final handing over documents to be submitted by the Contractor on completion of the installation shall comprise the following:

- a) Operation and maintenance manuals (03 copies)
- b) Commissioning sheets (03 copies)
- c) Test reports (03 copies)
- d) As built drawings (03 copies)

These documents should be supplied to the Engineer within 30 days on issue of taking over certificate.

10.0 TRAINING OF OWNER'S STAFF

Bidders shall submit with the Bid, a full proposal of the recommended training necessary for the owner's personnel to attend to routine testing, maintenance service and minor repairs including an indication of the duration of such training. The number of persons required to be trained shall be determined jointly by the Engineer, and the contractor.

The scope of training shall include on-site training and such training shall be prior to hand-over of the system. Technical training and system operation instructions to the owner's personnel shall also be provided during the commissioning and performance tests phases of the system.

System operation instructions shall be given by an experienced and competent representative of the Contractor who is thoroughly conversant with the air conditioning system installed

11.0 SITE TESTING AND COMMISSIONING

Bidders shall submit with the Bid, a complete proposal with time schedule for testing and commissioning of the air conditioning system. The program shall include a trial operation of all main equipment with any necessary adjustments to ensure that the system is working correctly. The Contractor shall provide all instruments and equipment together with commissioning engineers and adequate assistance for carrying out the commissioning and testing activity, which shall be done in accordance with the recommendations of relevant standards. If any portion the works fails to pass the tests, the Contractor shall, at his own expense carry out such alterations or replacements as are required to the satisfaction of the Engineer. The Engineer shall be at liberty to call for further commissioning when such alterations have been completed to their satisfactory. The Contractor shall provide commissioning spares at his own expense.

Spare parts earmarked for maintenance shall not be used during this period.

12.0 MAINTENANCE CONTRACT

Bid shall submit the terms and charges for service and maintenance contract along with the Bid.

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specification - Fire Detection

23553-01-TN-DT-SP-9800

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| Version | Issuer | Summary of Changes | Date of Issue |
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| 1.0 | URO | Initial Issue | 20.09.2023 |
| 2.0 | URO | Tender Issue | 14.12.2023 |

GENERAL TECHNICAL SPECIFICATION

2.1 General

This section specifies the requirements for the manufacture, transport, delivery to site, unloading, complete erection/installation, site testing, setting to work and maintenance for a period of one year of the Addressable Fire Detection system for the protection of goods, personnel, buildings etc. of proposed SACEP HQ building, Colombo, Sri Lanka

This section of the specification includes the supply, installation, connection and testing of the microprocessor controlled, addressable automatic fire detection and alarm equipment required to form a complete, operative, coordinated system for the building. Fire detection and alarm system shall include, but not be limited to, alarm initiating devices, alarm notification appliances, control panel, annunciator, power supply and wiring as shown on the drawings, listed in the bills of quantities and specified herein.

2.2 Scope of Work

The scope of work includes the following;

- (a) Preparation of Installation shop drawings and obtaining approval from Local Fire Authority.
- (b) Supply of all equipment and materials required for a new, microprocessor controlled fire detection and alarm communication system for the proposed patient wards at Kulhudhuffushi island in Maldives.
- (c) Provide all required labour and installation of the complete system.
- (c) Preparation of shop drawings conforming to the requirements of Fire Services Department with any revisions required in layouts and points to conform to the requirements of authority.
- (d) The contractor shall perform all the equipment and devices standard testing as directed by the Consulting Engineer. The Contractor shall bear the cost for such tests and any items found defective shall be replaced at no extra cost. Such replaced items shall be re- tested for verification.
- (e) Obtaining certificate of conformity from Fire Services department on completion of work.
- (f) The Contractor shall submit 3 hard copies + 1 soft copy of Operation & maintenance Manuals, which shall contain Product literature, Specific operating instructions and Maintenance instructions.
- (g) Training of the employer's staff for proper operation of the system.
- (h) Maintaining the system during the defects liability period.

2.3 Applicable Standards / Publications

All equipment and material used and Fire detection and Alarm System shall meet the requirements of the relevant standards / publications.

A. British Standards Institution

BS 5445 Components of automatic fire detection systems

Part 5: Heat sensitive detectors

Part7: Specifications for point type smoke detectors using scattered light transmitted light or ionization

Part 8: Specifications for high temperature heat detectors

BS 5839 Fire detection and alarm systems for buildings
Part 1: Code of practice for system design, installation and servicing
Part 2: Specifications for manual call points
Part 4: Specifications for control and indicating equipment

B. National Fire Protection Association (NFPA) - USA:

No. 70 National Electric Code (NEC)
No. 72-1996 National Fire Alarm Code
No. 101 Life Safety Code

C. Underwriters Laboratories Inc. (UL) - USA:

No. 50 Cabinets and Boxes
No. 268 Smoke Detectors for Fire Protective Signaling Systems
No. 864 Control Units for Fire Protective Signaling Systems
No. 268A Smoke Detectors for Duct Applications.
No. 521 Heat Detectors for Fire Protection
No. 464 Audible Signaling Appliances.
No. 38 Manually Actuated Signaling Boxes.
No. 1481 Power supplies for Fire Protective Signaling Systems.
No. 1971 Visual Notification Appliances.

D. Fire Regulations of Institute for Construction Training and Development, Sri Lanka

E. All requirements of the Fire Services Department of Municipality.

2.4 Approvals

A. The system must have proper listing and/or approval from one or more of the following internationally recognized agencies:

BSI British Standards Institution

UL Underwriters Laboratories Inc, USA

2.5 Basic Requirements

- a. The fire detection and alarm system shall be a monitored addressable system.
- b. The detection system shall include automatic fire detectors and manual call points.

- c. Generally, each detector shall have a unique address. However, if a room/compartment is provided with more than one detector, then all the detectors in that room/compartment may be grouped together and may have a single common address.
- d. Each manual call point shall have a unique address.
- e. Fire alarms shall be given by audio and visual devices. Each alarm device shall have a unique address.
- f. An addressable fire alarm control panel shall be provided. It shall be possible to map inputs to outputs as required.
- g. Power for initiating devices and notification appliances shall be from the main fire alarm control panel.
- h. A single ground or open on any system signaling line circuit, initiating device circuit, or notification appliance circuit shall not cause system malfunction, loss of operating power or the ability to report an alarm.
- i. Alarm signals arriving at the main Fire Alarm Control Panel shall not be lost following a power failure (or outage) until the alarm signal is processed and recorded.
- k. The fire alarm control panel should be communicate with Building BMS system via common network protocol (BACnet)

2.6 Mode of Operation on Fire Signal

The contractor shall propose, for approval by the Engineer, complete mode of operation of the system.

2.7 Equipment and Materials

All equipment and components shall be new, and the manufacturer's current model. The materials, appliances, equipment and devices shall be tested and listed by a nationally recognized approvals agency for use as part of a protected premises protective signaling (fire alarm) system. All equipment and components shall be installed in strict compliance with each manufacturer's recommendations.

2.8 Main Fire Alarm Control Panel

2.8.1 General

The main Fire Alarm Control Panel (FACP) shall contain a micro-processor based central processing unit (CPU). The FACP shall communicate with and control the equipment used to make up the system:

2.8.2 Functional Requirements

The main FACP shall perform the following functions:

1. Supervise and monitor all addressable detectors and monitor modules connected to the system for normal, trouble and alarm conditions.
2. Supervise all initiating signaling and notification circuits throughout the facility
3. Detect the activation of any initiating device and the location of the alarm condition. Operate all notification appliances and auxiliary devices as programmed.
4. Visually and audibly annunciate any trouble, supervisory or alarm, condition on panel display
5. *The fire alarm control panel should communicate with Public Address System installed in the building*

2.8.3 Alarm Functions

When a fire alarm condition is detected and reported by one of the system initiating devices or appliances, the following functions shall immediately occur:

1. The alarm indicator on the control panel shall flash.
2. A local audible device in the control panel shall sound a distinctive signal.
3. When the Acknowledge button is pushed the audible alarm shall stop and indication light shall stop flashing and shall give a steady light.
4. A LCD display shall indicate all information associated with the fire alarm condition, including the type of alarm point and its location within the protected premises.
5. Printing and history storage equipment shall log and print the event information along with a time and date stamp.
6. All system outputs assigned via pre-programmed equations for a particular point in alarm shall be executed, and the associated system outputs (alarm notification appliances and/or relays) shall be activated.

2.8.4 Trouble Functions

When a trouble condition is detected and reported by one of the system initiating devices or appliances, trouble functions similar to alarm functions indicated in sub-clause 2.8.3 shall immediately occur:

2.8.5 Supervisory Functions

When a supervisory condition is detected and reported by one of the system initiating devices or appliances, supervisory functions similar to alarm functions indicated in sub-clause 2.8.3 shall immediately occur:

2.8.6 System Capacity

The control panel shall have the capacity for connection of 45 or more addressable detection devices & 1 detection loops & the fire alarm control panel shall be expandable.

All programming or editing of the existing program in the system shall be achieved without special equipment and without interrupting the alarm monitoring functions of the fire alarm control panel.

2.8.7. Central Processing Unit (CPU):

The Central Processing Unit shall communicate with, monitor, and control all other modules within the control panel. Removal, disconnection or failure of any control panel module shall be detected and reported to the system display by the central processing unit.

The CPU shall contain and execute all control-by-event programs for specific action to be taken if an alarm condition is detected by the system. Control-by-event programs shall be held in non-volatile programmable memory, and shall not be lost even if system primary and secondary power failure occurs.

The Central Processing Unit shall also provide a real-time clock for time annotation of all system displays. The Time-Of-Day and date shall not be lost if system primary and secondary power supplies fail.

The CPU shall be capable of being programmed on site without requiring the use of any external programming equipment.

Each peripheral device connected to the CPU shall be continuously scanned for proper operation. Failure of any peripheral device to respond to an interrogation shall be annunciated as a trouble condition.

2.8.8 Display

The system display shall provide all the controls and indicators used by the system operator and may also be used to program all system operational parameters.

The display assembly shall contain, and display as required, custom alphanumeric labels for all addressable detectors and modules.

The system display shall provide an 80-character back-lit alphanumeric Liquid Crystal Display (LCD). It shall also provide light-emitting-diodes (LEDs), which will indicate the status of the system parameters such as AC POWER, SYSTEM ALARM; SYSTEM TROUBLE, and DISPLAY TROUBLE.

The system display shall provide a key-pad with control capability to command all system functions, entry of any alphabetic or numeric information, and field programming. Two different password levels shall be accessible through the display interface assembly to prevent unauthorized system control or programming.

The system display shall include, but not be limited to, the following operator control switches: SIGNAL SILENCE, LAMP TEST, RESET, SYSTEM TEST, and ACKNOWLEDGE

2.8.9 Enclosure

The main fire alarm control panel shall be housed in a cabinet suitable for surface or semi-flush mounting. Cabinet shall be corrosion protected, given a rust-resistant prime coat, and manufacturer's standard finish.

The door shall provide a key lock and include a transparent opening for viewing all indicators.

2.8.10 Power Supply

The main power supply shall operate on 230V AC, single phase, 50Hz, and shall provide all necessary power for the FACP. It shall provide all the necessary internal operating power for the FACP and power for operation of external alarm notification appliance circuits. It shall include a battery charger for 24 hours of standby using dual-rate charging techniques for fast battery recharge.

It shall provide meters to indicate battery voltage and charging current.

Upon loss of mains power, the power supply unit shall automatically revert to battery power.

When main AC power is restored, the control unit shall automatically revert back to normal operation without need for any manual switching procedure.

2.8.11 Operators Terminal

The following standard operator full-system functions shall be provided:

1. Acknowledge Switch:
2. Signal Silence Switch:
3. System Reset Switch:
4. Lamp Test Switch:

2.8.12 Video Display Terminal

The Video Display Terminal shall provide a visual display and an audible alert of all changes in status of the system and shall annotate such displays with the current time-of-day and date. A detachable keyboard shall be provided that may be used for programming, testing, read status and control of the system.

2.8.13 Printer

Printer shall be of the automatic type, printing code, time, date, location, category, and condition.

The printer shall provide hard-copy printout of all changes in status of the system and shall time-stamp such printouts with the current time-of-day and date. The printer shall be standard carriage with 80-characters per line and shall use standard pin-feed paper. The printer shall be enclosed in a separate cabinet suitable for placement on a desk top or table. The printer power shall be 230V AC, 50 Hz.

2.8.14 Field Programming

The system shall be programmable, configurable and expandable in the field without the need for special tools, laptop computers or electronic interface equipment. There shall be no firmware

changes required to field modify the system time, point information, equations, or annunciator programming/information.

It shall be possible to program through the standard FACP keyboard all standard functions. All field defined programs shall be stored in non-volatile memory.

2.8.15 System Circuit Supervision

The FACP shall supervise all circuits to devices and annunciate loss of communications with these devices. The CPU shall continuously scan above devices for proper system operation and upon loss of response from a device shall sound an audible trouble, indicate which device or devices are not responding and print the information in the history buffer and on the printer.

2.9 Automatic Fire Detectors

The following types of automatic fire detectors shall be provided, as appropriate to the location as indicated in the drawings.

- (i) Smoke detectors - Photoelectric type
- (ii) Heat detectors

All the above detectors shall be of point type suitable for surface mounting.

Detectors shall be addressable, and shall connect to the fire alarm control panel's Signaling Line Circuits. If a room/compartiment is provided with more than one detector, then all these detectors may have a common address. In such case, an addressable control module along with conventional detectors may be provided, instead of individually addressable detectors, for the particular room/compartiment.

Addressable smoke and thermal detectors shall be provided with a LED. LED shall flash under normal conditions, indicating that the detector is operational and in regular communication with the control panel and LED shall be placed into steady illumination by the control panel, indicating that an alarm condition has been detected.

The detectors shall be ceiling-mount and shall include a separate twist-lock base which includes a tamper proof feature.

The detectors shall provide a test means whereby they will simulate an alarm condition and report that condition to the control panel. Such a test may be initiated at the detector itself (by activating a magnetic switch) or initiated remotely on command from the control panel.

2.9.1 Smoke Detectors - Photoelectric type

The photoelectric smoke detector shall operate on the principle of smoke detection by light scatter and shall have no moving parts of components subject to wear.

The electronic circuits shall be of the solid state type and hermetically sealed to prevent disturbances due to dust, dirt or humidity. They shall further be protected against electrical transients and electromagnetic interference and shall not be damaged from reversed polarity or faulty zone wiring.

The design of the circuitry shall be such as to suppress false alarms due to deceptive transient phenomena eg. vibration, shock, insects etc.

It shall be possible to test the sensitivity of a detector in the field. The response sensitivity shall be field adjustable to a minimum of two predetermined, factory calibrated levels.

A wire mesh shall be fitted to the detector windows to prevent the entry of insects into the Measuring Chamber.

The detector shall be complete with the mounting base and it shall be capable of being installed in to the base by a simple push-twist movement.

The detector shall be an off-white colour. The detector shall be capable of being reset from the central control panel.

2.9.2 Heat Detectors

The heat detectors shall be of combined rate-of-rise and fixed temperature type.

The detectors shall incorporate thermistors, depending upon the type, to detect the fixed temperature level and the rate of temperature rise, working in conjunction with solid state electronic circuits which shall be hermetically sealed to prevent disturbance by dust, dirt or humidity.

The circuitry shall be protected against electrical transients and electromagnetic interference and no detector shall be capable of being damaged from reversed polarity or faulty zone wiring.

The detector shall have no moving parts or components subject to wear.

It shall be possible to test the sensitivity of a detector in the field.

The combination type detector shall respond to a temperature rise at the rate of 10°C per minute and to temperatures exceeding 60°C.

The detector shall be an off-white colour.

The detector shall be capable of being reset from the central control panel.

2.10 Manual Call Points (Break Glass Units)

The manual call points shall be of addressable type and electrically compatible with the automatic detectors. Manual call point shall be of the break-glass type in a shatter-proof, corrosion resistant housing of pleasant, streamlining appearance and design permitting its use as a semi-recessed unit.

All inscriptions, texts (which shall be in English) and markings shall be on the front plate of the manual call point or behind the glass and not on the glass, so that the glass may be easily replaced. The cover must be secured against unauthorized removal. Every removal of the cover shall release the alarm.

The alarm contacts shall be of a self-cleaning design to prevent failure after a prolonged period of inactivity in unclean environments.

It shall be possible to test the call point without breaking the glass.

It shall use a key operated test-reset lock, and shall be designed so that after actual emergency operation, it cannot be restored to normal use except by the use of a key.

All operated stations shall have a positive, visual indication of operation and utilize a key type reset.

The exterior finish shall be in standard signal red.

2.11 Alarm Sounder

Fire Alarm Sounder shall be an electronic sounder with frequency characteristics complying with the frequency requirements of BS 5839 Part 1 or equivalent. Sounder output shall be not less than 85 dB (A). A volume control shall be incorporated inside the unit enabling the sound output to be set to suit a wide range of locations. Alarm sounder shall be suitable for surface mounting.

2.13 Addressable Detector Monitor Module

Addressable monitor modules shall be provided to monitor alarm initiating devices, controlling of lifts, Air Conditioners, Fire Pumps etc in case of a fire situation.

An LED shall be provided that shall flash under normal conditions, indicating that the monitor module is operational and in regular communication with the control panel.

2.14 Isolator Module

Isolator modules shall be provided to automatically isolate wire-to-wire short circuits on an SLC loop. The isolator module shall limit the number of modules or detectors that may be rendered inoperative by a short circuit fault on the SLC Loop. At least one isolator module shall be provided for each floor or protected zone of the building.

If a wire-to-wire short occurs, the isolator module shall automatically open-circuit (disconnect) the SLC loop. When the short circuit condition is corrected, the isolator module shall automatically reconnect the isolated section.

The isolator module shall not require any address-setting, and its operations shall be totally automatic. It shall not be necessary to replace or reset an isolator module after its normal operation.

It shall provide a single LED that shall flash to indicate that the isolator is operational and shall illuminate steadily to indicate that a short circuit condition has been detected and isolated.

2.15 Battery

Sealed lead-acid batteries shall provide emergency power.

Battery shall have sufficient capacity to power the fire alarm system for not less than twenty-four hours of alarm upon a normal AC power failure.

The batteries shall be completely maintenance free. No liquids shall be required. Fluid level checks refilling, spills and leakage shall not be required.

2.16 Battery Charger

Battery charger shall be completely automatic, with constant potential charger maintaining the battery fully charged under all service conditions. Charger shall operate from a 230-volt 50 hertz single phase source.

It shall be rated for fully charging a completely discharged battery within 48 hours while simultaneously supplying any loads connected to the battery.

It shall have protection to prevent discharge through the charger.

It shall have protection for overloads and short circuits on both AC and DC sides.

2.17 Wiring

Wiring shall be in accordance with IEE Wiring Regulation-17th Edition and as recommended by the manufacturer of the fire alarm system. Number and size of conductors shall be as recommended by the fire alarm system manufacturer, but not less than 1.5mm² for Initiating Device Circuits and Signaling Line Circuits and Notification Appliance circuits.

In locations where PVC conduits are embedded in the concrete slab PVC insulated fire resistant cables shall be used for wiring the fire alarm system. In locations where embedded PVC conduits are not available cables drawn through exposed GI conduits, with fire resistance capability complying with BS 6387 CWZ shall be used for wiring.

All field wiring shall be completely supervised. In the event of a primary power failure, disconnected standby battery, removal of any internal modules, or any open circuits in the field wiring; a trouble signal shall be activated until the system and its associated field wiring are restored to normal condition.

2.18 EXIT/ FIRE EXIT SIGN BOARDS

The following types of sign boards shall be used at the locations on drawings.

Exit sign board shall comply with BS 5378. Text and symbols on board shall be green on white background.

The following types of sign boards shall be used at the locations on drawings.

Fire Exit sign boards which indicate the EXIT route shall bear direction arrow and the international symbol for fire escape on one side or both sides wherever applicable.

Exit Sign boards which indicate on Exit door shall bear the text EXIT.

2.19 Installation

2.19.1 General

Installation shall be in accordance with the applicable standards, as shown on the drawings, and as recommended by the major equipment manufacturer.

2.19.2 Main Alarm Control Panel

Main control panel shall be surface mounted on the wall of the Reception area at ground Floor.

2.19.3 Detectors

The locations of detectors, as shown on the drawings, are approximate. The contractor shall adhere strictly to the manufacturer's installation instructions when deciding the final locations and the method of installation. Special emphasis shall be laid on achieving prescribed minimum distances between detectors, and from structural beams, walls, ceilings, etc. to the detectors.

Fire detectors shall be surface mounted underneath ceilings and soffits.

2.19.4 Manual Call Points

Manual Pull Stations shall be suitable for surface mounting or semiflush mounting and shall be installed approximately 1.25m above the finished floor.

2.19.5 Alarm Sounders and Visual Signaling Units

The locations of alarm sounders and visual signaling units, as shown on the drawings, are approximate. The contractor shall adhere strictly to the manufacturer's installation instructions when deciding the final locations and the method of installation. In areas where alarm sounder may be ineffective, ex. where the background noise is excessive, visual signaling units shall also be used.,

2.20 Tender Stage Documentation

Tenderer shall adequately and accurately describe the proposed system and concepts at the time of tendering, supported by a full set of drawings, specifications and catalogues describing the various components belonging to the fire detection and alarm system.

Sufficient information, clearly presented, shall be included to determine compliance with specified requirements as indicated in drawings and specifications.

Manufacturer's name(s), model numbers, ratings, power requirements, equipment layout, and device arrangement shall be included.

2.21 Contract Stage Documentation

The Contractor shall provide a full set of documents in duplicate, related to concept, design, installation, commissioning and the maintenance of the entire system and its components.

The following sets of documents are required as a minimum per system components:

- System description and operating principle
- Installation instructions
- Connection diagrams
- Commissioning instructions
- Operating instructions
- Detailed maintenance instructions and trouble-shooting guide

The following drawings in detail are required as a minimum:

- System block diagrams
- Wiring diagrams
- Plans showing detector locations and zoning
- Termination diagrams
- General arrangement plans, layout and outline drawings of system components.
- Position plans and sectional installation details

On completion of the installation and commissioning activities, the documentation shall be revised to incorporate any changes from the original and the final 'as-built' documentation shall be submitted in triplicate to the Engineer by the contractor as stipulated under General Requirements of the main Electrical Specification, in conjunction with which, this specification shall be read.

2.22 Software Modifications

All hardware, software, programming tools and documentation necessary to modify the fire alarm system on site shall be provided. Modification includes addition and deletion of devices, circuits, and changes to system operation and custom label changes for devices or zones. The system structure and software shall place no limit on the type or extent of software modifications on-site. Modification of software shall not require power-down of the system or loss of system fire protection while modifications are being made.

2.23 Guarantee

All work performed and all material and equipment furnished under this contract shall be free from defects and shall remain so for a period of at least one (1) year from the date of acceptance. The full cost of maintenance, labor and materials required to correct any defect during this guarantee period shall be included in the submittal bid.

2.24 Commissioning and Testing

The Contractor shall provide all instruments and equipment together with commissioning Engineers and adequate assistance for carrying out the commissioning and testing activity which shall be done in accordance with the applicable standards.

The commissioning and testing activity shall demonstrate that all equipment provided complies with the Specification in all particulars and that they have been properly and completely installed.

As a minimum the following tests shall be carried out.

- (a) Before energizing the cables and wires, check for correct connections and test for short circuits, ground faults, continuity, and insulation.
- (b) Open initiating device circuits and verify that the trouble signal actuates.
- (c) Open signaling line circuits and verify that the trouble signal actuates.
- (d) Open and short-circuit notification appliance circuits and verify that trouble signal actuates.

- (e) Ground initiating device circuits and verify response of trouble signals.
- (f) Ground signaling line circuits and verify response of trouble signals.
- (g) Ground notification appliance circuits and verify response of trouble signals.
- (h) Check installation, supervision, and operation of all smoke detectors.
- (i) Each of the alarm conditions that the system is required to detect should be introduced on the system. Verify the proper receipt and the proper processing of the signal at the FACP and the correct activation of the control points.

If any portion of the works fails to pass the tests, the Contractor shall, at his own expense, carry out such alterations or replacements as are required to the satisfaction of the Engineer. The Engineer shall be at liberty to call for further commissioning when such alterations have been completed to their satisfaction.

On satisfactory completion of the commissioning and testing activity, Contractor shall provide all necessary reports and records in triplicate set out to a format to be agreed with the Engineer.

The Contractor shall provide commissioning spares in sufficient quantities at his own expense. Spare parts earmarked for maintenance shall not be used during this period.

2.25 Instructions

Contractor shall provide instructions as required for operating the system. "Hands-on" demonstrations of the operation of all system components and the entire system including program changes and functions shall be provided.

The contractor and/or the systems manufacturer's representatives shall provide a typewritten "Sequence of Operation."

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specification - Fire Protection

23553-01-TN-FF-SP-9800

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Version Log

| Version | Issuer | Summary of Changes | Date of Issue |
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| 1.0 | URO | Initial Issue | 20.09.2023 |
| 2.0 | URO | Tender Issue | 14.12.2023 |

GENERAL TECHNICAL SPECIFICATION

1.0 GENERAL

1.1 SCOPE OF WORK

This section specifies the requirements for the design, manufacture, transport, delivery to site, unloading, complete erection/installation, site testing, setting to work and maintenance for a period of one year of the Fire Protection system for the protection of goods, personnel, buildings etc. of proposed patient wards at Kulhudhuffushi island in Maldives

The work covered in this section shall include, but not to be limited to all labour, materials, equipment and services required in connection with Fire Protection System and related work as stipulated in the specifications, drawings and the equipment list for proposed building.

To meet the requirements of the Local Fire Department regulations the following services shall be provided in the premises complying with BS standard and Fire Offices Committee (FOC) regulations and as detailed in the drawings.

1. Supply and Installation of Hose reel systems complete with fire pumps, pipelines, fittings, first aid hose reels, fire cabinets etc. in each and every floor as per drawings and specifications.
2. Supply and Installation of portable Fire Extinguisher at the locations shown on drawings.

Contractor should obtain all approvals and compliance from the Fire Regulation Authorities/Fire Services Department of Maldives before commencement of installation, during and after completion of the installation as specified by Fire Service Department of the Colombo Municipal Council.

1.2 Submissions

The Contractor shall submit for approval the following documents and samples in quantities as indicated:

1.2.1 Shop Drawings

Shop drawings of all piping systems, electrical circuit and wiring diagram and any other drawings necessary for fabrication and installation of the system.

1.2.2 Technical Literature of Equipment

Technical literature of all equipment proposed to be used in the system inclusive of dimensional drawings, capacity tables, test reports and other relevant information shall be supplied in triplicate for the Engineer to determine the adequacy and suitability of the equipment for the proposed fire protection system.

1.2.3 **Maintenance & Operating Manuals**

Maintenance and operating manuals of all equipment supplied shall be furnished in triplicate with detailed wiring of the equipment, piping & valving arrangements and instructions of the regular maintenance of the equipment. Frequency of lubrication and specifications of the lubricants recommended shall also be provided. All manuals should be printed, and ring bound with.

A schedule which may be in the form of a material list giving all particulars together with ordering references of all replaceable parts for all the equipment which will be supplied.

1.2.4 **Samples**

Samples of all materials to be supplied under the contract such as pipes and multiple fittings such as valves, strainers, electric components shall be supplied to the Engineer for approval. Such samples shall be kept with the Engineer until completion of the Works and same will be released to the Contractor on completion of work. The items of supplies used for the project shall be at least equal in quality to the approved sample.

1.2.5 **As-Built Drawings**

On completion of the installation, the Contractor shall prepare a set of As-built drawings incorporating all changes made to the original design and drawings, which drawings shall represent an accurate description of the installed systems. These drawings shall be bound with covers in to an album and handed over to the Engineer.

1.2.6 **HANDING OVER DOCUMENTS**

The final handing over documents to be submitted by the Contractor on completion of the installation shall comprise the following :

- | | | |
|----|-----------------------------------|------------|
| a) | Operation and maintenance manuals | (3 copies) |
| b) | Commissioning sheets | (3 copies) |
| c) | Test reports | (3 copies) |
| d) | As built drawings | (3 copies) |

These documents in required number of copies specified should be supplied to the Engineer within 30 days on issue of taking over certificate.

1.2.7 **TRAINING OF OWNER'S STAFF**

Bidders shall submit with the bid, a full proposal of the recommended training necessary for the owner's personnel to attend to routine testing, maintenance service and minor repairs including an indication of the duration of such training.

The number of persons required to be trained shall be determined jointly by the Engineer, and the Contractor.

The scope of training shall include on-site training and such training shall be prior to hand-over of the system. Technical training and system operation instructions to the

owner's personnel shall also be provided during the commissioning and performance tests phases of the system.

System operation instructions shall be given by an experienced and competent representative of the Contractor who is thoroughly conversant with the fire protection system installed.

1.2.8 TESTING AND COMMISSIONING

Bidders shall submit with the bids, a complete proposal with time schedule for testing and commissioning of the fire protection system. The program shall include a trial operation of all main equipment with any necessary adjustments to ensure that the system is working correctly. The Contractor shall provide all instruments and equipment together with commissioning engineers and adequate assistance for carrying out the commissioning and testing activity which shall be done in accordance with the recommendations of relevant Standards. If any portion of the works fails to pass the tests, the Contractor shall, at his own expense carry out such alterations or replacements as are required to the satisfaction of the Engineer. The Engineer shall be at liberty to call for further commissioning when such alterations have been completed to their satisfactory. The Contractor shall provide commissioning spares at his own expense.

Spare parts earmarked for maintenance shall not be used during this period.

1.2.9 MAINTENANCE CONTRACT

Bidder shall submit the terms and charges for service and maintenance contract along with the bid.

2.0 FIRE PROTECTION SYSTEM

2.1 GENERAL

Firefighting system should connect to the existing firefighting system in the land.

The distribution pipe network shall be kept pressurized at all times.

The hose-reels shall be housed in Fire cabinets located as indicated in the drawings.

The work shall conform to BS 5306: Part 1 except where otherwise required by this Specification.

Swing Type Fire hose reels complying with BS 5274 shall be installed at each level in the locations shown in the drawings. The hose reels shall be 3/4"(20mm) connected to the hose reel riser system by flanges of heavy duty galvanized steel pipe to BS 1387.

Hose reel riser pipe work shall be heavy duty galvanized iron (GI) pipes to BS 1387 with Victualic grooved couplings or similar approved mechanical couplings.

The distribution pipe network shall be kept pressurized at all times.

The pipes shall be run concealed in ceiling voids where available and in the ducts provided. The hose-reels shall be housed in Fire Hose Reel cabinets located as indicated in the drawings.

The work shall conform to BS 5306: Part 1 except where otherwise required by this Specification.

2.2 STANDARDS

The installation shall comply with the following regulations:

Part I - General Technical Specifications for Fire Protection and Detection System

British Standard Specifications BS 5306

- Part 1 - Hydrant Systems, Hose Reels and foam inlets (formerly CP 402)
- Part 3 - Portable Fire Extinguishers
- Bs 334 - Fire Hose Couplings and Ancillary equipment
- Part 1 - Specification for landing valves for wet risers
- Bs 5274 - Fire hose reels (water) for fixed installation
- BS 5446 - Part 1

National Fire Protection Association of America (NFPA)

- 2.2.1 If the specification, capacities and sizes given are not adequate or have to be changed to suit an equipment of any manufacturer for producing required design conditions the Contractor shall include his charges for these with the quotation. Once the contract is awarded no extra cost will be made to the Contractor for such changes.
- 2.2.2 All the materials shall be new without any defects and to be approved by the Engineer.
- 2.2.3 All the approvals required to be obtained prior to the installation and after the completion shall obtained by the Contractor from the respective Local Bodies.
- 2.2.4 All builders work required with respect to plinths and foundations, opening on walls and floors and any additional provisions required shall be included in the Scope of Work.

2.3 DESIGN CONDITIONS

- Water flow rate at wet riser - 1 l/s
- pressure required at furthest hose reel nozzle - 1.5 bar
- water quantity at furthest hose reel connection - 0.5 l/s
- maximum static pressure in hose reels when water is shut off - app. 2.5 bar

2.4 OTHER REQUIREMENTS

- 2.4.1 If the specification, capacities and sizes given are not adequate or have to be changed to suit an equipment of any manufacturer for producing required design conditions the Contractor shall include his charges for these with the quotation. Once the contract is awarded no extra cost will be made to the Contractor for such changes.
- 2.4.2 All the materials shall be new without any defects and to be approved by the Engineer.
- 2.4.3 All the approvals required to be obtained prior to the installation and after the completion shall obtained by the Contractor from the respective Local Bodies.
- 2.4.4 All builders work required with respect to plinths and foundations, opening on walls and floors and any additional provisions required shall be included in the Scope of Work.

2.5 FIRE PROTECTION SYSTEM DESCRIPTION

2.5.1 FIRE HOSE REEL SYSTEM

2.5.1.1 FIRE HOSE REEL RISER

50mm diameter GI heavy duty pipes shall be used for the risers.

2.5.1.2 FIRE HOSE REEL CABINET

Fire cabinets shall be located as indicated in the drawings. They shall be fabricated out of **1.5mm thick steel sheet** and protected with a coat of epoxy based zinc chromate enamel Red paint.

The doors shall have wired glass panel and shall be hung on piano hinges to be openable through 180° swing. The door shall also be fitted with a break glass type cubicle and the key shall be kept in it.

The size of each cabinet shall be made to accommodate the following equipment, but should not exceed 850mm (W) x 450mm (D) x 1000mm (H) which will be the standard size for all the floors.

- 01 No. - Hose Reel- manual, swivel type with shut off valve, (3/4") 20mm diameter, and 30m length
- 01 No. – 3kg CO₂ Portable Fire Extinguisher
- 01 No. – 9lt CO₂/H₂O Portable Fire Extinguisher

The Fire Hose Reel Cabinet door should bear the words "**FIRE HOSE REEL CABINET**" in Red letters at least 50mm high on a White background.

In addition all the provisions should be made as required in BS 5306 Part I or equivalent.

2.5.1.3 FIRE HOSE REEL

Fire hose reels shall be provided internally at each fire cabinet as shown in the drawings.

Hose reel shall be of the manual, recessed pattern, swing type (according to location and as scheduled) complete with 30m of 20mm (internal diameter) non-collapsible, non-kink reel hose and nylon spray/jet/shut-out nozzle suitable to provide a jet of approximately 6m in length and 30 litres/ minute delivery .

The fire hose reel shall conform to **BS 5274**. The hose shall comply with the requirements for type A (design working pressure of 15 bar) hose specified in **BS 3169**.

All water passage shall be in non-ferrous corrosion resistant materials.

The side plates of the hose reel shall be of pressed steel and all metal work shall be finished in stove-enameled signal red.

To facilitate ease of installation and maintenance, a ball valve and union shall be fitted between the rising main and the hose reel.

The hose reels nozzle retainer or hose guide and the inlet valve should be fitted at a height of about **900mm** above floor level.

Reels shall be of sufficient size to carry the length of hose fitted, excluding the nozzle, within the space defined by the end plates.

The hose shall be capable of being run out of the reel, through the hose guide where fitted, in any generally horizontal direction up to the limits of the hose length.

Each length of hose shall be durably marked at the nozzle end and at intervals not exceeding 10m, with the following information:

- (a) Manufacturer's name or identification
- (b) The number of the specified BS with the type letter suffix e.g. BS 3169/A
- (c) The nominal bore size, e.g. 20mm
- (d) Month and year of manufacture e.g. 10/95
- (e) The design and working pressure

This information may be conveniently presented in the following manner.

MR/BS 3169/A/20mm/01/95/15 bar

Hose reel brackets shall be firmly fixed to the wall so that casual knocks received during normal use of the building and the stresses incurred during use for fire-fighting will not prevent the unimpeded use of the hose reel.

2.5.2 VALVES

All valves shall be new, of approved manufacture, which includes Crane, Johns, Lacey, Newman Header, Richards, Toya and De Zurik, or as approved. Samples of valves proposed for use shall be submitted for approval.

All valves shall be placed in accessible positions for operation and repairs. The connections between each valve and adjacent piping or equipment shall be made either with a flange (65 mm dia and above) or a union (up to 50mm dia).

The valves and glands shall be designed to withstand without leaks, the system pressures whether the pumps are in operation or not.

Each isolating valve shall be provided with a means for attaching a strap so that the hand wheel may be secured in any desired position to prevent unauthorized use.

A purpose-made strap of leather or reinforced plastic material not less than 12mm wide nor less than 2mm thick and a small non-ferrous padlock to secure the two ends of the strap shall be supplied with each valve.

Alternative means of securing the valves against unauthorized use may be offered.

Straight pattern valves shall be of the full-way gate type.

The bodies of valves up to and including 50mm diameter shall be of cast gunmetal or bronze. Bodies of valves 65mm diameter and above shall be of cast iron. Castings shall be of good quality, clean and smooth and free from scale or falls.

The system drain valves shall be 25mm diameter, key operated type with hose unions fitted to the discharge end.

2.5.3 EXPANSION BENDS AND ANCHORS

Any continuous straight pipe run in excess of 30 meters on one side of an anchor point shall be fitted with expansion bends or flexible connections.

2.5.4 PRESSURE GAUGES

Pressure gauges 100mm dia. maximum, shall be installed in the following locations:

- (a) Top-most point of wet riser
- (b) In the positions shown in the drawings and where deemed necessary

The gauges shall be provided with a device to dampen pulsations and the fixing of the gauge shall be such that it may be removed and re-fitted without shutting down the line.

2.5.5 PIPES

Pipes shall be Galvanized Mild Steel to BS 1387, heavy gauge.

All pipes and fittings shall be new, of approved manufacture and the right grades. Each length of pipe shall be thoroughly cleaned and blown out to remove all scale and dirt before erection. Rusting pipes and fittings and piping and fittings of classes other than specified will be rejected.

2.5.6 PIPE WORK JOINTS AND FITTINGS

Pipes of 50mm diameter and smaller shall be screw jointed. At dismantling points or where pipe work is connected to an appliance (eg. hose reel), ground-in spherical seated unions shall be used.

2.5.7 PIPE SUPPORTS

Pipe work shall be supported so as to permit free movement due to expansion and contraction. Pipework supports shall be arranged as near a possible to joints and changes in direction, and each support shall take its due proportion of the load. The spacing of the supports shall be in conformity with the recommendations of the grooved coupling manufacturer but shall not exceed the centres given below. Where there are two or more pipes, the spacing shall be based on the centres required by the smallest bore pipework.

| Size of Pipe (mm) | Intervals for Horizontal runs (m) | Intervals for Vertical runs (m) |
|----------------------|--------------------------------------|------------------------------------|
| 20 | 2.4 | 3.0 |
| 25 | 2.4 | 3.0 |
| 32 | 2.7 | 3.0 |
| 40 | 3.0 | 3.7 |
| 50 | 3.0 | 3.7 |
| 65 | 3.7 | 4.6 |
| 80 | 3.7 | 4.6 |
| 100 | 4.0 | 4.6 |
| 125 | 4.5 | 5.5 |
| 150 | 5.5 | 5.5 |

Vertical rising pipework shall be supported at the base to withstand the total weight of the riser. Branches from riser shall not be used as a means of support for the riser.

Brackets screwed to walls shall be secured by expanding plugs or other purpose designed fixing devices to suit the material of the wall (e.g. brick, concrete, hollow block etc., Wooden or plastic plugs will not be permitted.

Pipework of 65mm size and above subject to expansion and contraction and hung from supports shall be suspended on swivel hangers unless otherwise agreed with the Engineer.

For horizontal pipelines, hangers shall be of split ring adjustable type hung on mild steel rods. Caliper hooks may not be used. Where pipelines run along walls, columns or ceilings, brackets may be used.

A support shall be installed not more than 600mm from each change of direction.

Special care shall be taken when making piping connections to equipment (e.g. pump set) to ensure that the connections are properly aligned and that no stresses and strains are imposed on the equipment.

2.5.8 PIPEWORK - GENERAL

The whole of the installation, including all valves and fittings, should be satisfactory to the local fire authority. Before any work starts, plans showing details of the arrangements proposed shall be submitted to the fire authority and its approval obtained.

The design and installation of the hose-reel system shall be closely correlated with all other services being provided in the building.

All fittings shall, as far as practicable, be the same size as the pipes connected to them. Bushed outlets will only be accepted if the required outlet size of a fitting is not standard manufacture.

All changes in the direction of a run piping shall be made with standard bends, springs or long turn fittings. Elbows may be used with the concurrence of the Engineer where space restrictions do not permit the use of easy bends.

Pipes shall be removed after cutting and shall be thoroughly cleaned before erection. Open ends left during the progress of work shall be temporarily closed with purpose-made metal or plastic plugs of caps, or blank metal flanges.

No pipe shall be installed so as to cause unusual noise from the flow therein under normal operation.

Joints shall not be made in thickness of any wall, floor or ceiling or in any inaccessible space, and pipework shall not be embedded in the structure of floor unless otherwise instructed by the Engineer.

Where pipework passes through walls, floors or ceilings, sleeves shall be provided. Pipework passing through floors shall be provided with 3mm mild steel floor and ceiling plates fastened securely to the sleeve. Sleeves shall be formed from pipes of suitable larger diameter and the space between pipework and sleeves shall be plugged with an approved sealant, which will not cause hindrance to pipe expansion and contraction and will not run.

All piping shall generally be run parallel to the axes of the building, concealed in the false ceilings and ducting where possible, arranged to conform to the architectural and

structural requirements and to suit the necessities of clearance for the work of other trades. The clearance between pipework and the wall and any other fixtures shall be not less than 25mm.

The pipework shall be graded to ensure venting and draining.

Reinforced moulded bellows expansion joints with integral flanges shall be incorporated into the suction line between the pump set and the sump to prevent the transmission of vibration to the sump connection. The joints shall adequately restrained and supported in accordance with the manufacturer's recommendations.

2.5.9 AIR VENTS

Automatic air vents shall be used at the top of riser.

They shall have gunmetal or brass bodies, non-ferrous or stainless steel floats and guides and non-corrodible valves and seats. An air outlet, tapped to accept a drain line should be provided.

A manual test cock shall be fitted to the automatic air vent so that it is possible to check the vent is not air bound due to the orifice being clogged and to enable manual venting if the automatic vents fail.

The automatic vent shall be isolated from the system with a gate valve to permit cleaning and repair if necessary.

Air release pipes shall be run to discharge at the nearest visible point to be agreed with the Engineer and where maintenance personal can regularly check for leakage.

2.6 PORTABLE FIRE EXTINGUISHERS

2.6.1 GENERAL

Portable fire extinguishers shall be of the re-chargeable, metal-bodied type containing and extinguishing agent expelled by the action of internal pressure. They shall be manufactured to BS EN 3 or equivalent and approved by the Fire Service Department of Maldives.

The extinguishers shall be Colour Coded to BS for easy identification and shall be fitted with a visual "discharged" indicator to prevent accidental use of an empty cylinder.

The extinguisher shall be operated by piercing, opening and/or breaking a sealing device and thus releasing the contents. The method of operation shall be readily apparent. It shall not be necessary for any movement of the actuating mechanism or mechanisms to be repeated in order to initiate discharge of the extinguisher.

All portable Fire Extinguishers shall comply with BS Codes and extinguish shall be released by means of a lever-operated valve provided with a safety pin. The extinguisher

shall be capable of controlled partial discharge. All extinguishers marked with clear instructions for use in the English language.

The quantity, types, sizes and locations of the extinguishers to be provided shall be in accordance with the Drawings and Part II of the Specifications.

The following portable fire extinguishers shall be installed in each floor as shown in the drawings.

- * 3 kg CO₂ fire extinguisher fully charged with metal bracket fixed on to the wall or keep at the fire hose reel cabinet.
- * 9 litre water CO₂ fire extinguisher fully charged with metal bracket fixed on to the wall or keep at the fire hose reel cabinet.
- * 6 kg ABC dry powder fire extinguishers fully charged with metal bracket fixed on to the wall at MSB Room at Ground Floor.

Types of Extinguishers

All extinguishers shall be provided according to the type and capacities as indicated in the drawings. Classifications of five classes are according to BS4547.

Water Types

These shall be general purpose extinguishers of either gas pressure type, water/CO₂ cartridge type, soda acid type or air-charge stored pressure type as specified, being suitable for Class 'A' fires. Each extinguisher shall be supplied complete with plunger, hose and nozzle and mounting brackets. Extinguishers shall comply with BS 1382, BS 138 and BS 3709 as applicable. Water type extinguishers shall be painted in red.

Compressed Gas Types

These shall generally be CO₂ type intended primarily for Class 'B', Class 'C' and Class 'E' fires, being provided complete with alloy cylinder, valve assembly, hose and discharge horn. Extinguishers shall be painted RED, and comply generally with BS 3326 or equivalent.

Foam Types

These extinguishers are intended for use on Class 'A' and Class 'B' fires, and can be either of AFFF type or CO₂ cartridge type. They shall comply generally with BS 740 or equivalent. These shall be installed complete with hose, nozzle and mounting brackets and painted RED in colour.

Dry Chemical Types

These shall be ordinary dry chemical extinguishers (sodium bicarbonate base, potassium bicarbonate base, potassium chloride base or potassium bicarbonate urea base) suitable for use on Class 'B' and Class 'C' fires or multipurpose dry chemical extinguishers (ammonium phosphate base) suitable for Class 'A', Class 'B' and Class 'C' fires. They may be either cartridge/cylinder operated type or stored-pressure type, and generally to BS 3465 or equivalent. Where specified, they shall be provided with special long-range nozzles. Dry chemical type extinguishers shall be painted RED.

Dry Powder Types

These extinguishers and agents shall be intended for use on Class 'D' fires and specific metals, following special techniques and manufacturer's recommendations. They may be hand portable, cartridge- operated or wheeled models as applicable. The extinguishing agent shall generally be composed of sodium chloride base agent.

The body colour for such extinguishers shall be RED.

2.6.2 MOUNTING

All internal extinguishers shall be wall mounted and attached in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5m above the floor and in no case shall the clearance between the bottom of the extinguishers and the floor is less than 1m. The extinguishers shall be positioned so that the instructions for operation face outward.

2.7 FINISHES

Valves, hose reels and similar manufactured item of plant and equipment shall be completely fitted and finished in the manufacturer's works. Any deterioration or damage to manufacturer's finishes during storage and installation shall be made good by the Contractor at his own expense, to the satisfaction of the Engineer.

The surface of all ferrous metal work including pipework brackets, hangers, steelwork etc. Which are not protected by galvanizing, works applied primer or protective paint shall be cleaned to remove all grease and rust and then given one liberal coat of anti-corrosive red lead primer and finished with two coats of approved quality signal red enamel.

Those parts of the installation required to be left unpainted (e.g. brass work) shall be so left.

Direction of flow shall be adequately indicated on all pipework.

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specification - Medical Gas

23553-01-TN-GS-SP-9800

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|---------|--------|--------------------|---------------|
| 1.0 | URO | Initial Issue | 20.09.2023 |
| 2.0 | URO | Second Issue | 27.11.2023 |
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GENERAL TECHNICAL SPECIFICATION

1.0 General

The Proposed patient ward at Kulhudhuffushi Island in Maldives consists of 01 Nos. Dialysis room, 01 Nos. Emergency treatment room, 02 Nos. Special need rooms, 04 Nos. Critical patient rooms, 08 Nos. Moderate patient rooms with 02 Nos Nurse stations. This contract is for the supply and installation the Piped Medical Gas system for this building connect with existing Cylinder manifolds & Medical Vacuum at the above premises. The work on the medical gas supply system shall be carried out by a firm specialized in this type of work in Maldives.

The suppliers of the equipment shall be those engaged in manufacturing of such devices and equipment of type and size required whose products have been in satisfactory use in similar service for not less than 5 years.

1.1 Applicable Standards

The products and work shall comply with the Health Technical Memorandum 2022 and British Standards for Medical Gas System.

1.2 Guarantees

- (a) All equipment, materials and workmanship shall be guaranteed for a period of one year, beginning with the date of acceptance of the works in writing.
- (b) The contractor's warranty shall include at ***least 4 preventive maintenance*** inspections of the system to repair and replace any items found to be defective during this one year period.

1.3 Required Submittals along with the Offer

- (a) Data on products offered for the installation.
- (b) Lists of recommended spares & consumable for one year period.
- (c) Details of terminal units offered for each separate installation.

1.4 Responsibilities of Bidders

- (a) Bidders shall examine all drawings and specifications issued and shall visit the site of the work. Bidders must be familiar with the codes, rules and regulations (and the local interpretation) in effect at the site of work.
- (b) Where any of the above are at variance with the drawings and specifications, the code requirements shall take precedence and any cost necessary to meet these shall be included in the Bid Price.
- (c) The contractor is assumed to be skilled in the trade and is solely responsible for compliance with health and safety regulations, performing

the work in a safe and competent manner, and installation procedures required for the work as outlined in these documents.

1.5 **Engineer's Drawings**

- (a) The Engineer's Drawings, plans are intended to be diagrammatic. They are not intended to show every item in its exact location, the exact dimensions or all the details of the equipment proposed to ensure that the equipment would fit in the available space.
- (b) Installations shall be within the limitations imposed by the architectural, structural, electrical and plumbing requirements with adequate space for maintenance.

2.0 **PRODUCTS**

2.1 **General**

- (a) All products shall be first-line quality of grade and type shown on the drawings and specifications or equivalents accepted by the Engineer in writing.
- (b) All products shall be in current production with no notice having been given that this product is to be drastically changed, modified or discontinued from production.
- (c) The Contractor, by submitting, certifies that equipment being proposed is proper for the application intended and that it has the capacity called for.

2.2 **Complete System**

All products, materials and accessories shall be furnished and installed as required for a complete system ready for Employers beneficial use.

3.0 **EXECUTION**

3.1 **Workmanship**

- (a) All work shall be performed by competent mechanics using proper tools and equipment to produce first-quality work. All work shall be neatly installed, accessible for maintenance and complete with all accessories required.

PARTICULAR SPECIFICATION

1.0 SCOPE OF WORK

1.1 General

The Proposed patient ward at Kulhudhuffushi Island in Maldives consists of 01 Nos. Dialysis room, 01 Nos. Emergency treatment room, 02 Nos. Special need rooms, 04 Nos. Critical patient rooms, 08 Nos. Moderate patient rooms with 02 Nos Nurse stations. This contract is for the supply and installation the Piped Medical Gas system for this building connect with existing Cylinder manifolds & Medical Vacuum Plant at the above premises. The work on the medical gas supply system shall be carried out by a firm specialized in this type of work in Maldives.

1.2 Location of Site

The Proposed patient ward at Kulhudhuffushi Island in Maldives.

1.3 Scope of Contract

Supply and installation of the following equipment shall be in accordance with the requirement of HTM 2022 & C11.

- I. Distribution piping, Zone wall units with indicators & Alarm, Area valve & service units with alarm, lockable line valve etc.
- II. Terminal units and piping for vacuum system. The system shall be connected to the vacuum plant.
- III. Terminal Units as shown in the drawing fix at bed head panel.
- IV. Supply of Medical gas Accessories specified in the BOQ

1.4 Tests on Completion

All equipment shall be carefully inspected and tested at the site after erection to show that they operate satisfactorily and meet the requirements of HTM 2022. These tests shall be carried out in the presence of the Engineer and shall be to his satisfaction.

2.0 TECHNICAL SPECIFICATION

2.1 Terminal Units

a) General

The medical gas terminal unit shall be designed, manufactured and tested to comply with the requirements of BS 5682 and HTM 2022. Each terminal unit shall be gas specific and shall only accept the correct medical gas probe.

Gas specific components within a terminal unit shall be pin indexed to ensure that a correct gas specific assembly is achieved and each gas specific component shall be identified to the requirements of BS 5682.

Wall Mounted Terminal Units

Wall mounted Terminal units at the locations shown in the drawings for the respective gases shall be supplied and installed as shown in the drawing. The mounting height of the terminal unit is 1.5 m.

| | |
|--------------------|---------------------------------------|
| 01 No. Oxygen | 4 bar |
| 01 No. Medical Air | 4 bar |
| 01 No. Vacuum | 400 mm Hg below atmospheric pressure. |

2.2 Vacuum System

The medical vacuum system shall be designed to maintain a vacuum of not less than 400 mm Hg below a standards atmospheric pressure of 760mm Hg (ie. An absolute pressure of approximately 360 mm Hg) in the pipe line at remote terminal unit.

Bacterial filters shall be provided in parallel between the drainage traps and the reservoir. The arrangement and capacity of the filters shall be such that one filter may be serviced without interrupting or restricting the vacuum service as a whole. The filters shall have a penetration not exceeding 0.05% when tested by the sodium flame test in accordance with BS 3928. Proper arrangement shall be made for safety when changing the filters.

A drainage trap shall be installed between the filters and the pipeline. The bowl of the trap should be sterilizable. The trap bowl should be transparent or be fitted with a transparent window. The trap and filter may be combined.

The exhaust gases shall be discharged outdoors, above roof level away from windows and other air intakes. The filters shall prevent the risk of contamination arising from the discharge from the pump. A "hazard" warning should be displayed in a prominent manner near the discharge point.

The vacuum system shall be operated by minimum two identical air cooled, oil lubricated rotary sliding vane pumps complete with contracts, valves, bacterial filters, safety devices, silencers etc., mounted on a horizontal receiver vessel in

a package configuration and each vacuum pump shall be driven by a 3/50/400V TEFC electric motor with Class F insulation as a minimum. The system shall have a capacity of 2200 l/min of free air.

Vacuum pump inlet filters shall be fitted to prevent foreign bodies from entering the pump and the exhaust shall incorporate oil separators to minimum oil loss.

Pipe work shall incorporate non-return valves to protect both the vacuum system and receiver vessel from pressurization due to inadvertent pump reversal.

The receiver vessel shall be constructed and tested to BS 5169, Class 111 and incorporate an inspection access panel and manual drain. Isolating valves shall be provided so that the system may be used while work on the reservoir is in progress. The capacity of the reservoir shall be determined in accordance with the recommendations of HTM 2022 and shall be such as to ensure that the number of stop/start cycles does not exceed 30 per hour.

The control panel and electrical installation shall conform to current IEE Regulations and Standard alarm facilities as recommended. The standby pump shall operate automatically during periods of peak demand or in the event of a duty pump failure. The pumps shall be provided with a timer controlled automatic change-over system to ensure both pumps are kept in regular use. The range of the timer shall be adjustable between 0-30 minutes. A running hour recorder shall be provided for each pump.

The vacuum pump package shall be designed to enable isolation of any one component for maintenance purposes without interrupting the system operation. Motors above 5 K The vacuum pumps shall be mounted on anti-vibration mounts properly selected by the equipment supplier to minimize transfer of noise and vibration to the structure of the building.

A vacuum gauge at least 100 mm diameter, complying with BS 1780 shall be fitted of the receiver or control gear. It shall be calibrated 0-760 mm Hg (or 0-1000 mb) and indicate 0 at atmospheric pressure. The gauge shall be marked with a signal blue band in the working range.

The system shall be supplied with one year's supply of oil and spare control system fuses.

2.3 **Fixed Pipe Lines**

a) Pipes

Pipes used for internal installations and any installations carried in protective pipes, shall be of copper to BS 2871 Part 1 Table X or equivalent to above standard. Pipe fittings and valves for Oxygen (O₂), Vacuum and Medical air (MA₄) should be degreased. Pipes of diameter up to and including 54 mm internal diameter shall be steam cleaned internally, dried, shot blasted and blown through with medical quality air and individually capped at both ends after passing a visual internal inspection. Pipes above 54 mm shall be similarly cleaned if this can be done economically or they may be solvent cleaned with an approved agent such as trichloroethylene or methyl chloride leaving no poisonous residues, then dried and individually capped at both ends after a visual inspection. Bundle pipes should be sealed with an adhesive tape marked

"medical gas pipes".

The selection of pipe diameter shall meet the requirement of the relevant BS standard. The pipes shall be designed for a pressure drop of 5% for Oxygen, Nitrous Oxide and medical air from the manifold to the remote terminal unit. The minimum outside diameter of the pipe used shall be not less than 12 mm.

b) Joints

Joints shall normally be made on site by silver copper phosphate brazing using British Standard 1845 type AG 14 alloy. Brass brazing should not be employed. Where screwed joints are permitted they may be made with unsintered. (degreased) P.T.F.E. tape.

All brazed joints shall be completed by flux less brazing technique in inert CO₂ or N₂ atmosphere.

2.4 **Fittings and Valves**

(a) General

Fittings and valves shall be supplied already cleaned and degreased and in sealed plastic bags identifying them as medical gas fittings. Fittings should be of the "high duty" type suitable for steam services gauge pressures upto 17 bars.

(b) Zone Wall Unit, Area Valve and Service Unit and Line Isolation Valve

Zone Wall Unit (ZWU), Area Valve & Services Units (AVSU) with Alarms and lockable line valve of acceptable quality and reputed make shall be installed as indicated in the drawings.

(c) Valves

Valves of the lever operated ball type shall be provided, with a clear indication of the 'ON' and 'OFF' position. Valves on the distribution system shall be of the non-lubricated type and constructed of non-ferrous materials. They shall preferably be designed for capillary joint connections to the pipelines by silver brazing. Where screwed connections are provided for pipe line connections they should have threads in accordance with BS 3648 or pipe threads to BS 21 but this does not exclude valves having integral union joints with other threads.

(d) Valve Accessibility

Valves shall be readily accessible in an emergency from the area served by the sections of pipe work and they should be mounted at a height of 1.22 m from floor level in positions, which are unlikely to be obstructed by other equipment or apparatus. They should be clearly marked to indicate

their functions in simple language describing the areas affected by the operation of each valve.

Each valve outside the system area shall be mounted in a standard box irrespective of their function. Any valve larger than those for 28 mm O.D. pipe which are not required to be operated in an emergency may be accommodated in readily accessible parts of the duct, or in ventilated cupboards, provided the valves are lockable in the open and closed positions. Every valve shall be fitted with an identity number plate for operations purposes.

(e) Valves Boxes

Each box should be lockable and each emergency valve box shall be fitted with a suitable breakable cover. The box shall be provided with vents at the top and bottom and be large enough to allow adequate access for maintenance and for the fitting of the identification label. The keys for the boxes shall be non-interchangeable. If this involves an impossible range of keys, then at least the non-interchangeability feature may be limited either to valve boxes within one building or to those in adjacent departments within the building. The cover must be non-interchangeable with other covers, if it is marked with the name of a gas.

2.5 Installation Procedure

The medical gas pipe risers shall be concealed in the riser ducts while the lateral runs and down drops to terminal units shall be exposed.

Pipelines shall be suitably protected where there is a possibility of physical damage eg. from the passage of trolleys. Clearance of 150 mm shall be maintained between the fixed pipelines and all other services. A minimum clearance of 6 mm shall be preserved where services cross.

Care shall be taken to prevent the pipes coming into contact with electric cables and wiring to minimise the risk of electric shock in the event of a fault on the adjacent cables.

No joints in pipe work other than the silver copper phosphate brazed capillary joint to a terminal unit tail pipe or a connection to a valve in a box should be buried within the thickness of walls, partition or floors. Where this is unavoidable the pipe shall be carried in a copper sleeve. Where pipe work has to be buried within a partition, terminal units and boxed valves with tail pipes extending into the ceiling void or duct shall be used.

Further protection to the pipelines shall be provided in the following circumstances.

- i. Where pipes pass through walls, partitions or floors they should be fitted with sleeves of copper pipes to BS 2871 and provided with appropriate wall or ceiling plates.

- ii. Where the pipes come into contact with timber treated with fire-resistant or flame-retardant compounds, contact shall be avoided by the use of impermeable, non-metallic materials such as PVC spacers or adhesive PVC tape. If spacers are used they shall not be liable to drop out due to subsequent movement of the pipe or timber or due to shrinkage. Such precautions are not required where untreated timber is used or where the timber is effectively sealed with paint or varnish before the pipes are fixed to it.

Valves for oxygen and nitrous oxide shall be carefully located and positioned so that any leakage from the valves cannot result in a build up of gas in an unventilated space eg. ceiling void, unventilated roof space. Valves shall not be inserted in the middle of main distribution runs but on the branches at points as close as possible to the main run. A main shut off valve shall however be inserted in a ready accessible position at the bottom of each rising main on the distribution system.

Valve boxes shall as far as practicable be located so that the covers are flush with the surface of the building structure.

The pipeline shall be adequately supported at sufficient intervals in accordance with the table given below to prevent sagging or distortion. Supports for surface mounted pipe work shall provide clearance to permit painting of the surface. Where it is essential for pipes to cross electric cables or conduits, they shall be supported on both sides of the crossing and prevented from touching the cables or conduit. Supports should be of suitable material or suitably treated to minimise corrosion and to prevent electrolytic action between pipes and supports.

| Metric sizes outside dia. mm | Maximum intervals for vertical runs (meters) | Maximum intervals for horizontal runs (meters) |
|------------------------------------|--|--|
| 12 | 1.2 | 1.0 |
| 15 | 1.8 | 1.2 |
| 22 | 2.4 | 1.8 |
| 28 | 2.4 | 1.8 |
| 35 | 3.0 | 2.4 |
| 42 | 3.0 | 2.4 |
| 54 | 3.0 | 2.7 |
| 76 | 3.6 | 3.0 |

A full way drain cock shall be provided at the bottom of each vertical run on the compressed air system. These shall be of the same high quality as the other valves on the distribution system and shall be sited carefully so that no damage could occur to them.

Pipelines should be identified in accordance with BS 1710 and colour banding of the pipelines. Colour band identification shall be provided near to valves, junctions, walls etc. Each gas pipe should be identified in 6 mm letters. Self-adhesive, adhesive plastic or clip-on labels of approved manufacture may be used for this purpose. A band 150 mm wide is usually adequate. All colour-coded tapes applied by the manufacturers should be removed before a pipeline is identified in accordance with this paragraph. Care should be taken to maintain pipeline identification during painting.

2.6 Electricity Supply to Medical Gas Installation

All electrical works required in connection with the medical gases system shall be carried out under this section of the works and shall be allowed for in the quoted rates. The wiring shall be in PVC insulated copper cable enclosed in rigid PVC conduit. The conduit shall be concealed in ceiling voids & ducts where available and in the building fabric where they shall be exposed. In other areas (operating theatre etc.) all surface wiring shall be carried out in surface PVC casing.

All electrical works shall be carried out in accordance with the I.E.E. Wiring Regulations.

All electrical drawings shall be approved by the Engineer.

2.7 Earthing

Pipe lines should be bonded to the consumer's earth terminal as required by Regulation D10 of the IEE Regulations. This bonding should be made as near as possible to the point at which the pipe line enters building from the system. The size of the bonding conductor should be in accordance with Table D.2M of the Regulations. The pipe lines should not themselves be used for earthing the electrical equipment.

Flexible connections in the fixed pipelines should not normally be used but if they are specially approved they should be similarly bonded.

2.8 Spares and Tools

The Contractor shall also supply a list of set of recommended spares required for the trouble free operation of the system for a period of 2 years from completion of the free maintenance period of one year.

3.0 TESTING AND COMMISSIONING

Before the installation is formally handed over, the following checks and tests shall be carried out.

1. Pressure test for leakage in pipe lines only

2. Check valve tightness and correct valve zoning
3. Test relief valve operations
4. Pressure test for leakage on complete installations
5. Check for satisfactory mechanical operation and non-interchangeability of each terminal by means of test probes
6. Check for cross connections
7. Check flow rates and pressure at each terminal unit
8. Check total flow rate and delivery pressure
9. Check satisfactory operation of manifold change over valves
10. Check performance of alarm signalling system
11. Purge the completed installation with medical air and check the internal cleanliness of the system
12. Purge the complete installation with the working gas.

The formal commissioning procedure should be completed in accordance with the Hospital Technical Memorandum No. 17 - Commissioning of Engineering Services.

Tests and checks shall be carried out in the presence of the Engineer at times to be agreed with the Engineer.

After completion of work the following checks shall also be carried out.

- i) Tests on the identity of gas supplied at each terminal unit
- ii) Test on the quality and purity of gas at each terminal unit.

Procedures (1), (2), (3) stated above shall be completed in sequence for one gas at a time. After completion of procedure (4) (separately for each gas) and (5) arrangements shall be made for tests (6) and (7) to be completed for the whole installation in one session. The remainder of the procedures shall then be completed in the order given for each gas.

3.1 **Pressure Tests for leakage in pipe lines**

The completed pipe lines with all ends sealed (but terminal units not fitted) and all valves on the distribution system open, but with control panels and theatre fittings disconnected shall be tested to twice the working pressure or 10.5 bar whichever is greater and shall be held for 24 hours and no leak should occur during this period.

3.2 **Valve Tightness Test**

On completion of the pressure on the pipeline all isolating valves shall be tested for 15 minutes at a gauge pressure of 6.9 bar for tightness by closing them in sequence and releasing the pressure on the downstream side. No leak shall occur during these valve tests.

3.3 **Relief Valve Test**

On completion of the isolating valve tightness test the pressure on the pressure gas system may be reduced for the purpose of testing the safety valves. The service safety valve shall be fitted and this shall be tested to ensure that it discharges safely at 125% of the working pressure.

3.4 **Tests for proving correct connections on the piped medical gas systems**

Each system (Oxygen, Nitrous Oxide, medical air (MA₄ & MA₇), Vacuum and AGSS) shall be tested in turn, preferably at the same session. The test shall not commence until all work on the installation is complete. Should any alteration to the system be made, the test shall be repeated.

3.5 **Medical quality compressed air shall be used for this test**

The system under test shall be connected at the normal working pressure. The other system shall be isolated at their source but all other isolating valves on all system shall be OPEN.

Checks shall be carried out to ensure that the test air is delivered from every terminal unit bearing the name of the "gas" and is not delivered from any other terminal unit.

3.6 **Total flow rate and delivery pressure test**

This test shall be carried out to simulate working conditions by providing an appropriate number of small metered leaks while further typical flow rate and pressure tests are taken at vulnerable and representative points in the installation. The total leak rate shall be approximately equal to the total design flow.

The test may be made with the bobbin type flow meters or plug-in type metering equipment as designed to pass the quantities specified. The calibrated jets shall conform to BS 720.

Jet metering devices shall be stamped to show,

- 1) Jet size
- 2) Air equivalent of "medical gas" for which it is calibrated
- 3) Rate of flow and pressure for which it is calibrated.

The test shall be carried out with medical quality compressed air at a gauge pressure of 4.1 bar and not with the oxygen or nitrous oxide as the case may be. Test jet units for medical gases shall be calibrated to pass 40 litres, 20 litres and 15 litres per minute at a gauge pressure 3.9 bar. Units for compressed air shall be calibrated to pass 250 litres per minute and 50 litres per minute at a gauge pressure of 6.9 bar.

3.7 **Tests for manifold change over valve**

The action of the manifold change over valve shall be tested by connecting a small cylinder of the working gas or of medical quality compressed air on each side of the manifold and discharging to a carefully sited leak while the operation

of the pressure gauges and change over valve is checked. Each half of the manifold shall be tested on this manner. The test shall be carried out on every automatic manifold during the period when the flow rate tests are in progress.

3.8 Signaling System Test

This test shall be carried out simultaneously with the test of the manifold change over valves.

3.9 Purging Medical Gas Installation

Each system shall be purged with the working gas on completion of all other tests on the installations.

3.10 Quality and Purity Check

When the medical compressed air supply is first commissioned the air quality and freedom of contamination shall be proved to the Engineer. The concentration of carbon monoxide and carbon dioxide shall be within the limits.

The purity of gas shall be tested for contaminants at terminal unit or terminal units, the location of which will ensure the gas sample has traversed, the maximum length of pipe work being tested and/or when necessary, comparing the sample with the quality and the purity of the gas supply at the source. The identity of the gas shall be checked at every terminal unit. Purity standards applicable to medical gases include:

1. The British Pharmacopoeia or the European Pharmacopoeia
2. British Standard 4275 Recommendation for the Selection, Use and Maintenance of Respiration Equipment

4.0 MAINTENANCE MANUALS

The Contractor shall be required to provide complete as-fitted drawings, circuit diagrams valve charts and maintenance instructions.

Complete maintenance manuals shall be supplied and handed over at the time of satisfactory testing and taking over of the installation.

EMERGENCY CONSTRUCTION OF PATIENT WARDS AT KULHUDHUFFUSHI ISLAND IN MALDIVES

Specification – Water Supply Systems

23553-01-TN-WS-SP-9800

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TECHNICAL SPECIFICATIONS OF WATER SUPPLY, SEWERAGE AND WASTE WATER DISPOSAL SYSTEM

1. General

General Conditions and Special Conditions of Contract as described herein before apply to work under this Section.

2. Drawings

2.1 The Drawings accompanying these specifications are design drawings and generally are diagrammatic. They do not show every offset, bend elbow or junction box, which may be required for installation in the space provided. The contractor shall follow the drawings as closely as is practical to do so and shall install additional bends, offsets and junction boxes where required by local conditions from measurements taken at the building, subject to approval and without additional cost to the Owner. The Architect reserves the right to make any reasonable changes in outlet location prior to roughing in. It shall be the Contractor's responsibility to provide complete systems as indicated and as required by applicable codes. All connections and appurtenances shown in the various diagrams shall be included in the finished job. The Contractor shall visit the site prior to bidding to familiarize himself with all conditions.

2.2 It shall be the responsibility of each trade to co-ordinate with all others for proper and adequate installation clearances.

3. Ordinances, Codes and Regulations

All clarifications and modifications which have been cleared with appropriate authorities are listed under the applicable sections. Unless otherwise approved, products shall bear the mark of approval of Sri Lanka / British Standards Institutions as required by governing bodies, codes and ordinances.

4. Equipment, Material and Workmanship

4.1 Determine that each piece of equipment meets the detailed requirements of the Contract Documents and that it is suitable for the installation shown. Notify the Consultant of any shortcomings found during the tender period.

4.2 Where two or more units of the same class of equipment are furnished, used product of the same manufacturer. Furnish all materials and equipment, new and free from defects and size, makes, type and quality herein specified and approved by the Consultant. All equipments shall be installed in a neat and workmanlike manner.

5. Shop Drawings

5.1 The Contract Drawings shall serve as working drawings for the general layout of piping,

conduit, ductwork, and various items of equipment. 5 sets of detail shop drawings shall also be provided, wherever required for proper co-ordination. All changes to the above drawings should also be submitted in 5 sets.

- 5.2 Manufactures detailed shop drawings shall be submitted for approval. Specifications and data sheets for all equipment shall be furnished. It shall be the Contractor's responsibility to see that all deviations from drawings and from specifications shall be specifically noted on these drawings and called to the Consultants attention otherwise approval shall be automatically voided.
- 5.3 Equipment shop drawing submittals shall be in quintuplicate and shall consist of a single sheet, or sheets if required for each piece of equipment, and shall give the specific data needed for consideration of approval. All pertinent data listed in the Specifications and in schedules shall be furnished, including all special features. In addition, the items shall be identified with the building and Specification Section they appear in by number.
- 5.4 In order to avoid delays in submitted shop drawings, stragglers may be submitted at a later date for inserting in the previously submitted indexed loose – leaf folder. All shop drawings to be submitted shall be indexed, and the original submittal shall note which shop drawings are to be indexed at a later date. Marked up catalogues are not acceptable and will be returned. It shall be the Contractor's responsibility to see that all submittals are in proper order, and that all equipment will fit in the space provided.
- 5.5 All shop drawings shall be submitted 30 days before execution of work covered by the said shop drawing.

6. Instruction Manuals

Three copies each of Manufacturers Instruction and Maintenance Manuals, which shall describe in detail the operation and servicing of the respective items of equipment shall be furnished. Furnish also 3 copies of spare parts list of items of equipment requiring servicing.

The above documents shall be furnished within 3 months of awarding of the contract.

7. As Built and Operation Manuals

Within 60 days of practical completion of work, the following shall be provided.

- (1) 5 copies of as Built Drawings which shall be an accurate description of the Works as installed.
- (2) 3 copies of Operation Manuals
- (3) 3 copies of Data Sheets listing out set points of control system.

8. Adjustments and Instructions.

- 8.1 Make necessary adjustments for each system and piece of apparatus installed using factory - trained and employed personnel for such systems as Clock Programmed and

Fire Alarm, Temperature Controls, and whenever practicable for other equipment, and instruct the operator and his staff in the operation of all Systems, during the currency of the project and commissioning period.

9. Excavation and Backfilling

9.1 General

Perform all necessary excavation and backfill required for the installation of Electrical and Mechanical work. Any conduit piping or other work damaged during excavation and backfilling shall be repaired at no expense to the Owner.

9.2 Water

Keep all excavations free of standing water. Excavations damaged or softened by water shall be re-excavated and filled back to original level with approved selected natural fill materials (placed and compacted as specified herein below under Item 9.vi) at no expense to the Owner. Provisions for storing, pumping, bailing out, draining out, dredging and disposal of subsoil water or rain water shall be made at no expense to the Owner.

9.3 Tests

During the progress of the work for compacted fill, the Owner reserves the right to provide compaction tests made under the direction of an independent testing agency.

9.4 Excavation

Excavate trenches to the necessary depth and width, removing rock roots and stumps. Cost of additional excavation, offsets, etc., shall be borne by the Contractor. Excavation material is unclassified. Width of trench shall be adequate for proper installation of piping or conduit.

The trench shall be widened if Consultant does not consider it wide enough for proper installation.

9.5 Bedding

Concrete bedding for drains shall, unless otherwise specified, be of Portland Cement Concrete having a mix proportioned in parts by Volume of 1:3:6, 150 mm thick, and of width indicated, benched half way both sides to the crown of the pipes.

9.6 Backfill

All backfill for trenches and other excavations shall be of on site stockpiled selected natural fill materials (unless otherwise specified), placed and compacted to the Consultant's approval. Backfill shall be compacted to 95 percent (90 percent permitted at sub grades below areas to be landscaped) of maximum density at optimum moisture content as determined by BS 1377.

9.7 Grading

Following backfilling, grade all trenches to the level of surrounding soil. All excess soil shall be disposed of at the site, stocked as directed.

10 Measurements, Lines and Levels

10.1 Check dimensions at the building site and establish lines and levels for the work specified in the Section.

10.2 All inverts, slopes and manhole elevations shall be established by instruments, working from an established datum point. Elevation, markers and lines shall be provided for the Consultant's use to determine that slopes elevations are in accordance with Drawings and Specifications.

10.3 Established grid and area lines shall be used for location of trenches in relation to building and boundaries.

11. Cutting Patching and Repairing

11.1 Cutting, patching and repairing required for the proper installation and completion of the work specified in each division, including plastering, masonry work, concrete work, carpentry work, and painting shall be performed by skilled craftsmen in these respective trades, all as specified in the appropriate divisions of the specifications. Holes, which are cut oversize, shall be fully filled so that it forms a tight fit on the pipe or other object passing through.

12. Foundations and Supports

12.1 Provide supports for all apparatus as specifically detailed and as required by the manufacturers of specific equipment.

12.2 All supports and bases of floor mounted equipment and airway casings shall be set on 50 mm minimum depth Portland Cement Concrete Pads. Concrete bases under Air Handling Units shall be higher to provide a minimum trap seal.

13. Machinery Guards

13.1 Provide 10 mm mesh guards of woven wire, with shaft holes for easy use of tachometers, for all moving machinery such as pulleys, belts and shafts. Guards shall be adequately framed to provide a sturdy installation. Maintain adequate clearance from moving parts.

14. Equipment Protection

14.1 Keep all pipe and conduit openings closed by means of plugs or caps to prevent the entrance of foreign matter. Protect all piping, conduit, ductwork, fixtures, equipment or apparatus. Any such item damaged prior to Final Completion of the Work shall be restored to its original condition or replaced at no expense to the Owner.

- 14.2** Protect all bright finished shafts; bearing housing, and similar items, until in service, no rust will be permitted.
- 14.3** Equipment and materials stored on the job site shall be covered or otherwise suitably protected at the direction of and to the satisfaction of the Consultant.
- 14.4** Electrical switchgear, panel boards, transformers, motor control centers etc., shall be completely covered against moisture, dust and foreign material. If covering become torn, they shall be replaced until the equipment is connected and operating.

15 Accessibility

The installation of valves, thermometers, clean cut fittings and other indication equipment or specialties requiring frequent reading, adjustments, inspection, repairs, removal or replacement, shall be conveniently and accessibly located with reference to the finished building. Thermometers and gauges shall be installed so as to be easily read from the floor.

16. Access Panels

Furnish access panels, where indicated and where required to provide access to valves, junction boxes and other appurtenances, panels shall be the type as required for the wall or ceiling construction. Doors shall be 450 x 450 mm size unless otherwise indicated.

17. Inserts and Sleeves

17.1 General

Layout work in advance of placing of concrete slabs or construction of walls. Furnish and set inserts and sleeves necessary to complete the works. Cost of cutting or patching made necessary as a result of this operation shall be at no expense to the Owner.

17.2. Pipe Sleeves

17.2.1 Wall Sleeves

Interior wall sleeves shall be 22 gauge galvanized steel, flush with wall on both sides. Sleeves shall be large enough in diameter to provide caulking from both sides using fire resistance materials.

17.2.2 Floor Sleeves

Interior floor sleeves for general areas shall be 22 gauge galvanized steel extending 25 mm above finished floor. All pipes passing through sleeves shall be caulked with approved rope and mortar and water tight. Insulated pipes shall have insulation butted to floor sleeve and sealed with insulated cement on both sides.

17.3 SLEEVES

17.3.1. Wall / Duct Sleeves

Wall, Duct sleeves shall be same as interior wall duct pipe sleeves, except minimum 10 gauges and properly blocked to prevent collapse during construction.

17.3.2. Shaft Wall Sleeves

Shaft wall sleeves shall be a section of the duct or fire damper, a minimum of 18 gauge for rectangular ducts, properly blocked to prevent collapse during construction.

Sleeve or fire damper shall be terminated at the wall and sealed with insulating cement on both sides. Minimum thickness of fire dampers shall conform to appropriate BS, or BS Codes of Practice.

17.4. Floor Sleeves

Floor sleeves shall be same as shaft wall sleeves.

17.5 Conduit Sleeves

17.5.1 Wall Sleeves

Exterior wall sleeves shall be galvanized steel, flush with wall on both sides. Sleeves shall be large enough to allow for chalking and should be made watertight.

17.5.2. Floor Sleeves

All pipes passing through sleeves shall be caulked with an approved rope and mortar.

Blocked out holes in the structure for electrical and telephone conduits and fuse duct shall be filled by means of 18-gauge metal plate on top and bottom and cavity filled with approved fibres with mastic binder between.

18. Cleaning

18.1 Electrical, mechanical and plumbing equipment fixtures, piping and duct work, shall be free of stamping and markings (except those required by codes, such as in lighting fixtures), iron cuttings and other foreign material.

18.2 Water steam and condensate systems shall be finished and flushed clean.

18.3 Hot, cold and drinking water system shall be cleaned thoroughly, filled with chlorinated water, and flushed with soft water.

18.4 Steam pipes and strainers shall be cleaned after 24 hours operation of the system, and thereafter until the system is thoroughly cleaned.

- 18.5** Air and gas system shall be blown through to clear dirt.
- 18.6** Electrical panels, switchboards, contractors and motor starters shall be vacuumed clean to be free of dust and debris, and bus-bars, coils and internal contacting surfaces blow free of dust.
- 18.7** Where transformers have been activated in excessively dusty areas the interiors shall be cleaned of construction dust.

19. Operator

- 19.1** The Contractor shall instruct thoroughly the Owner and his representative in the efficient operation of the entire system, in accordance with manufacturer's equipment manuals and instructions.
- 19.2** The entire mechanical and electrical apparatus shall operate at full capacity without objectionable noise or vibration.
- 19.3** Plant shall be operated for a period of one month before handing over.
- 19.4** Capacity of individual equipment as well as the entire system shall not be less than the specified values when tested and operated at field conditions.
- 20.3** Starters shall be furnished as suitable for performing the control functions required,(with the exception of system where the starters are furnished as part of the control package).
- 20.4** All interconnecting wiring within or on a piece of mechanical equipment shall be provided with the equipment unless shown otherwise.
- 20.5** The low voltage distribution shall be 400 volts, 3 Phase, 50 Cycles.

20. Piping Installation

- 20.1** Install unions in all non-flanged pipe connections to apparatus and adjacent to all screwed control valves, traps and appurtenances requiring removal for servicing so located that piping may be disconnected without disturbing the general system.
- 20.2** Provide dielectric couplings, unions or flanges between galvanized steel, Aluminum and copper pipe or tubing.
- 20.3** Install all piping so as to vent and drain.
- 20.4** Run all piping parallel to the building structure and support it sufficiently to prevent sagging.
- 20.5** Support all piping independently at apparatus so that its weight shall not be carried by this equipment.

- 20.6** All piping connected to coils, and apparatus requiring tube cleaning or removal as heat exchanges, shall be run clear of such area, except for removable connections.
- 20.7** Provide anchors, pipe rests or supports where necessary to support risers and maintain slopes in position and to prevent movement of piping and damage to the building.
- 20.8** Piping shall not be located over electrical equipment without adequate insulating protection against condensation dripping.
- 20.9** Piping connected to vibrating equipment shall be resiliently supported throughout the building.

21. Piping Joints

- 1.** Bell and Spigot Joints Shall be carried out with molten lead. The spigot of the pipe must be forced well home into socket and must be entered, so that the joint may be of even thickness all round. At least one complete lap of clean white hemp spun yarn shall be drawn into the bottom of the socket without being forced through the joint into the pipe, as many laps of tarred yarn as may be needed to leave the space of not less than 25 mm required for the lead shall then be forced into the joint and caulked tight. The joints shall then be run with molten lead in sufficient quantity so that after being caulked solid the lead may project 3 mm beyond the face of the socket against the outside of the spigot but must be flush with outside of the socket.

2. Screwed Joints

Pipe ends shall be reamed, dope or tape applied to male threads only, and be made up with not more than two threads showing beyond the fitting's end. Junctions of galvanized pipe to cast iron shall be made with tapped spigots or hand couplings screwed to the end of the galvanized pipe, with dope applied to the pipe thread (with the exception of brass joints, which shall be made with Teflon tape or equal).

3. Flanged Joints

- a. Flanges shall be cast iron or steel for screwed piping and steel welding neck or slip-on types for welded line necks and sizes. Pressure rating shall match the apparatus, valve or fitting to which they are attached.
- b. Gaskets shall be 2 mm thick, ring type, coated with graphite and oil to facilitate making a tight joint.
- c. Bolts and nuts shall be of adequate strength for the service intended and shall be dimensional compatible with the flanges as per relevant BS.Code.

7. P.V.C. Pipes

All P.V.C. Pipe joints should conform to B.S. 4514 / SLS 147: and SLS 659: Part 1 or any other specifications acceptable to the Consultants.

22. Hangers and Supports

- 22.1** Provide hangers to all pipes to clear insulation and guides where required, as well as to support piping. For attachment in concrete use swivel inserts of Uni struct manufacture continuous concrete type inserts, or equal.
- 22.2** Provide hangers within 1m of all changes in direction of mains and a minimum of three hangers per expansion bend. Provide all additional structural steel angles, channels or other members not specifically shown which are required for proper support.
- 22.3** Space hangers as noted below except on soil pipe, which shall have a hanger at each joint with a maximum of one per fitting. In areas of multiple fittings, sufficient hangers shall be provided to maintain proper slope without sagging.

P.V.C. Pipes

| Size (mm) | | | Vertical run (m) | Horizontal Run(m) |
|-----------|---|-----|------------------|-------------------|
| 32 | - | 40 | 1.2 | 0.5 |
| 50 | - | 63 | 1.2 | 0.6 |
| 75 | - | 110 | 1.8 | 0.9 |
| 160 above | | | 1.8 | 1.2 |

- 22.4** Provide floor stands, wall bracing, masonry piers etc., for all lines running near the floor or near walls and which can properly be supported or suspended by the walls or floors. Pipe lines near concrete or masonry walls may also be hung by hangers carried from wall brackets at a higher level than pipe. Hanging of any pipe from another is prohibited.
- 22.5** For all pipes above 100 mm the contractor shall ensure that all hangers and supports are designed to withstand any water hammer, which may occur during usage.

All hangers and supports shall be of hot dip galvanized finished with the minimum coating thickness of 85microne.

23. Pressure Gauges

Pressure gauges shall have not less than 100 mm dial face, steel body and gauge cock. Dial ranges shall be adequate for the pressure encountered.

24. Valves - General

24.1 General

Provide valves on branch pipe connection to mains and at connection to equipment where indicated. All valves shall be accessible and fully equal in size to piping. Support all valves where necessary. All valves should conform to the relevant B.S. Code.

24.2 Valves

1. All globe and check valves shall have working parts suitable for hot and cold water, oil and gas as required. Valves shall be tagged with permanent label under hand wheel indicating type of disc installed.
2. All valves in equipment rooms located over 2100 mm above floor shall be provided with chain wheels and chains extending to 1800 mm above floor.
3. All globe and gate valves shall have in excess of 25 percent Teflon impregnated packing.

24.3 Cocks

24.3.1 Gas

Leak proof brass cocks as required by the local gas Company Rules.

24.4 Foot Valves

Provide gunmetal foot valves with strainers of approved quality, where positive suction head is not available.

25 Pressure Service Valves

25.1 Fill Lines

On all systems, provide equilibrium type float valves with silencer tubes.

25.2 Strainers

Y-Pattern, with Monel mesh screen or perforated brass strainer. Screening area of strainer shall be a minimum of 500 percent greater than pipe area with 0.8mm inch maximum size holes. Strainers 3-inches and above shall have a flushing outlet with valve.

26 Air Elimination

Provide manual air vents, consisting of globe valve, where shown.

27. Piping Duct and Equipment Insulation

27.1 General

All tests shall be completed and all systems approved before the insulation is applied to equipment or piping. Apply all insulation in accordance with manufacturer's recommendation. Insulation shall be of approved manufactured type specifically intended for the service specified.

27.2 Piping

All piping insulation shall have the side and end joints butted tightly and the jacket applied smoothly with longitudinal and circumferential joint. All exposed ends shall be finished neatly with the jacket material and mastic. All jackets and adhesives shall be fire retardant. Vapour barrier of glass cloth covering shall be continuous over insulated fittings. Unions and expansion joints shall be built up 15 mm beyond adjoining insulation for identification. Use glass fibre insulation on flex connectors. All insulation with an integral vapour barrier shall have the joints and fittings covering sealed as recommended by the manufacturer.

All other piping insulation shall have the ends sealed with glass cloth at the fittings.

All piping insulation shall be the moulded type manufactured specifically for that purpose.

28 Tests

28.1 Test all pumping systems in the presence of the Consultant and Inspector from the local body where required. Provide ample advance notice of test dates. Provide all equipment material and labour necessary for inspections and tests and repair all work not passing tests. After repairs are made, repeat tests until entire systems are found satisfactory to the above authorities. Carry out all tests prior to concealing, insulating or backfilling over any piping. No exceptions will be made.

28.2 Test entire system of soil, waste and vent piping by water after the roughing in is completed and before the fixtures are set. After setting the fixtures, provide smoke test.

28.3 Water Tests

Test entire system or sections of system by closing all openings in piping except the highest opening and filling system with water to the point of overflow. If the system is tested in sections, plug each opening except the highest opening of the section filled with water. Keep the water in system or in portion under test for at least 45 minutes before inspection starts. The system must be tight at all joints. Maximum test pressure would be the 1.5 x System working Pressure.

28.4 Final Test

After fixtures are set, test system with smoke as follows: -

28.5 Smoke Test

Fill traps with water, and then introduce into system a pungent thick smoke produced by one or more smoke machines. When smoke appears at stacks on the roof, plug stacks and allow pressure of 25 mm water column to build up in system. Maintain pressure for 15 minutes before inspection starts. The system shall be tight at all joints.

28.6 Test all down - spouts or rain leaders and their branches within the building by water as described for the above soil, waste and vent system.

28.7 All Cold Water Piping

All cold-water piping shall be hydrostatically tested for a minimum of 24 hours without drop in pressure and test pressure shall not less than 1.5 times the working pressure.

28.8 All systems shall be tested in sections as required to expedite the work of other trades and meet construction schedules.

29 Equipment and Piping Identifications

29.1 General

Each piece of equipment shall bear a permanently attached identification plate listing the manufacturer's name, capacities, sizes and characteristics. In addition, a metal or Bakelite nameplate shall be secured to the unit housing or adjacent thereto giving the designations and system it services. A list of designations shall be furnished to the Consultant for approval prior to preparing the nameplate.

29.2 Pipe Markers

Each piping system shall be provided with colour bands corresponding to a colour code issued by the Consultant. Insulated pipes, which are not provided with sheet metal protection, shall be provided with G.I. band strips to which the colour band will be painted.

29.3 Valve Tags

Provide numbered brass disc attached by chain to each system main and branch valve for identification, including automatic valves etc., the tags shall be 6 mm dia. of standard manufacture, with numbers as indicated in line diagram provided by Consultant.

30. Air Balance and Operating Instructions

30.1 At the completion of the work, the adjustments of the system shall be done by a Professional Engineer who is approved by the Consultant.

30.2 The Mechanical Sub-Contractor shall furnish a helper and such ladders, scaffoldings and other equipment as necessary to make adjustment. Instruments shall be furnished by the Contractor and shall be calibrated and tested by an authority named by the Consultant. The mechanical sub-contractor shall make all adjustments as directed and then replace all covers, access panels, etc., removed during adjustment.

30.3 Include in tender the amount to cover the cost of balancing and adjusting the systems, setting up reset schedules, instructing the Maintenance Engineer in system operation and for preparing the operation and maintenance instructions.

31. Plumbing

31.1 Piping Materials

Provide piping materials as described for the following pipe system.

31.2 Soil and Waste, Storm Water

1. Underground piping and Main Horizontal Pipes Rigid PVC pipes and fittings conforming to SLS 147, SLS 659, BS 4514, BS 4660, BS 5255
Sewer and waste water main stacks from low noise polypropylene type to conform to comply with EN 1451-1 and DIN 19500.

31.3 Branch Wastes from Baths, Wash hand Basins and Sinks

1. Rigid PVC piping conforming SLS 147, SLS 659, BS 3943, BS 4514 and BS 5255 and fitting of rigid P.V.C. shall be moulded.

31.4. Above Ground

1. Rigid P.V.C. piping conforming to SLS 147, SLS 659, BS 4660, BS 5481, BS 4576.

31.5 Inspection Chambers and Manholes

1. 150 mm thick reinforced concrete walls and bed using 1:2:4 mix unless otherwise stated. A waterproof membrane shall be provided as specified in the drawing. Masonry shall be plastered internally and rendered waterproof using waterproofing plastering materials.

31.6 Drop Connections

1. Drop manholes to be constructed conforming to BS 8301: 1985.

31.7 Vent Piping

Above Ground and Underground

1. Rigid PVC pipes and fittings conforming to SLS 147, SLS 659, BS 4514, BS 4660, BS 5255.

31.8 Domestic Water Supply

Above Ground and Underground

1. Hot water pipes in Polybutylene pipes.
2. Water supply pumping main rigid UPVC pipes type 1000 to SLS and with mounded fittings.

31.9 Traps

31.9.1 General

Provide traps on all fixtures connected to the waste systems, except for fixtures having integral traps. All traps shall have a seal of not less than 40 mm and not more than 100 mm.

31.9.2 Exposed Traps

Exposed traps for fixtures shall be chromium plated cast brass as per BS.

31.9.3 Cast Iron Traps

Traps installed in connection with cast iron pipe shall be of the same quality complying with BS 437, and grade of the pipe, the size of the outlet shall correspond to the socket of the pipe receiving it.

32. Chlorination

32.1 General

Upon completion of all tests and after necessary replacements have been made, disinfect all domestic water piping.

32.2 Method

After thoroughly flushing the system with water to remove sediment, fill system with a solution containing 50 parts per millions of chlorines. After four hours' retention, the system shall be drained re-flushed and returned to service.

32.3 Drains

Provide floor and roof drains of the sizes and types as shown. Caulk inside joints. Provide clamping collars for drains where waterproof membranes occur and for location in supported slab. (Other than slabs - on ground).

33. Plumbing Fixtures

33.1 General

Provide plumbing fixtures of the type and quality indicated for location as shown on Architectural and Plumbing Drawings.

33.2 Fixtures

Complete with fittings, supports, fastening devices, faucets, valves, trap and appurtenances as required.

33.3 Vitreous Ware

As indicated in architectural drawings.

33.5 Porcelain Lined Ware

As indicated in Architectural drawings.

33.5 Fittings and Fixture

Heavy brass castings properly finished and chrome plated.

33.6 Escutcheons

Brass, chrome plated.

33.7 Warranty

All fixtures warranted not to erode, discolour, scale, or scratch.

33.8 Fixtures Set and Connected

To soil, waste, vent and water supplying in neat, finished and uniform manner.

33.9 Connections

Equal height, plumb and set at right angles to floor, wall or both unless otherwise indicated or directed.

34 Specification - Water Supply

34.1 Scope of Work

The work covered in this Section shall include, but not be limited to all materials, labour, equipment and services as stipulated in the drawings, specifications and schedule rates inclusive of the following:

- a) The Municipal connection to the main water supply line already exist at site , wash out lines from the sump to Main Waste Line as shown in Drawings.

- b) The wiring of all equipment up to the isolators and starters.
- c) The entire hot and cold water piping distribution system including supply and installation of hot and cold water pipes and fittings, pressure reducing valves and accessories, isolating valves tings within the building.

34.2 General

This Special Specification is to be read in conjunction with the General Specification.

34.3 Level Datum

Levels quoted on the contract drawings are based on a fixed Datum at site. It shall be the Contractor's responsibility before commencing the contract to obtain from the Consultant in writing the location and value of the permanent benchmark to be used. All temporary benchmarks shall be referred thereto.

34.4 Contractor to use Special Plant if required

The Contractor shall if the Consultants so require supply and use such special plants and tools in executing the work as the Consultants may direct.

34.5 Access and site Roads

The Contractor shall be deemed to have fully informed himself as to the suitability of the roads to the site and the roads within the site. He shall exercise due care in the use of such roads and shall make good any damage caused by their use. The Contractor shall provide such temporary site roads as are necessary.

34.6 Submissions of Samples

Before incorporating the finished work, any materials or articles which contractor has to supply under the terms of the contract, the contractor shall submit to the Consultant's Representative for his approval a sample shall be delivered to and kept at his office for reference. All the respective kinds of materials and articles used in the works shall be at least equal in quality to the approved samples. Each and every sample shall be a fair average of the bulk material, or of the articles, which it represents. The Consultant's representative may decide the method by which the sample to be taken from bulk shall be obtained.

Any or all of the materials and manufactured articles supplied by the Contractor for use on any of the work through this contract shall be subject in advance to such tests as may be deemed necessary by the Consultants. Samples of all such materials and manufactured articles together with all the necessary labour, materials, plant and apparatus for sampling and for carrying out of tests on the site of all such materials and manufactured articles shall be supplied by the Contractor at his own expense.

The cost of special tests ordered by the Consultants to be carried out by an independent

person at a place other than the site or place of manufacture or fabrication shall be borne by the Employer, provided the tests show that the materials, articles or workmanship are in accordance with the specification otherwise the costs of such special tests shall be borne by the Contractor.

34.7 Quality of Materials and Workmanship

The materials and workmanship shall be of approved quality.

34.8 Standards

Contractor shall follow British standard or EN standards.

34.8 Precautions against Contamination of the Works

The Contractor shall satisfy the Consultants that all his personnel working on the site are medically suitable to be in contact with a public water supply, and his personnel shall undergo any necessary medical test, at the Contractor's expense, to show that they are free from any infectious diseases and are not carriers of any such diseases.

The Contractor shall at all times take every possible precaution against contamination of the works and existing waterworks.

Throughout the contract, the site and all permanent and temporary works shall be in a clean, tidy and sanitary condition. The Consultants will give the Contractor due notice of his intention to carry out any inspections during the period of maintenance and the contractor shall upon receipt of such notice arrange for a responsible representative to be present at the times and dates named by the Consultants. This representative shall render all necessary assistance and take note of all matters and things to which his attention is directed by the Consultant.

35 Works Water Supply

The Contractor shall make suitable arrangements and bear all costs in connection with the provision and maintenance of works water supplies on site.

The water shall be of a chemical and purity standard such that it will not pollute, injure or cause any deterioration of the works.

36 Spoil Dumps

The Contractor shall not deposit excavated materials on public or private land except where directed by the Consultants in writing or with the consent in writing of the Local Authority of the owner or responsible representative of the owner of such land and only then in those places and under such conditions as the Local Authority, owner or responsible representative may prescribe.

37 Provision of Facilities for Consultants Inspection

The Contractor shall provide necessary tackle access and labour to enable the Consultant and/or the Consultants Representative conveniently to carry out such inspection, as they may deem necessary at all times during the currency of the contract.

38 Site

The tenderer before tendering is advised to visit the site by previous appointment with the Owner.

39 Nature of Tender

The Contractor shall carefully study the drawings and satisfy himself that the quantities are correct and fill in the prices in at the attached Bill of Quantities. It is to be distinctly understood that the total quantity tendered for is to complete the project. No variation or extras will be allowed. Any omission should be notified by the Tenderer when tendering stating the value of such omission. No alteration shall be made without the written permission of the Consultants.

40. Surplus Stock

In ordering materials for this contract the Contractor shall not be solely guided by the quantity in the bill. He should by proper measurements at the site satisfy himself as to the correct quantity of materials required for the work. No compensation shall be paid by the Owner on completion of the work for any surplus stock of any materials obtained for the purpose of this contract.

On completion of the contract the Architect may retain certain surplus stocks, which would be useful for the maintenance of the scheme and pay at the prices agreed upon at that time by the Consultants and the Contractor.

41 Pipe Trace

The Contractor shall set out the pipe trace and get it approved by the Consultants prior to commencing of work.

42 Pipe Measurement

In measuring the linear feet of pipe work, the length of specials along the axis of the pipe trace will not be deducted. The Contractors rate for specials should take this into account.

43 Literature on Materials

The Tenderer shall submit with his tender detailed literature and specifications from the manufacturers in respect of all equipment and materials included in his offer and give the name of manufacturer and the country of manufacturer of the materials and equipment.

44. PVC Pipes and Fittings

All pipes and fittings shall be in every respect suitable for storage, installation, use and operation in the conditions of temperature and humidity appertaining to Sri Lanka.

All pipes and fittings shall be suitable for a working pressure of 10bar unless otherwise specified.

Pipes, bends, couplers and similar fittings shall comply with British SLS 147, or BS 3505:1968. Specification for un-plasticised PVC pipe for cold water services, together with additional clauses set out in this specification of any other National Standard or Specification acceptable to the Consultants as providing equivalent or better quality of materials and workmanship than specified above together with the additional clauses set out in this specification.

Joints and fittings for use with - PVC pipe shall comply with SLS 659 "BS 4346 Part 12: 1970" together with additional clauses set out in this specification or any other National Standard or specification acceptable to the Consultants as providing equivalent or better quality of materials and workmanship than specified above together with the additional clauses set out in this specification.

45. Flanges

Dimensions of flanges shall be in accordance with B.S. 4504:1969. Flanges shall be suitable for a nominal pressure of 16kgf/cm² (NP 16).

47. Taps and Stop Cocks

Every tap when fully assembled shall be capable of resisting a pressure of at least 16 bar.

Every valve, spindle and other internal parts of the tap shall be made of a corrosion-resisting alloy.

Every tap shall have an efficient screw down valve.

The valve shall be made in one piece true all over and machined on the face on which the washer will be seated.

48. Excavation and Backfilling Trenches

The width of the trenches across the two vertical faces in original ground of the excavation for the various sizes of pipes shall be the minimum required for efficient working after allowance has been made for timbering and strutting and shall be approved by the Consultants.

Where pipes are not laid on concrete the bottom of the trenches as excavated shall be smooth and shall be free from stones and other projections.

Where rock is met with in the trenches the excavation shall be taken to a depth of 150 mm below the intended level of the bottom of the pipes and 150 mm selected filling

(approved by the Consultants) placed on the rock and consolidated to form a firm even bed for the pipe.

49. Trench Depth

Where the pipelines are to be laid on roadways there should be a clear cover of 1000 mm above the top of the pipe.

In the case of other pipe lines, a minimum of 300 mm clear cover over the top of the pipe should be allowed.

50. Backfill

The soil filled around and over the top of the pipes shall be free from stones, tree roots and other vegetable matter and filled with utmost care, so as to obtain the greatest possible compactness and solidity, the soil being screened if necessary to exclude material which would damage the pipe. The filling in the soil shall be compacted and where hand ramming is employed, in no case shall the number of men filling in be more than half the number of men ramming.

51. Pipe Laying

Pipe Jointing

Jointing of pipe to pipe or pipe to special fitting shall be carried out as recommended by the manufacture of the pipes. For pipes and fittings, jointing done with solvent joints shall be effectively protected from the direct rays of the sun immediately after they are laid until permission is given for the trenches to be refilled by the Consultant.

Cutting of PVC pipes - the cut shall be made in accordance with the manufacturer's recommendation and tools specified by the manufacturer. Laying of polypropylene pipes should be as per manufacturer's instructions.

52. Thrust and Anchor Blocks

Concrete thrust and anchor blocks shall be formed at bends, tees and valves in accordance with the typical sections shown on the drawings or otherwise as directed by the Consultants. The additional excavation shall be made after the bends etc., have been jointed and the concrete shall then be placed with all possible speed.

The concrete used for thrust and anchor blocks shall be 1:3:6. After placing the concrete, it shall be kept in view for not less than six hours. No pressure shall be applied in any section of main until the concrete has had at least three days curing.

At u - PVC fittings a polythene or equally suitable material membrane to the satisfaction of the Consultants shall be provided to separate the fitting from the concrete of the thrust or anchor block.

Anchors to prevent longitudinal slip shall be constructed where the slope of the pipe is greater than 1:3 or as otherwise directed by the Consultants.

53. Testing Water Mains

After each section of the pipeline has been laid, the ends shall be fitted with a blank clang; cap or plug and the section filled with water and free of air. The water in the pipe line shall then be put under pressure which shall be increased by means of a hand pump or other approved device to 50% above the highest working pressure in the section tested.

The leakage from the pipeline shall be ascertained from the net volume of water that has been pumped into the pipeline during the test periods. The leakage so ascertained shall not exceed the volume determined by the following formula.

For u - PVC pipelines –

| | | |
|------------------------------|---|--|
| Allowable leakage in gallons | = | P.D.L. Gallons per 100 ft in 24 hours. |
| Where D | = | Nominal diameter of pipe in inches. |
| L | = | Length of pipeline under test in miles |
| P | = | Test pressure |

54. Cleansing Water Retaining Structures

The inside of all water retaining structure and all interior pipe work shall be thoroughly cleaned and washed to remove contamination and the water from these operations removed by squeegees and drained away.

55. Sterilizing Water Retaining Structures and Pipe Lines

The inside of portable water retaining structures shall be filled to overflow with water containing 20 parts per millions of chlorine and left for at least 24 hours. They shall then be drained and filled with clean water from which samples for analysis shall be taken as per the instructions of the Consultants. If the result of the analysis is unsatisfactory the serializing process, refilling and sampling shall be repeated until the results of the tests are satisfactory.

After the pipe lines have been filled and flushed out of all debris and contamination matter, it shall be filled with chlorinated water containing not less than 10 parts per million free chlorines and left to stand 24 hours or such period as directed by the Consultants. The pipes shall be flushed and filled with treated water.

56. Specification for Centrifugal Electric Pumping Sets and Accessories

General Requirements:

This specification provides for the supply and installation of centrifugal electric pumping sets and accessories.

57. Literature on Equipment and Materials:

The tenderers shall supply detailed literature and specifications from the manufacturers in respect of all equipment and materials included in his offer and give the names of all such manufacturers and the Country of Manufacturer of the materials and equipment.

58. Calibration of Instrument and Meters

All instruments and meters shall be calibrated in the Metric Units as follows: -

- a. Pressures shall be indicated in metric water columns or Kg/cm²
- b. Flows shall be indicated in cubic meters/hour.
- c. Quantities shall be indicated in cubic meters.
- d. Water level shall be indicated in meters.

59. Installation of Plant and Equipment

The Contractor shall be responsible for installing all plant and equipment supplied by him in accordance with the specifications and drawings provided.

The supplying and fixing of all items such as brackets and supports, clamps and clips, plugs, bolts, screws etc., shall be carried out by the Contractor. Details shall be submitted for approval by the Consultants before fixing.

The Contractor shall also carry out all the mechanical and electrical installations adjustments and tests and provide his tools and testing equipment for this purpose.

This tender also provides for the supply and installation of pipes and fittings from the suction side of the pump up to the delivery side indicated in the drawing.

The pumps shall be of the centrifugal type with end/side suction and vertical/horizontal delivery. The shaft shall be of stainless steel and the impellers and guide rings of bronze. Each pump shall be provided with a 100 mm dia pressure gauge calibrated to read according to the head of the pump and a vacuum gauge calibrated to read from 0 to 30 ft. (0 to 10m) on the suction side. The speed of the pump shall not exceed 2900 rpm. The stuffing boxes of the casing shall be of ample depth for the reception of the packing and shall be provide with suitable glands with adjustable water seals and drip catches with tapped connection for lead away.

60. Characteristics of Pump and Motor

The tenderer shall include the actual characteristics with the corresponding tolerances particularly of the following: -

1. Pumps - Discharge as a function of head, efficiency curve, power absorbed curve and other test reports.
2. Motors - Efficiency at full load and half load, power factor at full load and half load, heating at ambient temperature of 40 C. Starting current as compared to normal full load current.

61. Testing the Pumps at Manufacturer's Works

Manufacturers shall test pumps prior to shipping. Results of pump tests carried out at the manufacturers works shall be provided at the time of delivery of equipment.

62. Starter

Each pumping unit should be provided with automatically operated (push button type) star delta starters with overload release and provision for float control. When tripped the starter should return to the off position. The starter shall incorporate an isolating MCB and lamp to indicate pump on position.

63. Automatic Start and Stoppage of Pumps

An arrangement for automatically starting/stopping the pumps when the sump/water tank is almost empty/full/fire reserve should be provided as specified in the controls drawing.

64. Spares and Tools

A complete set of tools shall be provided with each pumping set and list of these shall be submitted with the tender.

The successful tenderer shall supply 3 sets of spares lists with ordering references for the pumping set. The Tenderer should quote and submit an itemized and price list of spares required for each item of equipment namely pumps, motors, starters, etc., for the following.

1. Spares for keeping the unit in working order for 2 years of 7000 hours normal running.
2. Spares for complete overhauling of the units that are considered vital for the continued high efficient performance after 2 years of 7000 hours normal running.

The Tenderer should also hold out a guarantee that sufficient stocks or spares will be carried by him at all times. Manufacturer's leaflets should be submitted in support of each item.

65. Testing

The pumping unit shall be tested at Manufacturer's works prior to delivery and the manufacturer shall supply the test results of the pumping set including curves of Head, H.P. Input and overall efficiency plotted against 'Delivery' in gals/min. M3/hr).

After installation and setting to work of all the equipment the pumping sets shall be tested according to the satisfaction of the Consultants. The pumping sets shall be given continuous test runs for period of not less than six (6) hours to determine.

- a. That it is in satisfactory condition.
- b. That it is capable of delivering the specified quantity of water against the specified head when running at the specified speed.
- c. The power absorbed by pumps when doing such work.
- d. The efficiency and other specified characteristics.

The testing of pumps as detailed above and the other equipment for performance and accuracy shall be carried out by the Contractor and the costs of testing shall be borne by him.

66. Commissioning of Equipment

After satisfactory completion of all tests, the Contractor shall operate the equipment for 7 days and during this period instruct any person nominated by the Owner regarding the operation and maintenance of the equipment.

67. Maintenance Period

During the specified maintenance period, the Contractor shall attend to any repairs and make good all defects that may be detected or may arise to the equipment during the maintenance period. He shall also replace any equipment or part of the equipment, which fails or does not give satisfactory performance during the maintenance period.

These repairs and replacements shall be carried out within 10 days of being notified to do so and all expenses involved in this connection shall be borne by the Contractor.

68. Details Requirements of Plant

Electricity driven pumping unit, capacity and total head as specified in the B.O.Q.

Minimum overall efficiency expected is 40% (The efficiency of the pumps at the specified duty will be a consideration in evaluating the offer). An alternate offer for a pump of lower efficiency will be considered, if a suitable offer for a pump of the required efficiency is not available.

69. Operating and Maintenance instructions, Circuit Diagrams, Spares List etc.

The Contractor shall provide three sets of operating and maintenance instructions relating to all the equipment and detailed diagrams of wiring of the station and circuit diagrams for all switchboards etc.

A schedule which may be in the form of materials lists, giving full particulars together with ordering references of all replaceable parts for all the equipment should be supplied.

The Contractor shall be solely responsible for the provision of all labour, materials, plant and chemicals necessary for the carrying out of all testing operations. The water used for cleaning, flushing and sterilizing in accordance with this clause will be provided by the contractor. The contractor shall be responsible for all temporary works and other arrangements in connection with cleaning, sterilizing and flushing.