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TABLE E27: CHARACTERISTIC STRENGTH OF STEEL REINFORCEMENT

Type	Nominal Sizes (mm)	Yield Strength, f_y (N/mm ²)
Hot rolled grade 500 (MS 146)	All sizes	500
Steel Fabric (MS 145)	All sizes	500
Hard drawn steel wire (MS 144)	Up to and including 12	500
Cold worked (BS 4461)	All sizes	460

TABLE E28: DISTANCE BETWEEN SPACERS FOR EACH STRUCTURAL COMPONENT

No.	Structural component	Rebar diameter (mm)	Spacing/ distance (mm)
1.	Slab	6	500
		8	600
		≥10	700
		Steel fabric	500
2.	Column (Longitudinal direction)	≤10	500
		12 - 20	600 - 900
		>20	1000
3.	Beam (Longitudinal direction)	≤10	300
		12 - 20	400 - 700
		>20	800
4.	Footing	Similar to the slab	Similar to the slab.

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TABLE E29: NUMBER OF SPACERS FOR COLUMN AND BEAM IN TRANSVERSE DIRECTION

No.	Structural component	Width /height in mm.	No. of spacer.
1.	Column	≤ 100	2 nos.
		> 100	≥ 3 nos.
2.	Beam	≤ 100	2nos.
		> 100	≥ 3 nos.

TABLE E30: MINIMUM PERIODS BETWEEN CONCRETING AND REMOVAL OF FORMS

Vertical faces of beams, wall, columns, piles, foundation plinths and precast components	3 days
Slabs (props left under)	4 days
Removal of props to slab	10 days
Beam soffits (props left under)	8 days
Removal of props to beams	21 days

Note:

This table is applicable only for CEM1 cement. Where other types of cement, admixtures or additional material are to be used, the minimum periods between concreting and removal of forms shall be as approved by the S.O..

TABLE E31: RECOMMENDED MINIMUM CONCRETE STRENGTH FOR LIFTING AND HANDLING

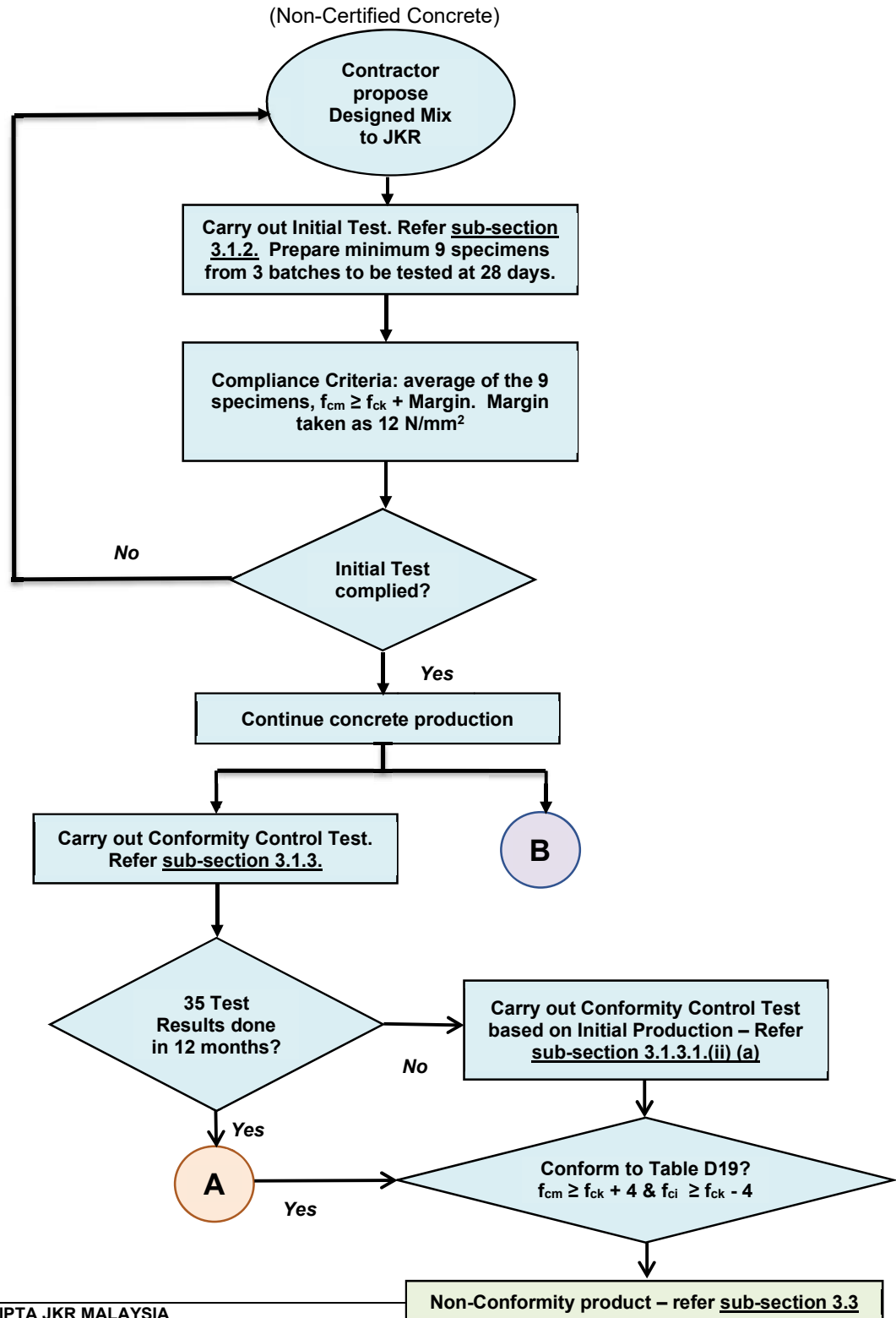
Application	Minimum concrete strength $f_{c,cube}$
Lifting which involves significant impact or high acceleration	15 N/mm ² *
All units where concrete strength for lifting is specified in drawing	2/3 of required design concrete strength
Eccentrically pre-stresses elements (tees, deep flooring units)	25 N/mm ²
Notes: * Dependent on anchor length or as recommended by insert manufacturer or otherwise specified Special care shall be taken with pre-stressed elements to ensure lifting devices are anchored in compression zones, unless covered by specific design	

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TABLE E32: RECOMMENDED CORRUGATED SLEEVE DIAMETER

Corrugated Sleeve Diameter (mm)	Dowel Bar Size (mm)
45	10, 12
55	16, 20, 25
65	25, 32
75	32

FIGURE E1A: CONCRETE CONFORMITY TESTING FLOW CHART FOR DESIGNED CONCRETE



(continued)

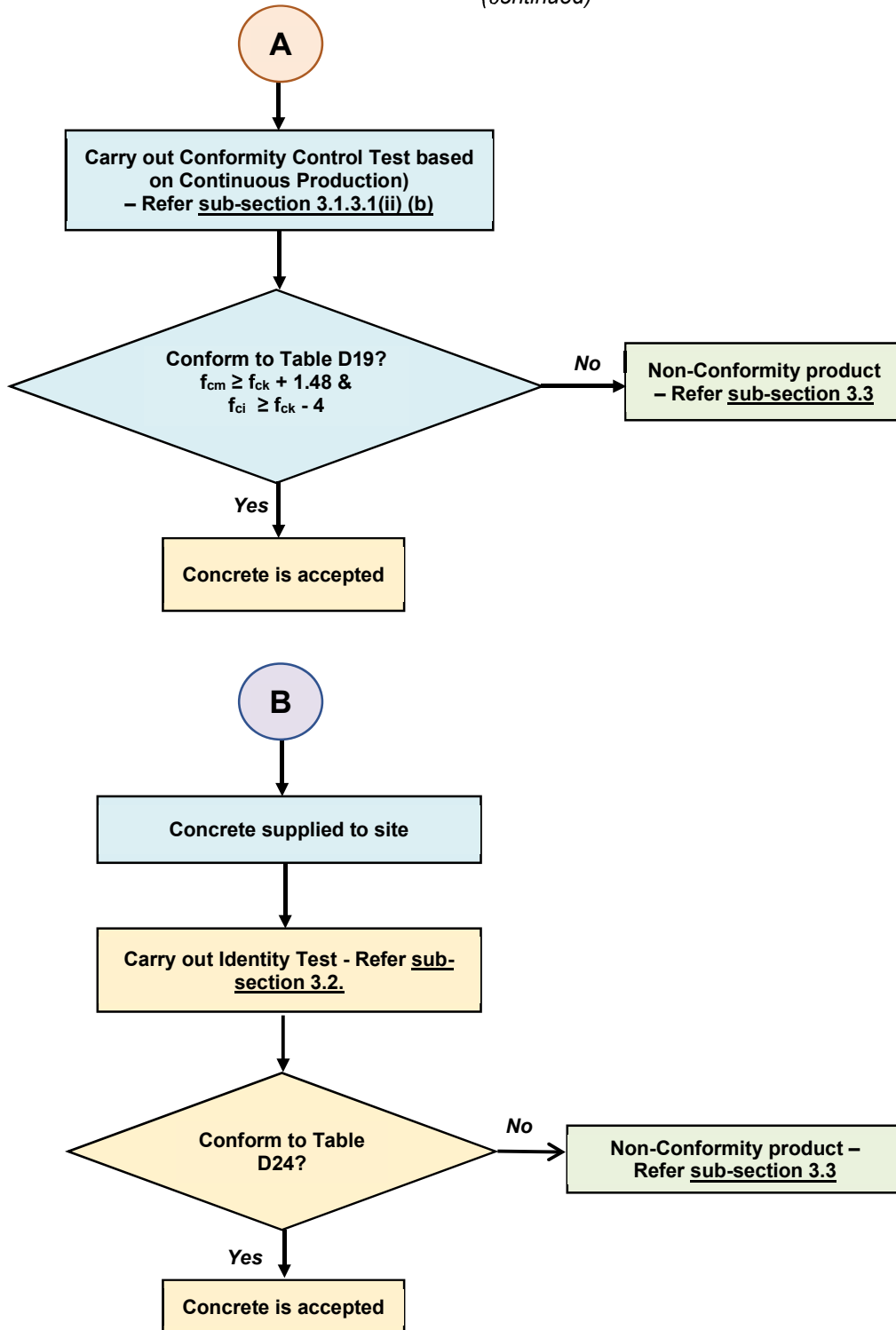


FIGURE E1B: CONCRETE CONFORMITY TESTING FLOW CHART FOR DESIGNED CONCRETE

(Certified Concrete)

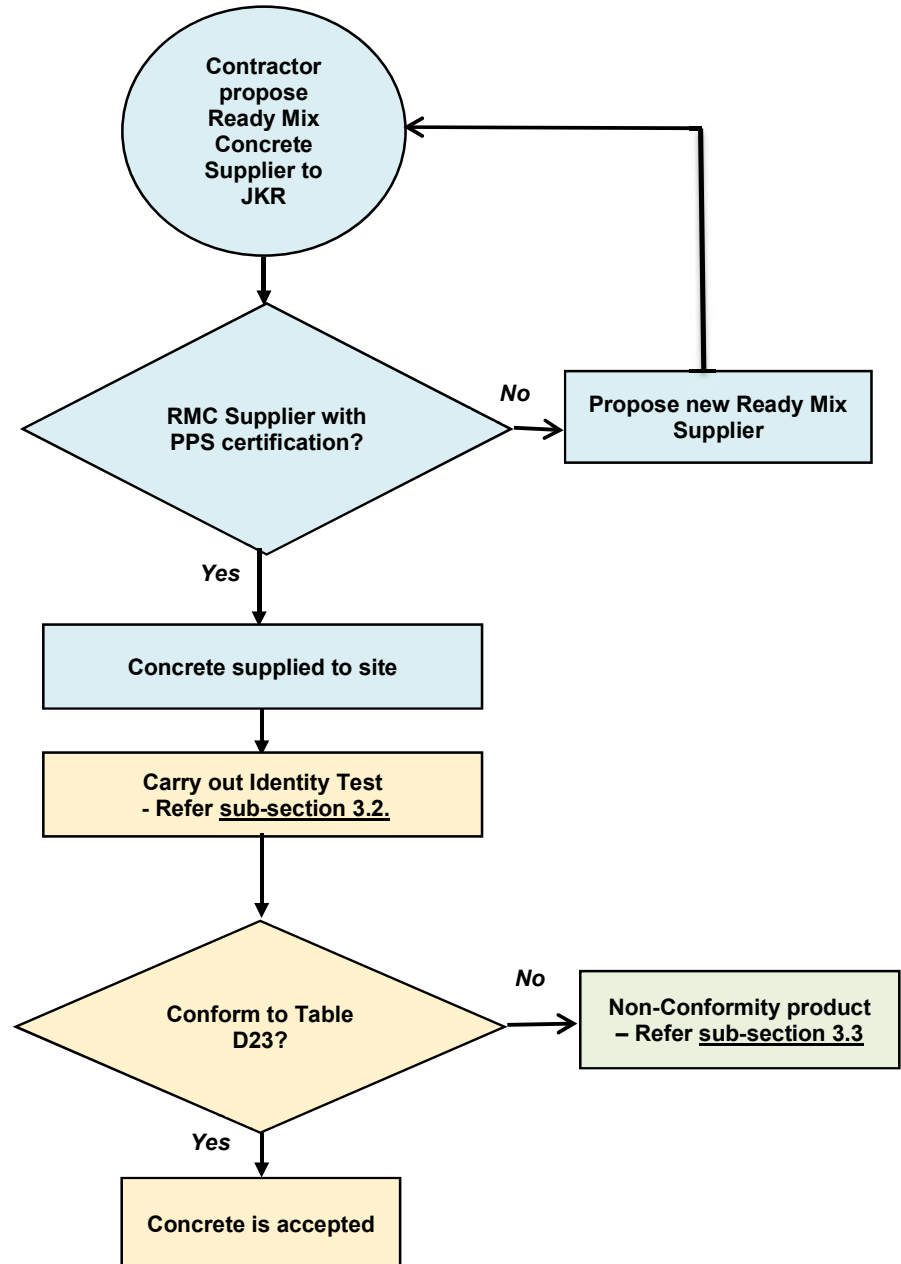


FIGURE E2: SLUMP TEST MEASUREMENT

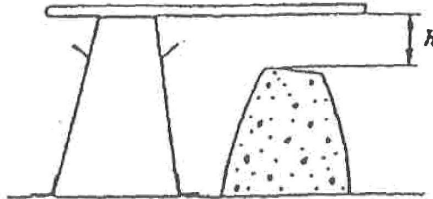


FIGURE E3: FLOW TEST MEASUREMENT

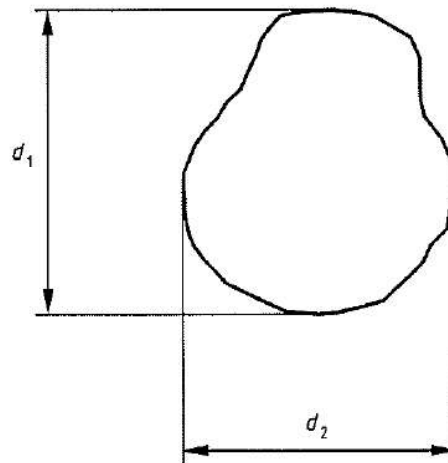


FIGURE E4: LIFT SHAFT ENCLOSURE

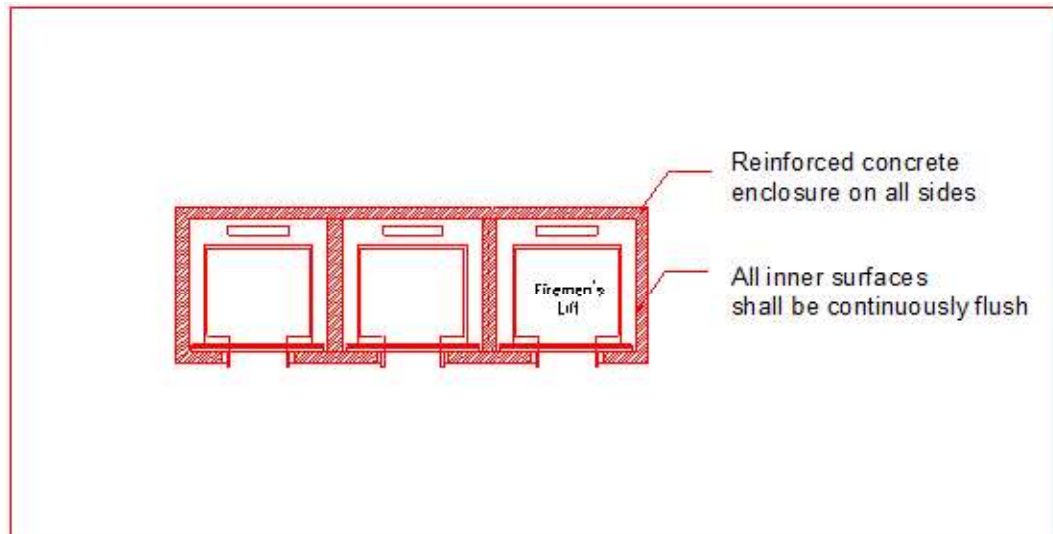


FIGURE E5: LIMIT OF ACCURACY OF SHAFT PLUMB ON ALL SIDES OF SHAFT ENCLOSURE

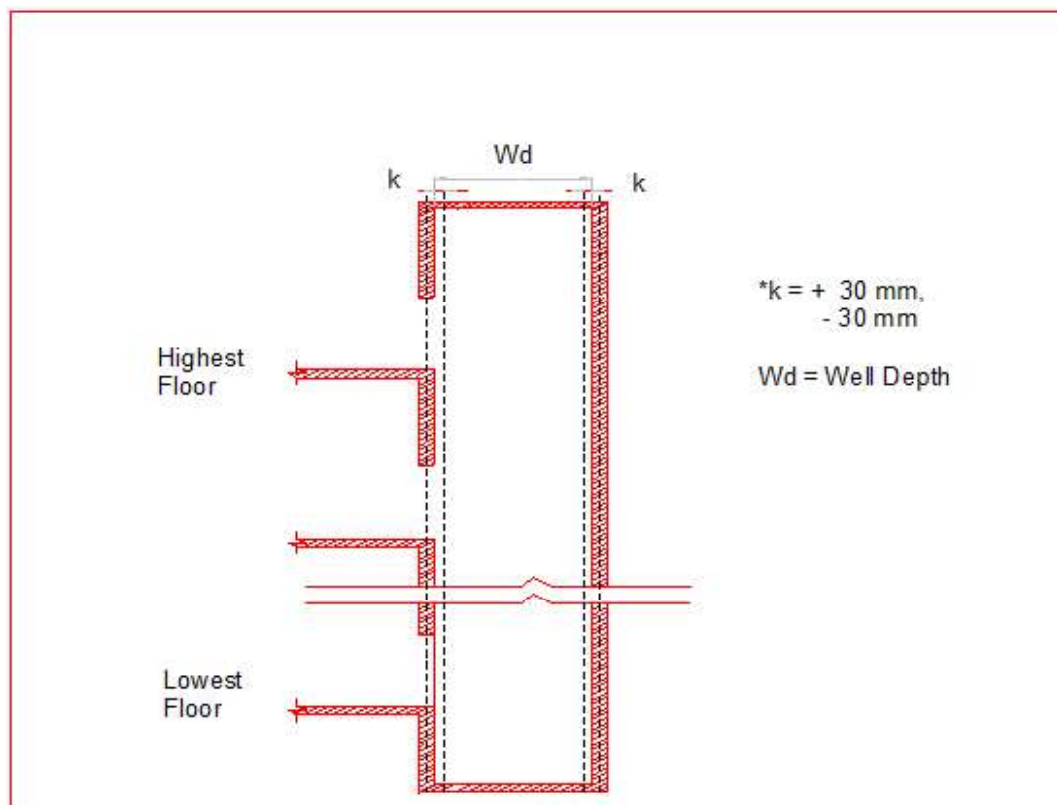


FIGURE E6. ACCURACY OF STRUCTURAL OPENING

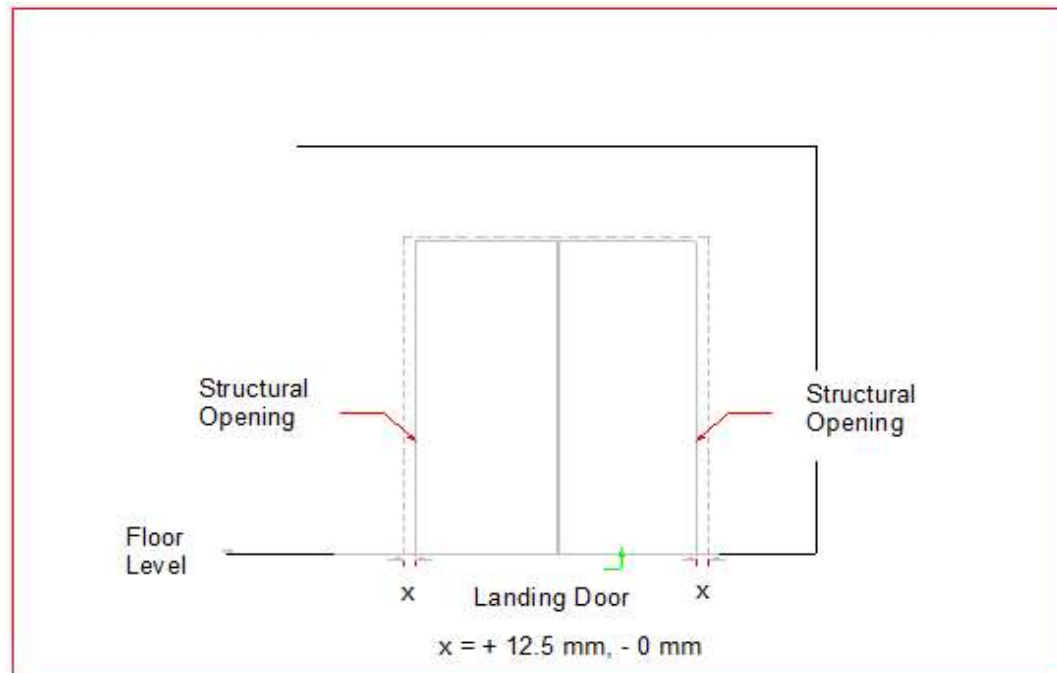


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1. Industrialised Building System (IBS)

- 1.1. Non-structural wall (NSW) system hereby refers to vertical building elements designed as non-load bearing internal walls which serve with functions as cited in Uniform Building By-Laws (UBBL 1984) 1984 and not being a party wall inside a building.
- 1.2. NSW system shall refer to solid wall, lightweight drywall partition, precast/prefabricated panels, etc.
- 1.3. Structural wall (SW) system hereby refers to vertical building elements designed as load bearing internal wall which serve with functions as cited in UBBL 1984 and being a party wall inside a building.
- 1.4. SW system shall refer to the blockwork system stated in sub-section 4.
- 1.5. Unless otherwise specified, all NSW or infill walls shall be constructed using proprietary blocks. Building materials considered for NSW construction may refer to sub-section 2 below. Each material type shall comply with the respective standard or manufacturer's specification. Build-up or configuration of NSW shall be strictly based on recommendations or/and design by solution provider.
- 1.6. Unless otherwise specified, design considerations of NSW shall comply with relevant parts of the current UBBL 1984 and shall take into consideration the following functional features, any one or in combination, and shall not be limited to:
 - 1.6.1. Structural stability. This includes consideration of external loadings, if any such as lateral wind or traffic pressure, heavy fixtures etc.;
 - 1.6.2. Thermal and fire resistance;
 - 1.6.3. Waterproofing;
 - 1.6.4. Acoustic performance; and
 - 1.6.5. Impact resistance.
- 1.7. Design for Wall Performances
 - 1.7.1. Structural stability
 - 1.7.1.1. All NSW shall be constructed only for their intended purposes and any additional loadings shall be referred to the S.O. for approval.
 - 1.7.1.2. Proprietary internal lightweight partition, including secondary framing shall be designed to meet specification requirements to ensure structural sufficiency and safety. The governing factor shall be based upon allowable deflection limit shall be of $L/240$ or $L/360 @ 250\text{Pa}$ or equivalent design code. L refers to height of wall in metre (m). 250Pa refers to lateral uniform pressure applying perpendicular to wall surface.

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1.7.2. Thermal and fire resistance

1.7.2.1. Material used for wall construction shall be classified as Class O building material in accordance Part IX, Ninth Schedule, UBBL 1984 and shall have an index of performance not exceeding 6 when tested in accordance with BS 476: Part 6 and Part 7.

1.7.2.2. Unless otherwise specified or shown on the Drawings, fire rated walls and partitions systems shall be constructed and calculated according to requirements and approval of the Director General of Fire and Rescue and comply with the UBBL 1984.

1.7.2.3. The glass wool, stone wool and cellulose insulation materials used shall comply with BS 476 - Fire tests on building materials and structures:

Part 4 : Non-combustibility test for materials;

Part 6 : Method of test for fire propagation for products; and

Part 7 : Method of test to determine the classification of the surface spread of flame of products.

1.7.3. Waterproofing for IBS

1.7.3.1. Where necessary, NSW shall be properly treated with proprietary waterproofing system as per respective manufacturer's recommendation, along with ten (10) years warranty coverage.

1.7.3.2. To lay Low Density Polyethylene (LDPE) 0.25mm membrane for damp proofing to be applied to the floors and walls that have direct contact with soil.

1.7.3.3. For wet areas such as bathroom, kitchen, balcony, applied two (2) coats flexible cementitious waterproofing at the rate of 1.0kg/m²/coat all accordance to manufacturer's specifications and instructions.

1.7.3.4. Upturn 300mm including 25mm angle fillet (R.C Shear Wall).

1.7.3.5. Upturn 1500mm including 25mm angle fillet (conventional brick and plaster wall, shower wall upturn at 300mm is sufficient for the shear wall.

1.7.3.6. Every RWDP to be treated with polyurethane sealant.

1.7.4. Acoustic performance

1.7.4.1. Where necessary, NSW shall be designed an acoustic performance with the sound transmission loss attenuation of not less than STC 45.

1.7.4.2. All party walls shall have an acoustic performance with the sound transmission loss attenuation of not less than STC 50.

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1.7.5. Impact resistance

1.7.5.1. Where applicable, walls shall be designed with some degree of security and impact resistance features. While solid wall structure is naturally to have high impact resistance capability, for drywall partitions this shall be evaluated in accordance with BS 5234: Partitions (including matching linings) – Part 2: Specification for performance requirements for strength and robustness including methods of test, or equivalent.

1.7.5.2. Drywall type of partitions and separating walls shall be designed to comply with the latest version of BS 5324 : Part 2.

2. Products, components and proprietary systems

2.1. Cement

The cement unless otherwise described, shall be CEM 1 complying with MS EN 197-1 and as specified under SECTION E :CONCRETING.

2.2. Sand

Sand for mortar shall comply with MS EN 12620 and as specified in SECTION E: CONCRETING.

2.3. Mortar

2.3.1. Mortar for masonry shall comply with MS 2506-2 and as specified under SECTION E: CONCRETING.

2.3.2. Mortar shall consist of one (1) part of cement to six (6) parts of sand, with the addition of an approved mortar plasticizer used strictly in accordance with manufacturer's recommendation. The ingredients for mortar shall be measured in proper gauge boxes and shall be mixed on a clean boarded platform or in an approved mechanical batch mixer.

2.3.3. All mortar shall be used within forty-five (45) minutes of mixing and no remaking up of mortar shall be permitted thereafter.

2.3.4. Mortar for brickwork below damp proof course or ground floor level shall be in the proportion of one part of cement and three parts of sand.

2.4. Waterproofing

2.4.1. General

2.4.1.1. All waterproofing shall have a minimum thickness of 0.2mm primer coating.

2.4.1.2. Unless otherwise specified, all waterproofing shall be continued 150mm up the parapet or wall and 100mm down into the rainwater down pipe.

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2.4.1.3. This section shall be read in conjunction with SECTION K: PLASTERING, PAVING AND FLOOR FINISH and SECTION N: PAINTING. All finishes that have direct contact with ground water and wet areas shall have proper and adequate waterproofing.

2.4.1.4. All application of water proofing shall be in accordance with the manufacturer's recommendations. before installation.

2.4.2. Types of waterproofing

2.4.2.1. Cementitious waterproofing:

2.4.2.1.1. All cementitious waterproofing shall have a minimum thickness of 1.0mm for each layer.

2.4.2.1.2. There shall be a minimum of two layer.

2.4.2.1.3. Cementitious waterproofing with acrylic additives shall be solid durable, elastic and shall be applied to steel and concrete surfaces.

2.4.2.1.4. Cementitious waterproofing with polymer additives shall be flexible, elastic, breathable, weak to sun exposure and shall be applied to storage tank, basement, swimming pool, pumping station and any other structures that are constantly in contact with water.

2.4.2.1.5. Cementitious waterproofing with crystalline additives shall seal concrete pores with quartz or silica and shall be applied to internal and external areas that do not have structural cracks or movement.

2.4.2.2. Elastomeric membrane waterproofing

2.4.2.2.1. Elastomeric membrane waterproofing shall be a rubbery emulsion liquid that cures into a thin rubbery membrane.

2.4.2.2.2. It shall be able to elongate in harsh sunlight, hence shall be used on flat roofs and outdoor areas.

2.4.2.2.3. The warranty shall be not less than ten (10) years

2.4.2.3. Polyurethane membrane

2.4.2.3.1. Polyurethane liquid mix shall cure into elastic waterproofing membrane.

2.4.2.3.2. It shall be able to used in wet damp floor areas, hence shall be laid over the materials like wooden and ceramic as top coat.

2.4.2.3.3. The warranty shall be not less than twenty-five (25) years.

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2.4.3. Damp Proof Course (DPC)

- 2.4.3.1. The DPCs shall be applied at the lower parts of the walls to restrict the movement of moisture rising up and through the walls complying with MS 1933-7-2007 Methods of test for masonry units- Part 7: Determination of water absorption of clay masonry damp proof course units by boiling in water
- 2.4.3.2. Damp Proof Course (DPC) Injection. This type of system involves a damp proofing injection being installed into the wall of the building which then acts as a barrier to stop moisture from rising from the ground above the DPC. Holes are drilled approximately 150mm above the ground level and the DPC injected into the wall.
- 2.4.3.3. Unless otherwise specified, the usage of bituminous damp proof courses shall comply with BS 8215: Code of practice for design and installation of damp-proof courses in masonry construction. The bitumen damp proof membrane shall be two (2) ply with a nominal mass of 1840g/m².
- 2.4.3.4. Usage of Bitumen type or polyethylene type as damp proof course shall be in rolls to suit the thickness of walls or brickwork. The damp proof course shall be bedded on a level bed of cement mortar (1:1) and lapped at least 150mm or the width of the damp proof course at running joints and intersections.
- 2.4.3.5. The damp proof course above ground shall be continuous for the whole length and thickness of the wall and be at least 150mm above finished ground level to prevent moisture from the ground rising through the foundation to the wall above ground, which otherwise would make wall surfaces damp and damage wall finishes.

2.4.4. Damp Proof Membrane (DPM)

- 2.4.4.1. DPMs are often made from polyethylene sheeting and shall be laid under concrete slabs and blocks.
- 2.4.4.2. It shall be a polyethylene sheet with sealed joint laid under a concrete slab to prevent the concrete from gaining moisture from the ground by capillary action.

2.4.5. Adhesive

- 2.4.5.1. The adhesive shall be used to prevent the penetration of water while also providing a strong bond or attachment to the substrate (such as concrete, metal, or wood).
- 2.4.5.2. Unless otherwise specified, the adhesive used shall comply to ISO 13007 standards.
- 2.4.5.3. Adhesive classification
 - a) The strength of ISO C1 (normal) shall be at least or more than 0.5N/mm²

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- b) The strength of ISO C2 (improved) shall be at least or more than 1.0N/mm².
- c) The early strength of fast set shall be at least or more than 0.5N/mm².
- d) The slip resistance of thixotropic shall be at least or less than 0.5mm.
- e) The capacity to be deformed for S1 (deformable) shall used between 2.5mm to 5mm.
- f) The capacity to be deformed for S2 (highly deformable) shall used at least or more than 5mm.
- g) Exterior glues plywood shall be compatible with exterior glues plywood.

2.5. Bricks and Blocks

2.5.1. General

All brick walls shall have galvanised expanded metal mesh (exmet) reinforcement with 750mm x 5mm diameter brickwork dowel bar complete with 75mm right angle bent to hook onto brickwork at every 4th course or accordance with manufacturer's recommendation.

2.5.2. Samples

Separate samples of each type of bricks and blocks taken at random from the load, shall be submitted to the S.O. for approval before the bricks and blocks are used. All subsequent deliveries shall generally be up to the standard of the samples approved. No soft, broken, twisted or otherwise defective bricks and blocks will be permitted to be used.

2.5.3. Clay Bricks

All ordinary clay bricks shall be machine-made, wire cut and shall be hard, well burnt, sound, square and clean all in accordance with MS 76: Specification for Bricks and Blocks of Fired Brickearth, Clay or Shale.

2.5.4 Cement Sand Bricks and Hollow Blocks

- 2.5.4.1. All cement sand bricks and hollow blocks shall comply with MS 2282 Masonry Units- Specification.
- 2.5.4.2. The dimensions of blocks shall comply with MS 1064: Guide to Modular Coordination in Buildings.
- 2.5.4.3. Wherever blocks are used, a modular sized block shall be used and constructed in accordance with the manufacturer's standards, requirements and method statements.
- 2.5.4.4 Only use cement sand bricks and hollow blocks supplied by approved manufacturers shall be used.

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2.5.1. Light Weight Concrete Block

- 2.5.5.1 Light weight concrete blocks shall comply with MS 2282 Masonry Units - Specification or BS EN 6073-1: Precast Concrete Masonry Units and shall be used and laid strictly in accordance with the manufacturer's instructions.
- 2.5.5.2 Light weight concrete blocks shall be free from asbestos or toxic substances.
- 2.5.5.3 Where light weight concrete blocks are used in lieu of clay bricks, a modular sized block shall be used according to manufacturer's standards, requirements and method statements.

2.6 Large Prefabricated Panels.

Large prefabricated panels when used shall conform to MS 1313: Code of Practice on Large Prefabricated Panels and shall be installed strictly in accordance with the manufacturer's recommendations.

2.7 Gypsum board

- 2.7.1 Gypsum board sheeting shall be a complete proprietary system, in accordance with the product data, approved sample and the relevant standards.
 - 2.7.1.1 BS EN 15283: Gypsum boards with fibrous reinforcement - Definitions, requirements and test methods; and
- 2.7.2 Provide moisture-resistant, impact-resistant, fire-resistant and acoustic-rated gypsum board systems where indicated or required.
 - 2.7.2.1 Moisture-resistant Grade (MR) gypsum board shall be suitable proprietary products for use in moisture-resistant construction in wet areas where normal gypsum board would be unsuitable.
 - 2.7.2.2 Fire-resistant Grade (FR) gypsum board shall be suitable proprietary products for fire-resistant construction.
 - 2.7.2.3 Impact-resistant Grade (IR) gypsum board shall be suitable proprietary products for impact-resistant construction

2.8 Fibre Cement Sheet

- 2.8.1 Fibre-cement (FC) sheeting shall be a complete proprietary system, asbestos-free, in accordance with the product data, approved samples, and the relevant Standards.
 - 2.8.1.1 MS 1224: Fibre-cement symmetrically corrugated sheets and fittings- Product specification and test method.
 - 2.8.1.2 MS 1296: Fibre-cement flat sheets- Product specification and test methods.

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2.9 Insulation (Acoustical and Thermal)

- 2.9.1 Unless otherwise specified or shown on the Drawings, acoustic wall panels and/or systems shall be constructed and calculated according to requirements of the acoustic specialist and approved by S.O.'s approval.
- 2.9.2 Thermal insulation system shall comply with MS1020: Thermal Insulation products for buildings - Factory made mineral wool (MV) products-Specification. Samples of the insulation material shall be submitted to the S.O. for approval before they are used and subsequent delivery shall be up to the standard of samples approved.
- 2.9.3 Unless otherwise shown on the Drawings, glass wool insulation shall be 50mm thick. It shall have a thermal transmittance (U-value) of not more than 0.035 W/m²K (tested at a mean temperature of 20°C based on MS1020. Unless otherwise specified the size of the glass wool insulation shall be 600mm x 1200mm. Glass wool insulation shall be fixed in accordance with the manufacturer's recommendation. and to the approval of the S.O..
- 2.9.4 Where stone wool insulation is to be used, it shall be 50mm thick. It shall have a thermal transmittance (U-value) of not more than 0.035 W/m²K (tested at a mean temperature of 20°C based on MS1020. Unless otherwise specified the size of the stone wool insulation shall be 600mm x 1200mm. Stone wool insulation shall be fixed in accordance with the manufacturer's recommendation and to the approval of the S.O..
- 2.9.5 Recommended type of spray applied cellulose insulation shall be:
 - 2.9.5.1 Thickness - 30mm;
 - 2.9.5.2 Thermal conductivity (k-value) = 0.0029 W/m·K tested to ASTM C-177;
 - 2.9.5.2 Fire retardant Class "O" complying with BS476 Part 6 & 7 and endorsed by Jabatan Bomba dan Penyelamat Malaysia (JBPM);
 - 2.9.5.3 Average moisture absorption of not more than 15% as per ASTM C739;
 - 2.9.5.4 Tested Noise Reduction Coefficient of NRC 0.75 at 30mm thickness; and
 - 2.9.5.5 Tested to be non-toxic and asbestos free, contain no carcinogenic materials and shall not cause any skin irritation to humans.

3. Type of Finishes to Walls and Partitions

The appropriate type of finishes for walls and partitions shall be as specified or as shown on the Drawings. The finishes and their dimensions shall be as specified in SECTION K: PLASTERING, PAVING AND FLOOR FINISH and SECTION N: PAINTING.

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4. Structural Wall (Blockwork System)

This clause shall apply to the construction of all load bearing blockworks with or without steel reinforcement. All lines, levels, grades, dimensions and cross-sections shall be as shown on the Drawings and/or directed by the S.O.. The full requirement is outlined in the *Specification for Load Bearing Blockwork System (JKR 20601-0252-18)* or the latest edition published by JKR.

4.1. Material

The block shall comply with the requirements of MS 2282 Masonry Units - Specification.

4.2. Compressive Strength

For all block units intended to be used in elements subject to structural requirements, the mean compressive strength shall not be less than 7N/mm². The manufacturer shall also declare the normalised compressive strength when relevant.

4.3. Density

The net dry density of the units shall be declared in kilogram per cubic metres (kg/m³) by the manufacturer in accordance with MS 1933 Methods of test for masonry units. The minimum dry density of the unit shall not be less than 1500kg/m³.

4.4. Structural Mortar

4.4.1. The recommended minimum compressive strength for prescribed mortar shall be class M6. The proportion of materials by volume shall be referred to **TABLE F1**.

4.4.2. The compressive strength of masonry mortar shall be determined in accordance with BS EN 1015 Part 11. The adhesion between the mortar and the masonry units shall be adequate for the intended use. The ingredients for mortar shall be measured in proper gauge boxes and shall be mixed on a clean boarded platform or in an approved mechanical batch mixer.

4.4.3. The characteristic compressive strength of masonry bonded with thin layer mortar shall be taken as the values given for mortar strength class M12 (mortar designation (i) in **TABLE F1**. The Contractor shall submit the manufacturer's specification and method statement to the S.O. for approval prior to the commencement of works.

4.5. Mortar Testing

The use of mortars shall be in accordance with the recommendation given in BS EN 1996. When samples are taken from a designed mortar in accordance with BS EN 1015 Part 2 and tested in accordance with BS EN 1015 Part 11, the compressive strength of the mortar shall not be less than the specified compressive strength. **TABLE E1** shows the relationship of compressive strength classes and the compressive strength of mortar at 28 days.

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4.6. Concrete Infill

Concrete infill for reinforced masonry shall be of minimum Class C25/30 (designed mix) or 30P (prescribed) with 10mm nominal size aggregates and specified in accordance with MS 523 Part 2. The minimum cement content, maximum free water/cement ratio and the concrete cover shall conform to the requirement in **TABLE F2**.

4.7. Blocklaying

- 4.7.1. Unless otherwise specified, all blockworks shall be laid on a full bed of mortar, and vertical joints shall be filled up fully. The average thickness of the vertical and horizontal joints shall be 10mm, exclusive of any key in the jointing surfaces of the units.
- 4.7.2. Unless specified, as work proceeds do not rack back corners and other advanced work higher than 1.2m above the general level. For facing work, complete the whole lift within one period of operation. Except where permitted by a proprietary system or by the designer, do not carry up any one leaf more than 1.5m height in one day.

4.8. Block Masonry Bonds

The running or stretcher bond of blocks are shown in **FIGURE F1** and **FIGURE F2**.

4.9. Services Holes and Chases

- 4.9.1. In order to eliminate unnecessary cutting away and making good, sleeves and chases should be provided during the erection of the masonry. In external walls, all sleeves and pipes should preferably be laid with a fall toward the outside. The installation of services should be completed before plastering or other finishing work is begun.
- 4.9.2. Where chases have to be cut, suitable power tools which do not operate by heavy impact should be used so that the recommended depth is not exceeded. Fixing units (blocks) where required, should be built into the wall or partition in the correct positions for skirting, rails and other items of joinery, fittings, etc.
- 4.9.3. In walls or leaves constructed of solid units, the depth of horizontal chases should not exceed one-sixth of the thickness of the single leaf at any point whilst the depth of the vertical chases should not normally exceed one-third of the thickness of the single leaf at any point.
- 4.9.4. The cutting of holes up to approximately 300mm square in the wall to accommodate items of equipment may be permitted.
- 4.9.5. Where heavy fittings are to be fixed to a wall, the effect on the stability of the masonry should be considered.

5. Samples and Mock-up

- 5.1. Samples and mock-up of wall construction shall be provided and approved by the S.O. prior to the commencement of the actual construction works. The size of the samples shall be determined by the S.O..

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5.2. The samples and mock-up for walls and partitions shall include connections between the following components where applicable:

- 5.2.1. Floor to floor to a minimum of 5m length;
- 5.2.2. Wall corners;
- 5.2.3. Lintels;
- 5.2.4. Stiffeners;
- 5.2.5. Door and window frames; and
- 5.2.6. All other walls between different materials.

5.3. Sample and Mock-Up Panels for Structural Wall (Blockwork System)

- 5.3.1. The Contractor shall construct a mock-up panel for the project with total build-up area more than 100m² using load bearing blockworks system.
- 5.3.2. Sample panels shall be built on Site in a protected position to provide an agreed standard for the work and treatment of joints before the commencement of the works subjected to the S.O.'s approval. Such panels shall be maintained throughout the contract and removed on completion.
- 5.3.3. The mock-up panel needs to be constructed to expose not less than 2m length x 1m height.

6. Walling / Construction

6.1. Brick Walling

- 6.1.1. Unless otherwise specified or shown on the Drawings, the whole of the brickwork shall be constructed with standard size clay bricks in mortar as described and the surface left ready for plastering.
- 6.1.2. All clay bricks shall be soaked in a suitable tank or pit for at least half an hour before being laid and shall be kept wet whilst being laid. The top of walls left off shall be thoroughly wet before work is resumed. All constructed walling must be left wet and properly protected from the direct sunlight during the following day
- 6.1.3. Cement sand bricks shall not be soaked but dipped in water before being laid and all constructed brickwork shall be protected from direct sunlight during the day on which it is laid and also during the following day and the Contractor shall provide sufficient means to ensure that this is done.
- 6.1.4. All bricks shall be properly bedded in mortar and all joints shall be thoroughly flushed up and raked out to a depth of 13mm as the works proceeds. No joint shall exceed 10mm in thickness.

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- 6.1.5. Brickwork shall be carried up perfectly true and plumb in a uniform manner. No one portion being raised more than 1m above another at one time. No overhand work shall be permitted, and scaffolding shall be carried up as the work proceeds. The vertical points of every alternate course shall be kept perpendicular over one another, and all perpends, quoins, etc. shall be kept strictly true and square.
- 6.1.6. All intersections and angles of walls shall be properly bonded together, and all walls and piers of lengths not multiples of brick sizes shall be cut and bonded in the best approved manner. No broken bricks shall be used except where required to form bonds.
- 6.1.7. All half brick (113mm) walls shall be reinforced at every fourth course with approved reinforcement (for example exmet) commencing two courses above floor level. For block walling, reinforcement shall be at every second course commencing one course above floor level.
- 6.1.8. All brick walls shall be constructed on reinforced concrete beams in accordance with the Drawings. No brick walls except lightweight partitions are allowed to be constructed on reinforced concrete slabs.
- 6.1.9. Unless otherwise specified, all toilet perimeter walls shall be constructed using clay bricks. Cement sand bricks shall not be used for toilet walls. All toilet and wet areas shall be of brickwork or approved proprietary wall system.
- 6.1.10. All half brick walls shall be built in Stretcher Bond.
- 6.1.11. All other brickwork shall be built in English Bond or as shown on the Drawings.
- 6.2. Facing Brickwork
- 6.2.1. All facing brickwork shall be executed in first quality approved facing bricks in Stretcher or Flemish Bond as shown on the Drawings, properly bonded into any backing walls, piers, etc.. Joints shall be raked out to a depth of 13 mm and point up in coloured cement mortar to approved tints, finished with a neat struck weathered joint.
- 6.2.2. Facing brickwork shall be kept perfectly clean and no rubbing down of brickwork will be allowed.
- 6.3. Stonework
- 6.3.1. Unless otherwise specified shown on the Drawings-all stone blocks used shall be of limestone or granite whichever is more readily available within the locality of the Site and shall be free from cracks, fissures or other defects to the approval of the S.O.. The stone blocks shall in general, have their largest faces parallel. Unless otherwise required, the maximum thickness of the stone blocks shall in no case exceed the thickness of the wall or portion of the structure into which it is being built.
- 6.3.2. Stone walling shall be laid random un-coursed or random coursed as shown on the Drawings. Through or bonded stones shall be used at one stone per metre square for random courses. Where the backing brick wall is shown, the through stone shall be properly bonded in such a brick wall.

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- 6.3.3. Unless otherwise shown on the Drawings, all stonework shall be bedded in cement and sand mortar (1:3) mix and finished with a flushed joint rubbed down with sacking. All interstices between individual stones shall be filled with mortar. Finish to exposed surfaces or random walling shall be hammer-dressed.

6.4. Hollow Block Walling

The cement sand block wall shall be laid in the manner specified for the brick wall. The hollow block shall not be soaked but dipped in water before laying. The hollow block wall shall be reinforced at every second course with reinforcement commencing one course above floor level.

6.5. Autoclaved Aerated Concrete (AAC) Block Walling

- 6.5.1. Where shown on the Drawings and/or described in the B.Q. or as an alternative to clay bricks, the Contractor may use AAC blocks for non-load bearing walls and partitions. The AAC block work shall be constructed strictly in accordance with the manufacturer's recommendations. Any extra cost in connection therewith shall be borne by the Contractor.
- 6.5.2. Only proprietary thin bed adhesive shall be used assembling AAC block wall. The bed adhesive mortar with minimum flexural strength of 0.44 MPa to all horizontals and perpend. The first course must be made true and level using a normal layer of mortar with a thin layer of adhesive to fully seal the perpend. The thin layer of proprietary adhesive shall be applied using a notched trowel to obtain an even distribution of adhesive to achieve joint thickness of 2mm to 3mm.
- 6.5.3. A damp-proof course slip-joint membrane shall be laid on top of the floor slab or beams before receiving the mortar bedding to allow for differential movement between the blocks and the supporting structure.
- 6.5.4. The AAC block work shall be laid in a manner that the vertical joint of the lower course shall be staggered at least 100mm relative to the vertical joint of the overlaying course.
- 6.5.5. Unless otherwise directed and/or shown, where concrete block walls about concrete faces, the face shall be flushed.
- 6.5.6. Control joints should be built into walls at spacing not greater than 8m centres, and at locations in accordance with manufacturer's recommendation.
- 6.5.7. Care must be taken to keep the walls clean, strictly in accordance with the manufacturer's recommendation. Excess adhesive must be removed progressively.
- 6.5.8. The wall surfaces may be finished with suitable surface coating that has the dual properties of being waterproof and water vapour permeable and shall be applied in accordance with the manufacturer's recommendation.
- 6.5.9. Only proprietary cement plaster of the same AAC block shall be used for external rendering of an external wall. The minimum thickness for the rendering of the external wall shall be 12mm thick.

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6.5.10. Only proprietary skim coat base and skim coat finish of the same AAC block shall be used for internal wall application. The recommended thickness of the skim coat base shall be between 2 - 4mm thickness and the skim coat finish of an internal wall shall be of 1 - 2mm thickness. Both coatings shall be applied as a two-coat system and applied according to manufacturer's instruction and to the S.O.'s approval.

6.5.11. All AAC block wall installation works shall strictly adhere to the manufacturer's method statement for installation works and to S.O.'s approval.

6.6. Parapet and Freestanding Wall

6.6.1. Any parapet and freestanding wall consisting of 155mm thick brick wall including plastering on both sides shall only be constructed to a maximum height of 900mm.

6.6.2. Where shown on the Drawings, freestanding walls above 900mm in height shall be constructed as per the engineer's detailed Drawings or to the S.O.'s approval.

6.6.3. Precast reinforced concrete copings shall be constructed on all external parapets and free-standing walls. The reinforced concrete coping shall be laid to fall, complete with 12mm half round throating.

6.6.4. Freestanding walls more than 3m length vertically and horizontally shall be constructed with reinforced concrete stiffeners to engineer's detail and with the S.O.'s approval.

6.7. Lintel and Stiffener

6.7.1. Unless otherwise specified or shown on the Drawings, lintels shall be provided to all openings and to be sized accordingly by the Contractor to the S.O.'s approval.

6.7.2. Reinforced concrete stiffeners shall be constructed at every minimum of 3m vertically and horizontally to strengthen brick and block wall system construction according to engineer's detail.

6.7.3. Alternatively, prefabricated lintel and stiffener may be installed to the manufacturer's details and as approved by the S.O..

6.8. Fasteners

Unless otherwise shown on the Drawings, fasteners or cramps for frames, metal windows and precast units shall be built in at 1m centres on the vertical side of the frame. Mild steel cramps shall be 25mm x 3mm x 225mm long for fixing wooden frames, etc. One end of the cramp shall be turned up and screwed to the back of the frame and the other end shall be split and fish-tailed for building in. Cramps which are to be fixed to concrete shall be embedded in concrete and built into brickwork as the work proceeds.

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6.9. Cutting

All cuttings such as arches, sinks, setbacks, and projections shall be properly formed. Chases and holes through walls and slabs for the passage of pipes, wiring and the like shall be neatly cut or formed. Upon the installation of the services pipes, the chases and holes through walls shall be properly sealed (Fire Stop) to prevent fire spread as required by the JBPM and UBBL 1984. Where plastering works are done on the cuttings, the surface shall be smooth and seamless.

6.10. Partitioning

6.10.1. Timber Framed Partition

- 6.10.1.1. All timber used for the timber stud framings for partition walls shall be as specified in SECTION I: TIMBER, JOINERY AND IRONMONGERY.
- 6.10.1.2. The wall partition consisting of timber frames shall consist of vertical and horizontal studs. The studs shall consist of approved timber hardwood with a minimum size of 50mm x 50mm unless otherwise specified. All horizontal and vertical studs shall be constructed at a maximum nominal spacing of 610mm centres.
- 6.10.1.3. The top most horizontal frame, referred to as the top plate shall be bolted or nailed to the ceiling and continuously erected using timber or metal stiffener securely fixed to the slab to the S.O.'s approval. The timber and metal stiffeners shall be spaced at 1220mm centres maximum.
- 6.10.1.4. The lowest horizontal frame, referred to as the bottom plate, shall be securely fixed using bolts or nails. Unless otherwise advised, all fixing to slabs, M12 expansion bolts shall be used at 1220mm centres maximum with galvanised mild steel strap, or equivalent, to the floor to the S.O.'s approval. All fixings to timber slabs shall be fixed at 600mm centres maximum.
- 6.10.1.5. Unless otherwise specified, dimension for timber panels shall comply with MS 1714 – Specification for visual strength grading of tropical hardwood timber.
- 6.10.1.6. Where proprietary timber partitions are used, they shall be constructed in accordance with the manufacturer's recommendations and to the S.O.'s approval.
- 6.10.1.7. Partitions, screens and vent panels, shall be constructed as detailed in the Drawings. Where shown, galvanised welded wire mesh or expanded metal of the required sizes and patterns shall be fixed to vent panels and window openings. The mesh shall be secured in position using rebated and mitred timber battens and screws.

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6.10.2. Metal Framed Partition

- 6.10.2.1. Steel sections such as, but not limited to metal framing and studs shall comply with ASTM C645, BS EN 14195, BS 7364 or other approved equivalent standards as appropriate, and to the approval of the S.O..
- 6.10.2.2. Unless otherwise specified, all metal framing for partitions shall be either galvanised or zinc alum coated steel 62mm C-Studs (vertical) and 64mm U-tracks (horizontal) of 0.5mm base metal thickness. The steel stud shall be manufactured from mild steel strip, with material specification complying to either one of the following:

Steel Grade Z2 with minimum yield strength of 210N/mm² and zinc coating type Z275 minimum, complying with BS EN 10143;

Steel Grade G300, with minimum yield strength of 300N/mm² and zinc-alum coating type AZ150 minimum, complying with AS 1397.
- 6.10.2.3. The stud which is to support a joint shall have a minimum fixing face width of 32mm for screw fixing and all other framing members shall not be less than 30mm. Drywall screws shall be at least 10mm longer than total thickness of plasterboards on each side of the partition wall. The plasterboards are laid staggered and fixed to the metal frames using drywall screws not exceeding 300mm centres.
- 6.10.2.4. The top most U-track (horizontal) shall be screwed to the ceiling and continuously erected using metal stiffener securely fixed to the slab. The metal studs directly supporting plasterboard sheets shall be spaced at 610mm centres maximum. The bottom U-track (horizontal) shall be securely fixed to the floor slab using bolts or screws. Unless otherwise advised, all fixing to slabs, M12 expansion bolts shall be used at 1200mm centres maximum with galvanised mild steel strap to the floor and to the S.O.'s approval.
- 6.10.2.5. Unless otherwise shown on the Drawings, the partitions shall not be erected more than 3000mm height. Partitions which are more than 3000mm height shall be supported by additional structural members, to structural engineer's detail and S.O.'s approval.
- 6.10.2.6. Partition above ceiling shall allow for cut out opening for service ducts or trunks and cable trays. The Contractor shall coordinate with all subcontractors on the exact location and size of the openings. For fire rated partitions, any gaps around any pipe ducts through the partition shall be properly sealed with an approved fire/smoke stop system by the fire stopping specialist.
- 6.10.2.7. If the full height partition has to be terminated below the ventilation duct route parallel to the partitions, the stud of the partition shall be secured to the support frame of the duct or extended secondary frame support. In such cases, space between the duct and reinforced concrete soffit need not be sealed up, unless it is of fire rated type of partition.

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6.10.2.8. The deflection of the metal frame partition system under service condition shall be controlled by the limit for the calculated deflection of the element chosen for the system and its intended use. The deflection shall not exceed $L/240$ or $L/360$ subject to the finishing material attached to the partition. Any system wall partition selected shall be installed strictly according to the manufacturer's specifications and details to the S.O.'s approval.

6.10.3. Plasterboard lining

6.10.3.1. The type of plasterboard used shall comply with BS EN 520. The specified plasterboard shall carry class 'O' approval from JBPM. Unless otherwise specified the plasterboards used for the works shall be minimum 12.5mm thick with standard length of 2440mm and shall be free of defects.

6.10.3.2. The deviations and tolerances shall be in accordance with BS 8212. When required, the deflection under load shall be determined in accordance with BS EN 520.

6.10.3.3. The appropriate type of sealant shall be used for the required type of plasterboard. Elastomeric sealants shall be used at the perimeter of the dry lining or partitioning to provide an airtight construction and to the approval of the S.O..

6.10.3.4. Jointing compound shall be of air drying or setting type, in accordance with BS EN 13963, and to the approval of the S.O. Jointing compound shall be applied as per manufacturer's recommendation and S.O.'s approval. The use of any additives to modify any of the properties of compounds shall not be permitted.

6.10.3.5. Jointing tape for plasterboards shall not be less than 48mm wide and not exceeding 60mm in accordance with ASTM C475 or equivalent, and the approval of the S.O..

6.10.3.6. Control joints shall be provided for a long continuous run of plasterboard wall spaced at not more than 10m apart.

6.10.3.7. Corner beads shall be provided as reinforcement to permit construction of true, concealed angles with gypsum base and panels.

6.10.3.8. Provision shall be allowed for the plasterboard partition system to support surface mounted fixtures by incorporating independent support framing hidden behind or exposed on the partition surface to provide adequate and appropriate support and to the approval of the S.O..

6.10.3.9. Wherever possible, full length plasterboard sheets shall be used to eliminate the need for sheet end butt joints. Where possible, joints on opposite sides of framing should be arranged to occur between different framing members.

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- 6.10.3.10. Plasterboard sheets shall be laid out to minimize butt joints and waste. Butt joints on adjoining sheets shall be staggered. Butt joints on opposite sides of the wall shall be staggered. The sheet shall be laid so that the vertical joints fall a minimum of 200mm from the edge of the opening.
- 6.10.3.11. Fire resisting systems consisting of more than one layer of plasterboards, the joints in successive layers should be staggered. In the case of walls sheeted on both sides' joints should be staggered on opposite sides of the wall.
- 6.10.3.12. Penetrations in the system shall only be allowed if installed in accordance to manufacturer's recommendation and tested at the Contractor's expenses. Penetration shall be strictly carried out in accordance with the requirements of the JBPM and to the approval of the S.O..
- 6.10.3.13. Fasteners shall have a corrosion-resistant finish and be appropriate for intended use, also in accordance with BS EN 14566 and BS 8212, or any relevant standards. The heads of fasteners shall be shaped so that they can be driven slightly below the surface of the plasterboard without punching through the paper liner.
- 6.10.3.14. Impact resistance of a partition system including gypsum plasterboard shall be determined in accordance with ISO 7892 and BS 5234-2.
- 6.10.3.15. The Contractor shall submit to the S.O., a manufacturer's warranty against any defect or damage to the proprietary plasterboard partition system which may arise during the period of five (5) years from the date of Certificate of Practical Completion. Terms of the warranty shall be such as shall be approved by the S.O..

6.11. Insulation Installation

- 6.11.1. Where necessary, insulation shall be installed so that:
 - 6.11.1.1. It abuts or overlaps adjoining insulation other than at supporting members such as studs, noggings, joists, furring channels and the like where the insulation must butt against the member;
 - 6.11.1.2. It forms a continuous barrier with ceilings, walls, bulkheads, floors or the like that inherently contribute to the thermal barrier; and
 - 6.11.1.3. It does not affect the safe or effective operation of a service or fitting.
- 6.11.2. Reflective insulation shall be installed so that:
 - 6.11.2.1. The necessary airspace to achieve the required R-value between a reflective side of the reflective insulation and a building lining or cladding;

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- 6.11.2.2. The reflective insulation closely fitted against any penetration, door or window opening;
- 6.11.2.3. The reflective insulation adequately supported by framing members; and
- 6.11.2.4. Each adjoining sheet of roll membrane being overlapped not less than 50mm; or taped together.
- 6.11.3. Bulk insulation shall be installed so that:
 - 6.11.3.1. It maintains its position and thickness, other than where it crosses roof battens, water pipes, electrical cabling or the like; and
 - 6.11.3.2. In a ceiling, where there is no bulk insulation or reflective insulation in the wall beneath, it overlaps the wall by not less than 50mm.
- 6.11.4. Fixing methods of insulation material shall be as below, or as recommendation of manufacturer:
 - 6.11.4.1. Use proprietary fixing methods which prevent long term sag, collapse or dislodgement; and
 - 6.11.4.2. Fasteners shall be suitable non-corrosive types.
- 6.12. Glass Partitions
 - 6.12.1. Unless otherwise specified or shown on the Drawings, all fixed glass wall systems shall be 8mm thick minimum, erected with a stainless steel framing system for sizes up to 1200mm x 4800mm maximum installed to manufacturer's recommendation and to S.O.'s approval. For sizes more than 4800mm, the panels shall be constructed according to manufacturer's
 - 6.12.2. Glass doors shall be installed complete with accessories as recommended by the manufacturer and to the S.O.'s approval.

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TABLE F1: MASONRY MORTARS

	Mortar designation	Compressive strength class	Prescribed mortars (proportion of materials by volume) (see notes 1 and 2)		Compressive strength at 28 days N/mm ²
			Cement (a): sand with or without air entrainment	masonry cement (b): sand	
 Increasing ability to accommodate movement, e.g. due to settlement, temperature and moisture changes	(i)	M12	-	-	12
	(ii)	M6	1 : 3 to 4	1 : 2½ to 3½	6
a. Cement, or combination of cements except masonry cements.					
i) Combinations produced in the mortar mixer from Portland cement CEM I conforming to MS EN 197 Part 1 and ground granulated blastfurnace slag conforming to MS EN 15167 Part 1 where the proportions and properties conform to CEM II/A-S or CEM II/B-S of MS EN 197 Part 1, except Clause 9 of that standard.					
ii) Combinations produced in the mortar mixer from Portland cement CEM I conforming to MS EN 197 Part 1 where the proportions and properties conform to CEM II/A-L or CEM II/A-LL of MS EN 197 Part 1, except Clause 9 of that standard.					
iii) Combinations produced in the mortar mixer from Portland cement CEM I conforming to MS EN 197 Part 1 and pulverized fuel ash conforming to MS EN 450 Part 1, where the proportions and properties conform to CEM II/A-V or CEM II/B-V of MS EN 197 Part 1, except Clause 9 of that standard.					
b. Masonry cement (inorganic filler other than lime)					
NOTE 1: Proportioning by mass will give more accurate batching than proportioning by volume, provided that the bulk densities of the materials are checked on Site.					
NOTE 2: When the sand portion is given as, for example, 5 to 6, the lower figure should be used with sands containing a higher proportion of fines whilst the higher figure should be used with sands containing a lower proportion of fines.					

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TABLE F2: MINIMUM CONCRETE COVER FOR CARBON STEEL REINFORCEMENT

Exposure situations	Concrete Grade in MS EN 206 and MS 523 Part 2 & MS 523 Part 3				
	C25/30	C28/35	C32/40	C35/45	C40/50
	Minimum cement content (kg/m ³)				
	300	320	340	360	380
	Maximum free water/cement ratio				
	0.65	0.6	0.55	0.50	0.45
	Thickness of concrete cover				
	mm	mm	mm	mm	mm
E1 ^a	20	20	20 ^b	20 ^b	20 ^b
E2	—	35	30	25	20
E3	—	—	40	30	25
E4	—	—	—	60	50
Exposure situation E1. Internal work and the inner skin of ungrouted external cavity walls and behind surfaces protected by an impervious coating that can readily be inspected, or external parts built. Exposure situation E2. Buried masonry and masonry continually submerged in fresh water or external parts built. Exposure situation E3. Masonry exposed to freezing whilst wet, subjected to heavy condensation or exposed to cycles of wetting by fresh water and drying out or external parts built. Exposure situation E4. Masonry exposed to salt or moorland water, corrosive fumes, abrasion or the salt used for de-icing.					
a. Alternatively, 1: 0 to ¼ : 3: 2 cement: lime: sand: 10mm nominal aggregate mix may be used to meet exposure situation E1 when the cover to reinforcement is 15mm minimum. b. These covers may be reduced to 15mm minimum provided that the nominal maximum size of aggregate does not exceed 10mm.					

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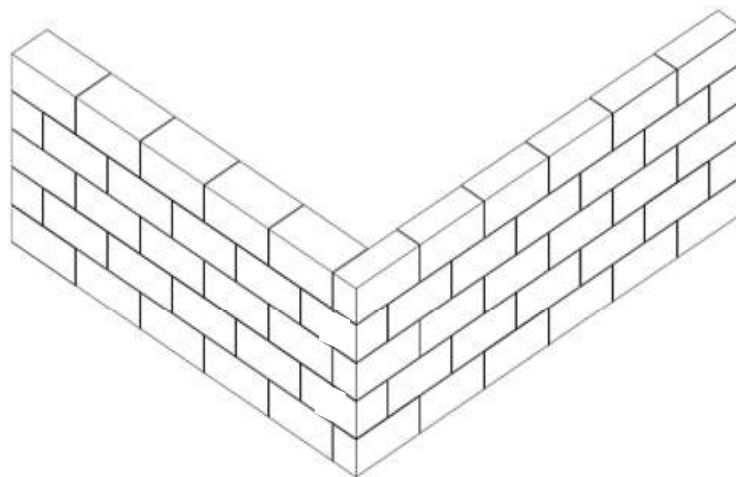


FIGURE F1: RUNNING OR STRETCHER BOND

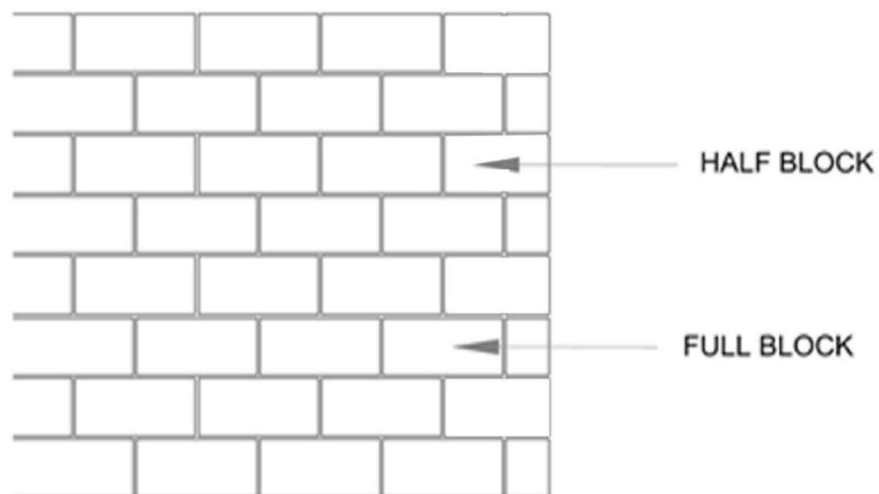


FIGURE F2: RUNNING OR STRETCHER BOND

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1. General

- 1.1. Unless otherwise stated, the pitch and batten gauge for each type of roof covering shall be strictly in accordance with the manufacturer's recommendation.
- 1.2. Unless otherwise approved, all roof covering pieces or accessories such as eaves, hips, ridges, valley etc., shall be of the same material as the general covering.
- 1.3. Use of plastic or polyurethane foam (PU foam) based insulation shall be prohibited due to health hazards. PU foam-based insulation releases toxic substances when heated and burned
- 1.4. Heat insulation material used shall be non-combustible under BS 476 Part 4 or EN13501-1 Class A1.

2. Interlocking Concrete Tiles

- 2.1. Interlocking concrete roof tiles shall be laid on timber or steel battens approved for roofing at spacing and tightly nailed or screwed as recommended by the manufacturer.
- 2.2. Unless otherwise specified, the concrete roof tiles shall be laid to slope in accordance with the manufacturer's recommended pitch and to the S.O.'s approval. The roof tiles shall conform to MS797 and unless otherwise specified on the drawings, it shall be laid on metal trusses system to engineer's detail and to the S.O.'s approval.
- 2.3. Water repellent materials backed with weatherproof self-adhesive compound for ridges and hips solution laid in accordance with manufacturer's instruction.
- 2.4. Verges, ridges, hips, valley tiles and complete with all roofing accessories shall be provided and laid to bond with the general roof tiling works in accordance with the manufacturer's recommendation.
- 2.5. Unless otherwise stated in the Drawings, where skylight roofing are to be used, they shall comply with UBBL 1984. The minimum thickness gauge and fixing system of the skylight roofing sheets is in accordance with the manufacturer's recommendation.

3. Clay Tiles

- 3.1. Unless otherwise stated in the Drawings, clay tiles shall be of 425mm to 490mm (length) x 280mm to 300mm (horizontal width) pattern conforming to BS 402 or SS 70 and shall be free from cracks, chips and warps.
- 3.2. Clay tiles shall be laid with a minimum head lap of 75mm to 95mm on timber or steel battens approved for roofing at spacing as recommended by the tile manufacturer. The tiles shall be firmly screwed or nailed at intervals as recommended by the roofing tile manufacturer and as approved by the S.O..
- 3.3. Ridge capping, hip and valley tiles complete with all roofing accessories shall be provided to match the general tiling works in accordance with the manufacturer's recommendation. All these shall be bedded in matching water repellent materials backed with weatherproof self-adhesive compound.

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- 3.4. Roofing components at roof eave to allow airflow and prevent the entry of birds and vermin into the batten cavity is recommended.
- 3.5. Unless otherwise stated in the Drawings, where skylight roofing are to be used, they shall comply with UBBL 1984. The minimum thickness gauge and fixing system of the skylight roofing sheets is in accordance with the manufacturer's recommendation.

4. Pre-painted Aluminium Roofing Sheet

- 4.1. Unless otherwise stated, where aluminium roofing sheets are to be used, they shall be of the type, gauge and finish as shown in the drawings and to be fixed strictly in accordance with the manufacturer's recommendation.
- 4.2. Unless otherwise stated in the Drawings, where skylight roofing are to be used, they shall comply with UBBL 1984.

5. Concrete Flat Roofs

- 5.1. Concrete flat roofs shall be as specified under SECTION E: CONCRETING.
- 5.2. To apply one (1) coat elastomeric breathable acrylic copolymer liquid followed by another two (2) coats of same water proofing with flexible UV resistant liquid applied membrane, reinforced with approved fibre mesh in between the coats.
- 5.3. Upturn 300mm including 25mm angle filler at every edge of the parapet wall. Every rainwater down pipe (RWDP) to be treated with polyurethane sealant.
- 5.4. Unless otherwise stated, waterproofing system required to be protected with minimum 50mm thick cement sand all in accordance to manufacturer's specification and instruction.

6. Pre-painted Steel Roofing Sheet

- 6.1. Unless otherwise stated, the metal roof decks shall comply with the following:
 - 6.1.1. Materials
 - 6.1.1.1. The roofing sheets shall with 55% aluminium, 43.5% zinc and 1.5% silicon or be produced from aluminium/zinc/magnesium alloy coated steel conforming to MS 2657 and AS1397 with 55% aluminium, 41.5% zinc, 2% magnesium and 1.5% silicon.
 - 6.1.1.2. The pre-painted finish over the aluminium/zinc alloy coated base steel or aluminium/zinc/magnesium alloy coated base steel shall conform to MS 2383 with at least 1000 hours of Cyclic Corrosion Test (CCT) to meet ISO 9223 Category 3 (C3) environment.
 - 6.1.1.3. The exterior finish coat shall have a nominal dry film thickness of 20µm over 5µm thick corrosion inhibitive primer on top side or weather side. The backing coat shall be with nominal dry film thickness of 5µm Shadow Grey over 5 µm corrosion inhibitive primer.



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- 6.1.1.4. Minimum steel yield strength shall be 300 or 550MPa.
- 6.1.1.5. The minimum aluminium/zinc alloy coating mass shall be 150g/m² (Coating Class AZ 150) or aluminium/zinc/magnesium alloy coating mass of 150g/m² (Coating Class AM150) on both surfaces.
- 6.1.1.6. The Contractor shall submit material warranty from the Material warranty shall be up to 30 years against perforation by corrosion, 15 years against flake and peel, 12 years against colour fading and 5 years against dirt staining for the project Site within ISO 9223 Category 3 (C3) environment or at least 1km from the atmospheric corrosive influence environment.
- 6.1.1.7. Unless otherwise stated in the Drawings, where skylight roofing are to be used, they shall comply with UBBL 1984. The minimum thickness gauge and fixing system of the skylight roofing sheets is in accordance with the manufacturer's recommendation.

6.1.2. Metal Sheet Profiles

- 6.1.2.1. Unless otherwise specified or shown on the Drawings, the metal sheet profile shall be of a concealed fixing system complying with MS2500 and Perakuan Pematuhan Standard (PPS) certificate under CIDB Act. The roofing sheets shall have the following requirements:
 - (i) Base Metal Thickness (BMT) = 0.42mm.
 - (ii) Total Coating Thickness (TCT) = 0.47mm (AZ150/AM150); 0.48mm (AZ200) *note: Total Coating Thickness (TCT) is the total thickness before paint.
 - (iii) After Painted Thickness (APT) = 0.50mm (AZ150/AM150); 0.51mm (AZ200) *note: After Painted Thickness (APT) is the total thickness after paint.
 - (iv) Cover width = 200mm to 980mm.
 - (v) Rib height = 25mm to 43 mm.
 - (vi) Coating = Pre-painted aluminium/zinc coated steel with AZ150 (150g/m²) or AZ200 (200g m²/) on both surfaces. or pre-painted aluminium/zinc/magnesium coated steel with AM150 (150g/m²) on both surfaces.
- 6.1.2.2. Where pierced fixing system complying with MS2500 is specified or shown on the Drawings, the roofing sheet shall have the following requirements:
 - (i) Base Metal Thickness (BMT) = 0.42mm.
 - (ii) Total Coating Thickness (TCT) = 0.47mm (AZ150/AM150); 0.48mm (AZ200) *note: Total Coating Thickness (TCT) is the total thickness before paint.



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- (iii) After Painted Thickness (APT) = 0.50mm (AZ150/AM150); 0.51mm (AZ200) *note: After Painted Thickness (APT) is the total thickness after paint.
- (iv) Cover width = 715 to 1015mm
- (v) Rib height = 16mm to 38mm
- (vi) Coating = Pre-painted aluminium/zinc coated steel with AZ150 (150g/m²) or AZ200 (200g m²/) on both surfaces. or pre-painted aluminium/zinc/magnesium coated steel with AM150 (150g/m²) on both surfaces.

6.1.2.3. Roll Former (RF), a manufacturer and supplier of a proprietary roofing system approved by JKR, or approved equivalent, which adheres to strict quality assurance procedures in the supply of materials, design with detailing and accessories manufacturing shall be responsible for the manufacturing, supply and delivery of the roofing system.

6.1.3. Fixing

6.1.3.1. Installation procedures shall conform to the recommendation of the manufacturer.

6.1.3.2. The roofing sheets shall be installed and fixed according to the following method:

- (i) Concealed fixing using approved clips compatible with the roofing sheet.
- (ii) Pierced fixing using approved fasteners compatible with the roofing sheet.

6.1.3.3. The roofing installer shall be registered with CIDB B15.

6.1.3.4. Metallic swarf and all other debris including nail, screws, mortar, construction materials etc. shall be swept away from the roof area and gutters regularly, particularly at the end of each day's work and at completion of the installation works.

6.1.4. Clips and Fasteners

6.1.4.1. Fasteners type shall comply with AS 3566 Class 3 and be certified as such by the supplier of fasteners.

6.1.4.2. The recommended type of fasteners shall conform to the following test:

- (i) Salt spray test - 1000 hours
- (ii) Kesternich test - 15 cycles.
- (iii) Humidity test - 1000 hours.
- (iv) UV test - 2000 hours.

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6.1.4.3. All fasteners and screws shall be of the self-drilling type either concealed or screwed fixing, complete with preassembled ethylene propylene diene monomer (EPDM) rubber washers.

6.1.4.4. All fasteners and screws head and body must be monolithic forming with the same material.

6.1.4.5. All fixing clips shall be manufactured from aluminium/zinc coated steel with AZ150 (150g/m²)

6.1.5. Flashing and Capping

Unless otherwise specified, approved 0.42mm BMT ridge capping, flashing, capping and trimming shall be manufactured to the required shape and sizes. The flashing and capping materials used shall be from the same material as the roofing sheets.

6.1.6. Sealants

Only neutral cure silicone rubber sealant type OCI N-192 or equivalent shall be used conforming to AS 3902.

6.1.7. Lightning Conductors

Aluminium lightning conductor is recommended for use on steel roof systems.

6.2. All fixing accessories shall be rust-resistant and of suitable design and construction as recommended by the manufacturer for the roofing system and as approved by the S.O.. All fasteners and screws shall be of the self-drilling type either concealed or screwed fixing, complete with preassembled EPDM rubber washers.

6.3. For identification and traceability record, all steel roof decking shall be printed permanently with branding text which will include Base Metal Thickness (BMT), coating mass, steel grade, type of finish coat, roof profile, colour and reference number for mill certificate. Meanwhile, storage and packaging of alum/zinc steel roof decking shall be strictly in accordance with the manufacturer's recommendation and comply with the S.O.'s requirements.

6.4. All roof decking sheets, capping, flashing etc. or wall cladding shall be new, clean, regular, straight and true to shape with sharp defined profiles, free from cracks, chips, bends and defects detrimental to practical use or from other surface imperfections.

6.5. At Site, the sheets shall be lifted from the transport carrier by a crane and properly stacked clear of the ground, ready to be lifted up to the roof structure for laying. Where sheets are to be manually lifted, care should be taken not to drag the sheets to avoid scraping away the surface coating.

6.6. Where storage is necessary, stack heights shall be kept to a minimum and the sheets shall be stacked in a sloping position. Sheets shall be stacked off a dry firm ground, under cover by tarpaulin or polythene sheets but ventilated and away from building operations. Should the stack sheets become wet, they shall be immediately dried to prevent staining and degradation of the surface coatings.

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- 6.7. The roof shall have the absolute water-tightness and the method of installation, fixing and fastening decking sheets, caps, flashings etc. including acoustical, insulation and expansion joints, whenever required shall conform strictly to the manufacturer's recommendation.
- 6.8. The completed portions of the roof shall be clear of all metallic particles such as blind rivet shanks, screws, nuts, nails etc. and dirty footprints should be wiped off to avoid early deterioration/corrosion and discolouration. Damages to the coating shall be repaired with touch-up paint as recommended by the manufacturer and approved by the S.O..

7. Roofing Sheet for Marine Environment (Coastal Areas)

- 7.1. The correct type of metal sheet profile shall be installed for coastal areas as recommended by the roof manufacturer and approved by the S.O..
- 7.2. Unless otherwise specified or shown on the Drawings, the roofing sheet for marine environment shall be produced with minimum aluminium/zinc alloy coating mass of 200g/m² (Coating Class AZ 200) or minimum aluminium/zinc/magnesium alloy coating mass of 150g/m² (Coating Class AM150) on both surfaces.
- 7.3. The aluminium/zinc alloy coated steel shall be manufactured and certified by SIRIM according to MS 1196 and AS 1397 or the aluminium/zinc/magnesium alloy coated steel shall be produced and certified by SIRIM according to MS 2657 "Continuous Hot-Dip Metallic Coated Steel Sheet and Strip - Coatings of Zinc Alloyed With Aluminium and Magnesium" and AS 1397 with 55% aluminium, 41.5% zinc, 2% magnesium and 1.5% silicon.
- 7.4. The pre-painted finish over the aluminium/zinc alloy coated base steel or aluminium/zinc/magnesium alloy coated base steel shall conform to MS 2383 and AS/NZS 2728 with 2000 hours of Cyclic Corrosion Test (CCT) to meet ISO 9223 Category 4 (C4) environment or with 4000 hours of Cyclic Corrosion Test (CCT) to meet ISO 9223 Category 5 (C5) environment. The exterior super polyester paint finish shall have a nominal dry film thickness of 20µm over 5µm thick corrosion inhibitive primer on top side or weather side. The backing coat shall be with nominal dry film thickness of 5µm Shadow Grey over 5µm corrosion inhibitive primer.
- 7.5. The material warranty from the manufacturer shall be submitted. Material warranty shall be up to 25 years against perforation by corrosion, 15 years against paint flake and peel, 12 years against colour fading and 5 years against dirt staining for the project Site within ISO 9223 Category 4 (C4) environment or between 201m to 1km from the calm marine environment or between 401m to 1km from the surf marine environment.
- 7.6. Fasteners used shall comply with AS 3566 Class 4 and be certified as such by the supplier of fasteners and to the approval of the S.O..
- 7.7. All fixings and associated components shall be manufactured from compatible metals and coated conforming to ISO 9223 Category 4 (C4) and Category 5 (C5) environment. Flashings shall be made from the same material as the roofing sheets.
- 7.8. Unless otherwise stated in the Drawings, where skylight roofing are to be used, they shall comply with UBBL 1984.

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8. Bituminous Corrugated Roofing Sheets

- 8.1. Unless otherwise shown on the Drawings, the bituminous corrugated roofing sheets shall have the following minimum requirements:
- 8.1.1. Length = 2000mm
 - 8.1.2. Width = 950mm
 - 8.1.3. Cover width = 855mm
 - 8.1.4. Thickness = 3mm
 - 8.1.5. Weight of material = 3.3kg/m²
 - 8.1.6. Thermal resistance R- value = 0.04mK/W
 - 8.1.7. Thermal conductivity = 0.066W/mK
- 8.2. Unless otherwise shown on the Drawings, the Bituminous Corrugated Roofing Sheets shall be laid at a minimum roof pitch of 5° on timber battens at spacing and tightly nailed/screwed as recommended by the manufacturer.
- 8.3. Ridge capping, nails and screws shall be provided to match the roofing sheets while ridges, verges, eaves, hips, valleys, side-wall and end-wall details shall be fixed strictly in accordance with the manufacturer's recommendation.

9. Bituminous Corrugated Roofing Tiles

- 9.1. Unless otherwise shown on the Drawings, the bituminous corrugated roofing tiles shall have the following minimum requirements:
- 9.1.1. Length = 1060mm
 - 9.1.2. Width = 400mm
 - 9.1.3. Wave height = 40mm
 - 9.1.4. Thickness = 3mm
- 9.2. Bituminous roofing tiles shall be laid at a minimum roof pitch of 9° and on timber or steel battens approved for roofing at spacing and tightly nailed/screwed as recommended by the manufacturer.
- 9.3. Ridge capping, nails and screws shall be provided to match the roofing tiles while ridges, verges, eaves, hips, valleys, side-wall and end-wall details shall be fixed strictly in accordance with the manufacturer's recommendations.

10. Fibre-cement Corrugated Sheets

- 10.1. Fibre-cement corrugated sheets shall comply with MS 1224. The thickness of the sheets shall be 3mm thick for shallow corrugation and 4mm thick for medium corrugation. The cement shall comply with MS 522: Part 1. Asbestos processed or unprocessed shall not be added to fibre-cement sheets.

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- 10.2. The surface intended to be exposed to the weather shall have a generally smooth finish. Variations of the surface appearance which do not impair the characteristics of the sheets as defined in MS 1224 are permitted.
- 10.3. Unless otherwise stated in the Drawings, where skylight roofing are to be used, they shall comply with UBBL 1984.

11. Heat Insulation

11.1. General

Heat insulation systems shall comply with MS 1020 and MS 1525. Samples of the insulation material shall be submitted to the S.O. for approval before they are used, and subsequent delivery shall be up to the standard of samples approved.

11.2. Reflective Foil

- 11.2.1. Reflective foil shall be fire-retardant double sided aluminium reflective foil bonded to reinforced high density polyethylene woven fabric comply with MS2095: 2014
- 11.2.2. The reflective foil materials used shall conform to fire safety requirements and BS 476 Part 6 & Part 7 (Class O): Fire Test on Building Materials and Structures on the following test:
- 11.2.2.1. Part 6: Method of test for fire propagation for products conforming to BS 476
- 11.2.2.2. Part 7: Method of test to determine the classification of the surface spread of flame conforming to BS 476
- 11.2.3. Reflective foil properties shall conform to the following:
- 11.2.3.1. Thickness : 137 ± 20 micron thick.
- 11.2.3.2. Grammage : $163 \pm 10\text{g/m}^2$.
- 11.2.3.3. Tensile strength: 500 N/ 50mm (MD), 500 N/50mm (Cross Direction) MD $\geq$ 9.5; CD $\geq$ 6.0.
- 11.2.3.4. Emissivity ASTM E408 $\leq 0.05(97\pm 2\%)$ / Reflectivity = 95%
ASTM C1371 ≤ 0.05
- 11.2.3.5. Initial Tear resistance: ASTM D1004 $>30\text{N} \geq 65.0$
- 11.2.4. Reflective foil material shall be used on its own with all types of roofs except with metal decking roof. Where the roof is of metal decking, the reflective insulation material shall be laid below stone wool or glass wool for effective thermal and acoustic performance.

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11.2.5. The reflective foil material shall be installed strictly in accordance with the manufacturer's recommendation. A uniform air space of 20mm to 50mm between the tile roof covering and the insulation material shall be provided to ensure the effectiveness of the reflective surface. All punctures shall be effectively sealed with similar reflective material to prevent air leakage and moisture transfer.

11.2.6. The reflective foil surface shall be free from any thin film of oil, plastic or lacquer coatings. All dust and/or moisture, if any, shall be thoroughly cleaned prior to installation. All dust and/or trademarks shall be limited to a maximum of 5% of the total reflective area. The insulation material shall be fitted closely around electrical outlet boxes, plumbing etc and taped securely to eliminate gaps or voids through which air or water vapour might pass into the cooler space.

11.3. Glass Wool Insulation

11.3.1. Unless otherwise shown on the Drawings, glass wool insulation shall be 85mm thick. It shall have R-Value @ R2.0 to R2.3 m²KW (tested at a mean temperature of 20°C based MS1020 and MS1525 tested according to ASTM C177/C518) and comply with MS1525. The glass wool insulation material used shall conform to BS 476 for Fire tests on building materials and structures on the following:

11.3.1.1. Part 6: Method of test for fire propagation for products conforming to BS 476

11.3.1.2. Part 7: Method of test to determine the classification of the surface spread of flame conforming to BS 476.

11.3.2. The glass wool insulation material used shall be of no added urea formaldehyde and as approved by the S.O.. Glass wool insulation shall be fixed in accordance with the manufacturer's recommendations and to the approval of the S.O..

11.3.3. Where a single skin metal roof is applied, galvanised wire mesh BRC 3316 or equivalent shall be used to support the reflective foil and the glass wool insulation.

11.3.4. Glass wool insulation material used shall be non-combustible under BS 476 Part 4 or EN 13501-1 Class A1:

Any reference to being Class O shall be construed as a requirement as following:

a. The material shall be non-combustible as per BS 476 Part 4; or

b. Classified as EN13501 Class A1 non-combustible material.

11.3.5. Glass wool insulation material used shall made of fibres, which comply with the exoneration criteria for carcinogenicity (Note Q) of the Regulation (EC) 1272/2008 and EUCEB certified.

11.3.6. Use of plastic or polyurethane foam (PU foam) based insulation shall be prohibited due to health hazards. PU foam-based insulation releases toxic substances when heated and burned.

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11.4. Mineral Wool Insulation

- 11.4.1. Unless otherwise shown on the Drawings, it shall have R-Value @ R2.0 to R2.3 m²KW (tested at a mean temperature of 20°C based MS1020 and MS1525 tested according to ASTM C177/C518). The mineral wool insulation material used shall conform to BS 476 for fire tests on building materials and structures on the following:
 - 11.4.1.1. Part 6: Method of test for fire propagation for products conforming to BS 476.
 - 11.4.1.2. Part 7: Method of test to determine the classification of the surface spread of flame conforming to BS 476.
- 11.4.2. The mineral wool insulation material used shall be of no added urea formaldehyde and as approved by the S.O.. Mineral wool insulation shall be fixed in accordance with the manufacturer's recommendations and to the approval of the S.O..
- 11.4.3. Where a single skin metal roof is applied, galvanised wire mesh BRC 3316 or equivalent shall be used to support the reflective foil and the mineral wool insulation.
- 11.4.4. Where a double skin metal roof is applied, underliner must be used to support the insulation components and supporting structure such as sub-girt, tophat, batten or other equivalent must be provided in between underliner and outer cladding to form the insulation system without compression.

11.5. Stone Wool Insulation

- 11.5.1. Unless otherwise shown on the Drawings, stone wool insulation shall be 50mm thick minimum. It shall have R-Value @ R2.0 m²-KW (tested at a mean temperature of 20°C based MS1020 and MS1525 tested according to ASTM C177/C518). The stone wool insulation material used shall conform to BS 476 for fire tests on building materials and structures on the following:
 - 11.5.1.1. Part 6: Method of test for fire propagation for products conforming to BS 476.
 - 11.5.1.2. Part 7: Method of test to determine the classification of the surface spread of flame conforming to BS 476.
- 11.5.2. The stone wool insulation shall conform to the following:
 - 11.5.2.1. Thermal conductivity 0.034 - 0.036 W/mK at 20°C mean temperature tested in accordance with ASTM C518.
 - 11.5.2.2. Noise reduction coefficients (NRC) of up to 1.0 tested to BS EN ISO354 at 50mm thickness.
 - 11.5.2.3. Non-combustible according to BS 476 Part 4 or EN 13501-1 and melting point of at least 1000°C in accordance with ASTM E794.



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- 11.5.2.4. No CFCs, HFCs, HCFCs or asbestos shall be used in the manufacture of the product.
- 11.5.2.5. No perceptible odour shall be present when tested in accordance with ASTM C665.
- 11.5.2.6. Not sustaining fungus growth under normal conditions according to ASTM C1338.
- 11.5.2.7. The metal plates (steel and aluminium) in contact with the insulation shall show no corrosion greater than that observed on the comparative plates in contact with sterile cotton according to ASTM C665.
- 11.5.2.8. Flame spread index less than zero (0) and smoke developed index less than five (5) according to ASTM E84.
- 11.5.2.9. Total VOC emission shall be less than 0.25 mg/m³ and particle emission shall be less than 0.02 mg/m³ tested according to ASTM D5116.
- 11.5.2.10. Moisture absorption shall be less than or equal to 0.04%vol. according to ASTM C1104/C1104M and water absorption shall be less than or equal to 0.5kg/m² (short-term immersion) according to EN1609.
- 11.5.3. The stone wool insulation material used shall be of no added urea formaldehyde and as approved by the S.O.. Stone wool insulation shall be fixed in accordance with the manufacturer's recommendation and to the approval of the S.O..
- 11.5.4. The insulation material must be protected from the exposure of rain, water immersion and chemical contamination during the storage and installation. If the insulation is in contact with water, adequate drying time must be allowed to ensure that the insulation is completely dried prior to covering of the roof covers. Stone wool insulation material used shall be non-combustible under BS 476 Part 4 or EN 13501-1 Class A1:
- i) Any reference to being Class O shall be construed as a requirement that;
- a. The material shall be non-combustible as per BS 476 Part 4; or
- b. Classified as EN13501 Class A1 non-combustible material.
- 11.5.5. The stone wool insulation shall be installed to the thickness specified and placed butt jointed. Wherever possible the Contractor shall avoid the compression of the insulation material. Stone wool insulation material used shall be made of fibres, which comply with the exoneration criteria for carcinogenicity (Note Q) of the Regulation (EC) 1272/2008 and EUCB certified.

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- 11.5.6. Where a single skin metal roof is applied, galvanised wire mesh BRC 3316 or equivalent shall be used to support the reflective foil and the stone wool insulation. Use of foam-based insulation shall be prohibited due to health hazards. Foam-based insulation releases toxic substances when heated and burned.
- 11.5.7. Where a double skin metal roof is applied, underliner must be used to support the insulation components and supporting structure such as sub-girt, tophat, batten or other equivalent must be provided in between underliner and outer cladding to form the insulation system without compression.

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1. General

- 1.1. This section gives overview of Rainwater Harvesting System and describes its key components.
- 1.2. The Rainwater Harvesting System is an alternative to reduce domestic water consumption in a building.
- 1.3. The Contractor shall comply with all relevant statutory requirement and regulations.
- 1.4. The completed Rainwater Harvesting System drawing shall be submitted to the local authorities for approval before installation.

2. Rainwater Harvesting System

2.1. General

- 2.1.1. Rainwater Harvesting System shall be provided complete with catchment area including all necessary accessories as specified.
- 2.1.2. Harvested rainwater shall be strictly used for non-potable uses only. Non-potable may include landscape irrigation, exterior washing and flushing of toilets.
- 2.1.3. The provision of the Rainwater Harvesting System shall be in accordance with the Rainwater Harvesting Guidebook and Urban Stormwater Management Manual (MSMA) by *Jabatan Pengairan dan Saliran Malaysia (JPS)*, and MS 2526-6: Urban Stormwater Management - Part 6: Rainwater Harvesting.

2.2. Pre-Filtration

- 2.2.1. Pre-filtration is required to keep sediment, leaves, contaminants and other debris from the system and to significantly cut down on maintenance by preventing organic build up in the storage tank.
- 2.2.2. All pre-filtration devices may include the first-flush diversion systems, filters and screens designed to remove debris from the captured rainwater before storage tank and should be of low maintenance.

2.3. Filter

- 2.3.1. The filter shall be provided to remove suspended pollutants from the captured rainwater for flushing and non-potable use.
- 2.3.2. A filter unit system consists of a chamber and shall be filled with filtering media such as carbon fibre, coarse sand and gravel layers to remove debris and dirt from rainwater before it enters the storage tank. The selection and type of filtering media shall be to the S.O.'s approval.

2.4. Storage Tank

- 2.4.1. The Contractor shall provide rainwater harvesting storage tank as described under SECTION W: WATER RETICULATION.

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2.5. Water Backup

- 2.5.1. The water backup system from the main water supply shall be provided to supply water when rainwater is not available in the rainwater tank
- 2.5.2. Any service pipe conveying potable to top-up a rainwater tank containing non-potable water shall have a backflow preventer of the dual check valve type; and the service pipe shall terminate at least 255mm above the overflow level of the rainwater tank.

2.6. Piping Works

- 2.6.1. The Contractor shall provide pipe works as described under SECTION W: WATER RETICULATION.
- 2.6.2. There shall be no cross connection between non-potable and potable water distribution system within the buildings.
- 2.6.3. Taps and outlets for non-potable water shall be clearly identified as 'Not for Drinking Purposes'.

2.7. Pumping System

- 2.7.1. The Contractor shall provide a pumping system as described in the *Rainwater Harvesting Guidebook and Urban Stormwater Management Manual (MSMA) by Jabatan Pengairan dan Saliran Malaysia (JPS), and MS 2526-6: Urban Stormwater Management - Part 6: Rainwater Harvesting.*
- 2.7.2. The Contractor shall supply and install electrical motors, starters and electrical switchboard for the pumping system to Engineer's details.

2.8. Metering

- 2.8.1. Suitable water meter approved by SPAN shall be supplied and installed where required.

3. Scope of Work

- 3.1. The Rainwater Harvesting System that is installed in the building shall fall under Mechanical scope of works.
- 3.2. The Rainwater Harvesting System which is located outside the building shall fall under Civil scope of works.

4. Rainwater Goods

4.1. Flashing

- 4.1.1. Unless otherwise shown on the Drawings, all flashing shall be of aluminium zinc alloy coated steel sheet, free from cracks, dross, scales, excess blisters and any other defects which might be detrimental to its wearing or working properties. Sheets shall be reasonably flat before forming and cutting.

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- 4.1.2. All steel sheets used for flashing shall be 0.8mm thick minimum. Flashing shall have a minimum depth of 200mm with the upper edge turned into the wall and pointed in cement or approved sealant. Where nails or screws are used for fixing, they shall be of the heavily galvanized type.
- 4.1.3. All fasteners to be concealed where possible. Install work with laps, joints and seams that will be permanently watertight and weatherproof. All laps shall be at a minimum of 200mm. The flashing work shall be performed by skilled workmen.
- 4.1.4. All fasteners used near marine environment shall comply with AS 3566 Class 4 and be certified as such by the supplier of fasteners and to the approval of the S.O..
- 4.1.5. All fixings and associated components near marine environment shall be manufactured from compatible metals and coated conforming to ISO 9223 Category 4 (C4) and Category 5 (C5) environment. Flashings shall be made from the same material as the roofing sheets.
- 4.2. Gutters
 - 4.2.1. General
 - 4.2.1.1. Where gutters are to be provided, they shall conform to the shape, dimensions and materials, free from distortions and defects detrimental to water-tight system. All gutters shall be provided and fixed complete with all necessary angles, squares and obtuse, stop end, outlets and other necessary gutter fittings and to be supplied by the same manufacturer unless otherwise shown on the Drawings.
 - 4.2.1.2. Gutter outlets shall be located at the position shown on the Drawings and each provided with leaf trap of the same material unless otherwise specified.
 - 4.2.1.3. All gutters other than those of reinforced concrete shall be properly fixed and adequately supported and all necessary brackets shall be provided. Brackets shall be of the type and pattern that will confirm to the profile of the gutter and shall be of galvanized steel screwed to the fascia.
 - 4.2.1.4. Unless otherwise shown on the Drawings, the gutter shall be uPVC and shall be laid to a minimum fall of 12mm in 1m with properly constructed laps or joints laid in the direction of flow.
 - 4.2.2. Aluminium Gutters
 - 4.2.2.1. Unless otherwise shown on the Drawings, all gutter linings, valley and eaves gutter shall be of aluminium and shall conform to the following sizes:
 - (i) Gutter lining: 1.2mm thick, 225mm minimum depth against walls, 330mm minimum width under roofing, to a fall of 50mm in 3m.
 - (ii) Valley Gutter: 1.2mm thick, turned under roofing 330mm minimum each side.

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- (iii) Eaves Gutter: 1.2mm thick jointed using soldered seams neatly and accurately executed.

4.2.2.2. Gutter linings and valley gutters shall be laid on 25mm thick close timber boarding adequately supported.

4.2.3. Unplasticised Polyvinyl Chloride (uPVC) Gutters

4.2.3.1. uPVC gutters shall be lead free conforming to BS EN 607 for gutter profiles and fittings and BS EN 1462 (Lead-Free) for the gutter brackets. All gutters and fittings shall be installed as recommended by the manufacturer with a product warranty as approved by the S.O..

4.2.3.2. The gutter shall be jointed using solvent cement conforming to MS628:Pt.2 and in accordance with the manufacturer's instructions. Expansion outlets shall be provided for the gutter as recommended by the gutter manufacturer and as approved by the S.O..

4.2.4. Galvanized Iron (G.I) Gutters

4.2.4.1. All gutters shall be supplied by specialized manufacturers approved by the S.O.. Each section shall be sufficiently rigid, edges and corners straight and the slopes perfectly uniform. G.I. gutters shall have the edges strengthened by suitable means.

4.2.4.2. Unless otherwise specified, the gutters shall have a minimum fall of 1 in 120. Adequate number of support brackets shall be provided so that there is no deflection even when the gutter is at full capacity. Each joint must have a support. Unless otherwise specified the supports shall be fabricated mild steel brackets. All junctions shall be thoroughly watertight. The joints may be made by riveting, bolting or soldering.

4.2.4.3. All joints between successive lengths of gutters shall have an overlap of at least 75mm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed watertight. Junction with rainwater down comers shall be made fully watertight and secured.

4.2.4.4. Gutters for marine environment shall be pre-painted finish with metallic coated steel with minimum aluminium/zinc alloy coating mass of 200g/m² (Coating Class AZ 200) conforming to ISO 9223 Category 4 (C4) and Category 5 (C5) environment.

4.2.5. Stainless Steel Gutters

4.2.5.1. The stainless-steel grade shall be in Grade 304 for normal atmosphere and Grade 316 for atmosphere with a high chloride content (e.g. near the sea, or in heavily industrialized areas) with standard bright mill finish.

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4.2.5.2. Unless otherwise specified, the gutters shall have a minimum fall of 1:120. Adequate number of support brackets shall be provided so that there is no deflection even when the gutter is full capacity. Each joint must have a support. Unless otherwise specified the support brackets shall be of the same material. All junctions shall be thoroughly watertight. The joints may be made by riveting, bolting or soldering.

4.2.5.3. All joints between successive lengths of gutters shall have an overlap of at least 75mm. The drop in the overlap shall always be in the direction of the fall of the gutter. Ends of gutters shall be closed watertight. Junction with rainwater down comers shall be made fully watertight and secured.

4.3. Rainwater Downpipes

4.3.1. General

4.3.1.1. All downpipes shall be provided complete with all necessary fittings including rainwater heads, rainwater shoes, radius, bends, pipe clips, offsets, leaf traps and everything else required.

4.3.1.2. Outlets on flat roof and balcony connected to downpipe shall be provided with an approved uPVC, or stainless-steel grating. Outlet shall be neatly dressed including sealing as necessary prior to applying asphalt prime flanges of roof outlet with bitumen or proprietary roofing waterproofing material to manufacture recommendation and as approved by the S.O..

4.3.2. Unplasticised Polyvinyl Chloride (uPVC) Downpipes

4.3.2.1. Unless otherwise shown on the Drawings, uPVC downpipes and fittings shall be lead-free and comply with BS EN 12200-1. The pipes shall be jointed with approved solvent cement in accordance with the manufacturer's instructions.

4.3.2.2. Where shown, approved circular uPVC downpipes shall comply with BS EN 1329-1. The pipes shall be jointed with approved solvent cement in accordance with the manufacturer's instructions.

4.3.2.3. Where shown, approved uPVC pipes cast inside Reinforced Concrete Columns/Buried Underground, the downpipes shall comply with BS EN ISO 1452-2 (heavy duty type). The pipes shall be jointed with approved solvent cement in accordance with the manufacturer's instructions.

4.3.2.4. Where shown, uPVC downpipes installed to side of walls or brick walls shall be fixed using special clips supplied by the gutter manufacturer. Pipe clips shall be installed at every 1.8m interval along the downpipes.

4.3.2.5. Where shown, uPVC downpipe fixed to concrete soffit or suspended slab shall include approved hot dip galvanized steel hangers, installed to manufacturer's recommendation and to S.O.'s approval.

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5. Testing and Commissioning

- 5.1. On completion of the Rainwater Harvesting System installation, the Contractor shall notify the S.O. that they are ready for inspection, testing and commissioning.
- 5.2. The Contractor shall carry out testing and commissioning to the S.O.'s approval as described in SECTION W: WATER RETICULATION and SECTION O: INTERNAL COLD WATER AND SANITARY PLUMBING SYSTEM.

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1. General

- 1.1. Unless otherwise specified or shown on the Drawings, the timber species used for the Works shall be as stated hereinafter in the **TABLE I1**: Schedule of Timber Grouping and Usage. The strength grouping for timber shall be in accordance with MS 544 as shown hereinafter in the **TABLE I2**: Schedule of Timber Species in Accordance with Strength Grouping.
- 1.2. All carpentry and joinery work shall include all necessary notching, halving, mortise and tenoning, wedging, scarfing, dovetailing, sinking for heads of bolts and nuts and trimming for opening.
- 1.3. All carpentry work shall be left with a sawn surface except where particularly described to be wrot. All joinery shall be wrot and finished with sand paper as required and all sizes stated are the finished sizes. Sizes for carpentry shall be within the tolerances stated in sub-section 2.1. and sizes for joinery shall be within the tolerances stated in sub-section 2.2.
- 1.4. Unless otherwise indicated on the Drawings, all fire protection materials and systems must show evidence that they have been subjected to the fire resistance test in accordance with BS 476 or other approved equivalent standards.

2. Timber Grades and Size Tolerances

- 2.1. Unless otherwise specified, sawn timber for carpentry work shall be as stated hereunder:
 - 2.1.1. Select Structural Grade - for roof truss
 - 2.1.2. Standard Structural Grade - for structural work
 - 2.1.3. Sound Grade - for General Market Specification (GMS) and strips
 - 2.1.4. Serviceable Grade - for scantling
- 2.2. Grading shall be carried in accordance with the Malaysian Grading Rules (MGR) For Sawn Hardwood Timber by timber graders registered with the Malaysian Timber Industry Board (MTIB). Every timber consignment shall be accompanied by the Grading Summary and Certificate of Compliance certified by registered timber grader. The sample of Certificate of Compliance is shown in **APPENDIX I2** as stipulated in MS 1714. Notwithstanding the certificate, the S.O. reserves the right to carry out independent tests at Makmal Anatomi Kayu, Forest Research Institute Malaysia (FRIM) or Fibre and Biocomposite Centre (FIDEC), MTIB to determine the species and Strength Group (SG). The sizes of sawn timber, except where otherwise specified, shall be within the margin of permissible variations stated hereunder:
 - 2.2.1. For widths, depths or thicknesses not exceeding 75mm - within 3mm of the specified size.
 - 2.2.2. For widths, depths or thicknesses exceeding 75mm - within 5mm of the specified size.

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- 2.3. The Contractor shall provide any necessary blocks, wedges or battens to compensate for irregular surfaces caused by any variations in size of timbers hereby permitted.
- 2.4. Unless otherwise specified or shown on the Drawings, sawn timber for joinery work shall be of Sound Grade (General Market Specification (GMS) and Strips) and Serviceable Grade (Scantlings). The finished size for joinery, unless otherwise specified, shall be within the margin of permissible variation stated hereunder:
 - 2.4.1. For widths, within 3mm of the specified finished size.
 - 2.4.2. For thicknesses, within 2mm of the specified finished size.
- 2.5. Unless otherwise specified or shown on the Drawings the required actual dimensions shall be referred to the common commercial timber sizes given in **TABLE I6**.

3. Treatment of Timber

- 3.1. All timber except the heartwood of the naturally durable timbers as scheduled in **TABLE I2** hereinafter and timber for formwork, scaffolding, and other temporary works shall be impregnated by means of vacuum pressure processes in accordance with MS 360 using Copper Chrome Arsenic (CCA) wood preservatives conforming to MS 733 in the treatment plant registered with the MTIB.
- 3.2. If a timber component has sufficient natural resistance to decay and insect attack by virtue of the natural durability of its heartwood, it may be used without treatment even where the hazard exists. The natural durability classification of Peninsular Malaysia and Sabah and Sarawak timbers for ground contacts can be found in MS 360 and as shown in **TABLE I4** and **TABLE I5**. Sapwood should not be used without preservative treatment.
- 3.3. All timber for internal use and direct contact with humans shall be coated with a minimum of two (2) coats of protective coating and shall be applied in accordance with the manufacturers' specification to S.O.'s approval.
- 3.4. Unless otherwise specified, the average moisture content for all timber shall not exceed 25% in accordance with MS 360. The moisture content shall be determined in accordance with one of the methods given in MS 837.
- 3.5. All timber shall be sawn or planed before treatment to achieve the finished cross-section required. As far as possible, all cross-cutting, boring, drilling or other processing should be carried out before treatment.
- 3.6. The pH value of the treating solution shall not be higher than 3.0 when determined by a glass electrode or pH paper at ambient temperature in accordance with MS 360.
- 3.7. The net dry salt retention shall be determined in accordance with one of the methods given in MS 360 and MS 821. The minimum salt penetration shall be determined by one the test methods given in MS 833.

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- 3.8. The material shall be collected by drilling to the required depth as recommended and shown in MS 360 **TABLE I4**. It can also be collected by sawing to the required depths and then chipped to the small size. Either sawdust or chipped materials shall be ground to fine powder.

- 3.8.1. The minimum net dry salt retention for CCA shall be as shown in the table below.

No	Use	Minimum Net Dry Salt Retention For CCA
i)	Interior and above the ground	5.6 kg/m ³
ii)	Exterior and above the ground	8.0 kg/m ³
iii)	Exterior and in contact with the ground (other than foundation piles)	12.0 kg/m ³

- 3.8.2. All sapwood shall be fully penetrated by the preservative and for heartwood, the depth of penetration shall be at least 6mm for the surface of the specimen and any cracked section which may appear.

- 3.9. The Contractor, when required by the S.O. shall produce a certificate from a preservative treatment plant which certifies that timber required to be impregnated by means of vacuum pressure processes has been impregnated and has achieved the necessary nett dry salt retention. Notwithstanding the certificate, the S.O. reserves the right to carry out independent tests to determine the nett dry salt retention and the result so obtained shall be conclusive.

- 3.9.1. Treatment certificate

- 3.9.2. A treatment certificate shall be produced for each batch of timber delivered from the treatment plant. The relevant charge sheets shall be attached with each treatment certificate. The following information shall appear on the certificate:

- 3.9.2.1. Name and address of buyer;
- 3.9.2.2. Project title/reference;
- 3.9.2.3. Name of treating company;
- 3.9.2.4. Name of preservative(s) used;
- 3.9.2.5. Average retention of preservative obtained;
- 3.9.2.6. Charge sheet number and date of treatment;
- 3.9.2.7. Species of timber treated together with sizes and volume;
- 3.9.2.8. Commodity and hazard class; and
- 3.9.2.9. Other registration number (where applicable)

- 3.9.3. The certificate shall be signed by authorized personnel of the treating company, certifying that the timber has been treated in accordance with MS 360.

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3.9.4. Timber treatment with other types such as heat treatment are allowed in accordance with relevant standards.

4. Moisture Content and Storage

- 4.1. At the time of installation, the moisture content of the timber for the various applications shall not exceed that as specified in **TABLE I3** in accordance with MS 544: Part 1.
- 4.2. Moisture content for foundation piles, formworks and temporary works is not critical for these applications and therefore is not specified.
- 4.3. Moisture content of timber shall be determined as follows as in accordance with MS 837. The summary of standard procedure are as follows:
 - 4.3.1. For determination of the average moisture content of test specimens, immediately weigh each of the test specimens or sections which are required to be free from saw dust and any loose splinters.
 - 4.3.2. In cases when it is not possible to weigh the test specimens or sections immediately after cutting, place them in previously tared packets of moisture-proof plastic films and tightly sealed.
 - 4.3.3. Dry the weighted test specimens or sections at a temperature of $103^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for at least 24 hours. To ensure that the test specimens or sections have attained approximately constant mass, a repeated weighing of two or three control pieces is required after further 2 hours. The difference in mass between the two successive weighing shall be less than 0.2%.
- 4.4. On delivery to the Site, all timber other than timber for foundation piles, formworks and temporary works shall be properly open-stacked, under cover. Kiln dried timber shall be properly wrapped and stored under cover if it is not used immediately.
- 4.5. Care should be taken on Site to ensure that the timber is adequately protected from the weather. This is particularly important with material dried to below 19% moisture content, since the full design load should not be applied if the moisture content rises above 19%.

5. Structural Assemblies of Timber

- 5.1. The workmanship and method of assembly of structural timber shall generally be in accordance with MS 544 and the following requirements:
 - 5.1.1. The quality of the surface, as finished, shall be appropriate to the position and use of the timber.
 - 5.1.2. When grade or other necessary marks are removed, provisions shall be made for remarking in accordance with Malaysian Grading Rules (MGR) for Sawn Hardwood Timber. Surfaces at any joint in an assembly shall be such that the parts may be brought into contact over the whole area of the joint before connectors are inserted or any pressure or restraint from the fastening is applied. These surfaces shall have a good sawn or planed finish.

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5.1.3. Bearing surfaces of notches and other cuttings shall be true and smooth and in appropriate relation to the other surfaces of the piece.

5.2. Notches other than at the ends of beams shall be U-shaped formed by parallel cuts to previously drilled holes. The diameter of the hole shall be equal to the width of the required notch.

5.3. Where splitting is likely to have a deleterious effect, end sealing is recommended. For timbers known to split and check especially after installation, the ends of the boards and scantlings shall be protected with a coating designed to minimise end checking and splitting. In severe cases where the ends and sides of heavy joists of timbers are liable to excessive split and check due to exposure to windward slanting sunlight, appropriate skirting or cover with a thin timber board shall be necessary.

6. Timber Joints

6.1. When solid timber members are to be joined together using mechanical fasteners, the workmanship and method of assembly shall be in accordance with MS 544: Part 5. The mechanical fasteners are as listed below:

6.1.1. Nailed Joint

Where necessary to avoid splitting, nails shall be driven into pre-drilled holes or diameter not greater than four-fifths of the diameter of the nails. Care shall be taken to avoid placing nails in any end split.

6.1.2. Screwed Joint

Lead holes shall be used to ensure good workmanship in making screwed joints. The diameter of the hole for the shank shall be equal to the diameter of the shank, and for the threaded portion, the diameter of the hole shall not be greater than seven-eighth of the diameter of the root diameter of the screw thread adjacent to the shank. Care shall be taken to avoid placing screws in any end split.

6.1.3. Bolted Joint

6.1.3.1. Bolt holes shall be drilled to diameters as close as possible to the nominal diameter of the bolt and in no case more than 2mm larger than the bolt diameter. Care shall be taken to avoid placing a bolt in any end split. A minimum of one complete thread should protrude from the nut.

6.1.3.2. A washer shall be fitted under the head of each bolt and under each nut. The minimum sizes of washers are shown in **Table I7** as given in accordance with MS 544: Part 6. Where joints using split-rings are to be used, as shown on the Drawings, the members of the joints shall be fitted together in their appropriate positions and clamped or spiked together before drilling. Alternatively, drilling jigs or multiple head boring machines may be used, or individual members may be marked out from the setting-out or by use of prepared templates.

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- 6.1.3.3. If either of the latter methods is employed, sample members (usually the first ones produced) shall be carefully checked against the setting-out.
- 6.1.3.4. In all instances holes for bolt positions shall be accurately determined by reference to the point intersection of the centre lines of the member. Great care is necessary if the first set member marked out is to be used subsequently as drilling templates. Greater accuracy can usually be obtained by using special marking or drilling templates located by a pin at the intersection of the centre lines.
- 6.1.3.5. Bolts holes shall be drilled at right angles to the surface of the joint. The contact surfaces of the members should be grooved to the appropriate dimensions as given in Part 6 of MS 544.
- 6.1.3.6. Drilling and grooving may be done in a single operation; alternatively, if the hole is pre-drilled the pilot of the grooving tool shall fit in the bolt hole, thus centring the groove about the hole.
- 6.1.3.7. Care shall be taken to ensure that all chips and shavings are removed, and rings shall be expanded before being placed in the grooves.
- 6.1.3.8. The joint shall be finally assembled and bolts inserted. Washers of the correct dimension shall be placed under the head of the bolt and the nut, and the nut tightened to hold the members together.
- 6.1.3.9. Recess for shear-plate connectors shall be accurately cut by means of a suitable tool to be appropriate dimensions as given in MS 544: Part 6.
- 6.1.3.10. Assembly of units shall be done on a level bed and in such a way as to avoid damage to any of the members and so that the finished structural units conform to detailed drawings and specifications supplied.
- 6.1.3.11. When assembly is to be performed on the Site, one set of component parts shall be fitted together and dismantled prior to dispatch to the Site, to ensure that the assembled structural units conform to the detailed Drawings and Specifications. Twisted or damaged members shall be replaced before erection on the Site.
- 6.1.3.12. Before proceeding with bulk production, a complete assembly of one of each framed truss or other structural unit shall be checked to prove the accuracy of the templates, etc. A similar check shall be carried out from time to time to control the wear and tear on templates and gauges.
- 6.1.3.13. Timber members and built-up units shall be marked in accordance with a marking diagram.

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7. Prefabricated Timber Roof Truss System

7.1. All prefabricated components shall be manufactured only by reputable licensed truss suppliers listed in J-TRUSS system online (Application and Approval of Truss System Provider) and approved by the S.O.. This supplier duly termed as 'System Provider' is responsible for the analysis, design, detailing, drawing, manufacture, material, handling and erection of the roof members, and their ancillary fixing components. The full requirement is outlined in the Specification for Prefabricated Timber Roof Trusses (JKR 20601-0190-12) or the latest edition published by JKR.

7.2. All projects shall be registered through J-Truss Online System in accordance with the latest requirement imposed by JKR Malaysia.

7.3. System Provider

The System Provider (S.P.) is a supplier of a proprietary roof truss system appointed by the Contractor and approved by the S.O., which employs Quality Assurance procedures in the design, detailing, connection, bracing, erection criteria and manufacture of truss components for the structural roof truss system.

7.4. Duties of Professional Engineer

7.4.1. The S.P. shall appoint a Professional Engineer (P.E.) whose duties shall include the following:

7.4.1.1. Preparation of roof truss analysis and design;

7.4.1.2. Preparation of drawings;

7.4.1.3. Design changes in every stage of work;

7.4.1.4. Certification for completion of roof truss installation;

7.4.1.5. Final certification for roof truss installation prior to issuance of Certificate of Practical Completion for the whole Works to the Contractor.

7.5. Fabricator

All trusses shall only be assembled by licensed fabricators approved by the S.P. and registered with CIDB. A copy of the CIDB registration certificate shall be submitted to the S.O. for verification.

7.6. Installer

All installation works shall be executed and supervised by qualified personnel with valid certificates issued by CIDB. The S.O. shall verify the identification and qualification of the installer prior to the installation.

7.7. General Truss Limitation

7.7.1. Prior to any prefabricated timber roof trusses works, the following general limitation shall be applied:

7.7.1.1. Maximum unsupported truss span 12m with permitted deviation of $\pm 0.05\text{m}$.

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7.7.1.2. Maximum truss spacing of 1.2m with permitted deviation of $\pm 0.025\text{m}$.

7.7.1.3. The minimum basic wind speed shall be 35m/s. However, the minimum basic wind speed shall be increased to 41m/s for lightweight roof covering.

7.7.1.4. Maximum roof pitch shall be of 45°.

7.8. Analysis, Design Report and drawings Submission

7.8.1. The S.P. through the Contractor shall propose to the S.O. for his approval a roof truss system which is safe, functional and conforming to design standard. Submission of proposal shall include truss analysis, design report, and construction drawings. The truss analysis shall indicate all loads, load combinations, connections criteria, bracings and tie-down of the truss. Design output of the truss members, battens, connections, tie-down and wall plates, anchors, bracings, truss accessories, splicing and stiffeners where related to the analysis shall be included in the design report. (In accordance with Specification Pre-Fabricated Timber Roof Truss - JKR 20601-0190-12).

7.8.2. All details in the construction drawings shall be sufficient to enable checking against the analysis and design report, by specifying and providing not limited to: the truss layout and configuration, timber grades, section properties of members, length of members in each truss configuration, properties of truss accessories, specification of fastener and anchor, tie-down and anchoring details and all types of connection details including the connection of all attachments to the trusses.

7.8.3. Technical specifications for fastener and anchor of which the design refers to shall also be submitted. Verification test certificate from an approved accredited laboratory on the technical parameter specified in the technical specifications shall be submitted upon request by the S.O..

7.9. Warranty

7.9.1. When a refabricated timber roof truss system is used, the Contractor shall submit to the S.O. a warranty from the S.P. certified by a P.E. with the following provisions:

7.9.1.1. All roof truss components shall be manufactured only by approved S.P. producing quality assured products and services.

7.9.1.2. System Provider's Warranty against any defects or damages which may arise during a period of ten (10) years from the Date of Practical Completion of Works due to any defect, fault or insufficiency in design, materials or workmanship or against any other failure which an experienced Contractor may reasonably contemplate but shall not include normal replacement and maintenance.

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8. Engineered Timber Product (ETP) for Structures

8.1. General

- 8.1.1. This sub-section shall apply to the construction of all structures or parts of structures to be composed of engineered timber products which is glue laminated timber (Glulam), laminated veneer lumber (LVL) and cross laminated timber (CLT) (refer Figure I1). The work shall be carried out all in accordance with this specification and the lines, levels, grades, dimensions and cross-sections shown on the Drawings and as required by the S.O..
- 8.1.2. Glue-laminated timber (Glulam) is a structural timber product manufactured by glueing together individual pieces of dimensioned timber, having their grain essentially parallel and manufactured in accordance with the relevant Standards. The laminations thickness is allowed within 2mm up to 50mm.
- 8.1.3. LVL is a structural timber product manufactured by bonding together rotary peeled or sliced thin wood veneers under heat and pressure. The minimum numbers of veneer shall be five (5) and maximum thickness of each veneer shall be 6mm.
- 8.1.4. CLT is a solid wood board which is manufactured by glueing boards/battens crosswise in several layers.

8.2. Design Requirement

8.2.1. Design Data

8.2.1.1. Load Item

All loads shall be clearly itemised as below: -

(i) Dead Load

Dead load shall be specified as per requirement in MS EN 1991-1-1, whichever standard adopted. However, the actual weight of ceiling, mechanical and electrical (M&E) services shall not be less than 0.25kN/m².

(ii) Imposed Load

The value and requirement of imposed load shall be as per MS EN 1991-1-1, whichever standard adopted. Notwithstanding to the value in the standard, the minimum value of imposed load shall be 0.25kN/m² distributed uniformly over the whole area supported and 0.9kN concentrated over a length of 125mm (or in the case of coverings, over a square of 125mm side so placed as to produce maximum stresses in the affected members).

(iii) Wind Load

- (a) The requirement of wind load shall be as per MS 1553 or MS EN 1991-1-4, whichever standard adopted, with the minimum basic wind speed as per sub-section 2.2 of this specification or the value in MS 1553 whichever higher.

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- (b) Load combinations shall be clearly identified (as per MS EN 1991-1-1, MS 544: Part 3 or other equivalent standards recognised internationally) and itemised to enable design checking to be carried out upon the most adverse conditions or the effect (of uplift) under consideration.

8.2.2. Design Standards

The design of ETP members, bracings, connections shall be in accordance with the following alternative of principal standards:

8.2.2.1. MS 544 Code of Practice for Structural Use of Timber

8.2.2.2. Any other equivalent standards recognised internationally

8.2.3. Eccentricity

The centroidal axes of the connected members should meet at a point, otherwise the effect of eccentricity of the connection should be taken into account in the design of the members and their connections.

8.2.4. Frame Stability

The analysis of ETP structure frame shall take the following requirements for frame stability:

8.2.4.1. Lateral forces i.e. wind load, notional load, seismic load, whichever governs.

8.2.4.2. Identification of loadpath for lateral stability.

8.2.4.3. Bracing system i.e. shear wall, steel brace etc.

8.2.4.4. Provision of ties for stability against progressive collapse

8.2.5. Designing to Avoid Tension Perpendicular to Grain

8.2.5.1. Whenever possible, joints should be designed to avoid causing tension perpendicular to grain stresses in ETP members.

8.2.5.2. Long lines of fasteners spaced together along the grain should be avoided, particularly if the bolts are in tightly drilled holes. These types of connections may induce tension perpendicular to grain stresses due to prying actions from secondary moments.

8.2.6. Load Suspended from ETP Member

Loads suspended from ETP beams or girders should preferably be suspended from the top of the member or above the neutral axis.

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8.2.7. Jointing, Connection and Bracing

8.2.7.1. Appearance

All connections/joints of ETP members shall be designed as concealed to provide neat joint appearances on all glulam ETP timber frames. Column to foundation and main rafter to column shall be constructed with flanges bolted connections with concealed internal connection to flange plates.

8.2.7.2. Uplift and Anchorage Loads

In cases where the ETP framing members must carry uplift and/or horizontal loads resulting from wind, seismic or construction conditions, such members are required to be anchored against any horizontal or vertical movements or incidental forces. As such, connection design shall include anchorage resistance to uplift and lateral movement apart from providing adequate bearing alone. The steel plate base shall be designed to be sufficient enough to take moment forces due to the frame being free standing structure during installation stage. The installation of J-Bolt (if required) shall be part of works of the main contractor.

8.3. Detailing and Drawings

8.3.1. Detailing Consideration

8.3.1.1. Consideration of Decay

- (i) Where an ETP member is exposed to the external weather conditions, all details shall ensure that water and moisture is dispersed and not allowed to pond or accumulate. Prevention of moisture and water entrapment can be achieved by measures such as the usage of moisture barriers, protective overhangs, flashings and other protective features.
- (ii) Arch and column bases shall be elevated a minimum of 300mm above the concrete floor level to cater potential for wetting of the floor.

8.3.1.2. Consideration of Shrinkage and Swelling

Whenever possible, all connections/joints detailing shall take into consideration the effect of timber swelling and shrinking due to moisture content changes in service to avoid splitting of members.

8.3.2. Detail Drawings

Construction Drawing shall consist of:

8.3.2.1. Layout Drawings

Layout Drawings shall indicate the plan view of all ETP members together with ties, bracing etc..

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8.3.2.2. Design Detail Drawings

The design detail drawings shall clearly indicate the following:

- (i) Shape of member
- (ii) Span, height, spacing, pitch, overhang and camber
- (iii) Designed wind load
- (iv) Structural capacity of member i.e. bending, shear, axial capacity etc
- (v) Magnitude and direction of forces transferred to the supporting structure
- (vi) Bracing
- (vii) Cambering

Each member shall be clearly drawn on a separate drawing that clearly itemises all member sizes, grade, lengths, angles, connector sizes, orientations and positions.

8.3.2.3. Bracing

Bracing layout and details shall be provided for the total ETP structure, by specifying the type of bracing and the connection details.

8.3.2.4. Connection

The connection method and fixing type of each member to member connection shall be clearly detailed to enable checking, installation and inspection. Type of connections shall be in accordance with sub-section 6.

8.4. Material and testing

8.4.1. Timber for ETP

8.4.1.1. Grade and Strength Group

Timber used for manufacturing of ETP intended for structural use shall be graded to Hardwood Structural Grade as stated in Table 1 MS 1714 by timber graders registered with the MTIB. The strength group shall be a minimum of SG5 or equivalent, in accordance with MS 544: Part 2. The cost involved in the visual strength grading shall be borne by the Contractor. Notwithstanding the certificate, the S.O. reserves the right to carry out independent tests at Makmal Anatomi Kayu, FRIM or Fibre and Biocomposite Centre (FIDEC), MTIB to determine the species and Strength Group (SG).

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8.4.1.2. Mixture of species

Timber of a single species shall be used in an ETP structure, and it is proven to be suitable for the manufacturing of ETP by the qualification test given in MS 758. Lamination of ETP members shall not be of a mixture of different timber species.

8.4.1.3. Moisture Content

The moisture content of the timber at the time of glueing, shall be within the range of 8% to 15% for non-treated timber and 11% to 18% for treated timber as stipulated in MS 758. The range of moisture content of the laminations in an ETP member shall be not greater than 4%. Method for the determination of the moisture content of is as stipulated in MS 837 or equivalent method. The summary of standard procedure to determine the moisture content is as stated in sub-section 4.4 of this section.

8.4.2. Preservative Treatment

8.4.2.1. The timber species should attain sufficient natural durability and resistance to decay and insect attack as stipulated in MS 544: Part 10.

8.4.2.2. Where it is not possible to use timbers which have sufficient natural durability, the timber shall be preservative treated. The treatment of timbers shall be in accordance with specification stipulated in MS 544: Part 10. If the preservative chemical is Copper Chrome Arsenic (CCA), it shall conform to MS 733 and sub-section 3.0 of this section. If any other preservative chemical is used, the main contractor shall provide necessary documents as may be required by the government's representative to prove the efficiency of the chemical treatment. Timber treatment with other types such as heat treatment are allowed in accordance with relevant standards.

8.4.3. Adhesive

8.4.3.1. Selection of Adhesive

The adhesive shall be capable of producing strong and durable joints, ensuring that the integrity of the bond is maintained throughout the intended lifetime of the structure. The adhesive shall meet the requirement for adhesive Type 1 and Service Classes as stipulated in Table 1 MS 758:2001.

8.4.4. Verification of Design Properties of ETP

The finished ETP shall comply with the required design properties as stipulated in MS 758. Verification shall be provided through:

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8.4.4.1. Qualification Tests

- (i) The Contractor shall be fully responsible to carry out qualification tests which shall be witnessed by the S.O.. The Contractor shall carry out a qualification test whenever a new process or process changes involving new adhesive, species combination, finger joint profile and lamination thickness.
- (ii) Unless otherwise stated and approved by the S.O. in writing, a minimum of five (5) qualification tests shall be carried out before any actual manufacturing is allowed.
- (iii) The Contractor shall provide in test report the information on the design properties which include characteristics values for bending strength, modulus of elasticity, compression strength, shear strength and tension strength. These properties values to be declared are characteristic values as shown on the Drawings.
- (iv) The test shall be carried out in accordance with BS EN 408 at any accredited approved laboratory at the expense of the Contractor.

8.4.4.2. Quality Control Tests

The Contractor shall provide information on the glue line integrity, results of delamination tests and results of glue line shear test as stipulated in MS 758. Unless otherwise stated and approved by the S.O. in writing, a minimum of ten (10) quality control tests shall be carried out before any actual manufacturing is allowed.

8.4.5. Coating Specification

- 8.4.5.1. All ETP members shall be coated with a minimum of two (2) coats of a clear construction sealer to provide a moisture resistant coating and shall be applied in accordance with the manufacturers' specification to the S.O.'s approval.
- 8.4.5.2. This should not be considered as a final finish as rectification of damage after erection shall be part of the Contract.
- 8.4.5.3. Details of the sealer used shall be documented and provided for on-going maintenance of the building.
- 8.4.5.4. All ETP members shall routinely receive a coat of protective sealer before shipping/transport and is wrapped for protection during shipping/transport and erection. The wrapping should be left in place as long as possible and ideally until permanent protection from the weather is in place.

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8.5. Manufacturing

8.5.1. Manufacturing Requirement

- 8.5.1.1. All glued laminated timber building components shall be manufactured and assembled by licensed glued laminated timber manufacturers approved by the S.O.. All the necessary documents relating to the proposed manufacturer such as valid licences or other certificates to the S.O. for approval prior to the commencement of any manufacturing work.
- 8.5.1.2. All glued laminated timber members shall be manufactured in a factory which has quality control and quality assurance procedures in place as approved by the S.O.. The S.O. reserves the right to visit the factory before giving any approval.
- 8.5.1.3. The manufacturing of ETP shall conform to MS 758 and relevant standards which specifies all the requirements for the manufacture of ETP which include among others;
 - (i) Production conditions – premises, and equipment and workmanship, quality assurance programme.
 - (ii) Adhesives - The adhesive shall meet the requirement for adhesive Type I and minimum Service Class 2 as stipulated in MS 758.
 - (iii) Manufacture – laminations, bonding, clamping, curing and conditioning.
- 8.5.1.4. When laminations are joined by finger joints these shall be produced in conformity with BS EN 385 or equivalent Malaysian standard. The finger joint of each lamella layer shall be laid in a staggered position.
- 8.5.1.5. The maximum permitted deviation from the average thickness within a lamination length of 1m is 0.2mm. Where non-gap-filling adhesives are used the limit deviation shall not exceed 0.1mm. The difference in thickness over the cross-sectional width of the lamination shall be less than 0.15% of the width and in no case exceed 0.3mm.

8.6. Fabrication

- 8.6.1. Prior to fabrication, the Contractor shall notify the S.O. the dates of tests that shall be carried out. The S.O. may appoint a representative in the event the S.O. cannot be present during the tests. The Contractor shall forward a copy of the test results jointly certified by the manufacturer for the S.O.'s acceptance and approval.
- 8.6.2. Prior to the manufacture and fabrication of the glued laminated timber, the Contractor shall provide two (2) copies of the following documents for the S.O.'s approval:
 - 8.6.2.1. Particulars of the manufacturer
 - 8.6.2.2. Quality assurance programme of the manufacturing process

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8.6.2.3. Method statement for assembly, installation, handling and transportation

8.6.2.4. Manufacturer's fabrication drawings

8.6.2.5. Manufacturer's assembly drawings

8.6.2.6. Grading summary of timber to be used in the manufacturing of glued laminated timber, issued by timber grader certified by MTIB

8.6.2.7. Results of qualification tests

8.7. Handling and Installation

The Contractor shall submit a method statement of installation for the approval of S.O.. The method statement shall explain the sequence of erection of ETP structures and required safety measures.

8.7.1. Handling

8.7.1.1. At all stages of construction, all ETP structures components shall be properly protected to prevent damage.

8.7.1.2. During on-site storage, ETP members shall be stored off the ground with spacer blocks spaced between members. If construction delays occur, the wrapping shall be cut on the underside to prevent the accumulation of water condensation. Proper transit, storage and construction methods are required to avoid rapid changes in the moisture content of members.

8.7.1.3. During handling, correct lifting equipment shall be used. All ETP members must be protected from damages due to strap, chains and wire ropes.

8.7.1.4. When ETP are stored on-site, they should be placed above the firm ground on a supporting block to protect them from water. If the ETP members are stored horizontally, the supporting block shall be spaced as such to prevent bending of the member. If the ETP members are stored vertically, they should be supported at the designed support location in a manner to prevent tipping or toppling.

8.7.2. Installation

8.7.2.1. The installation of ETP members shall be as the approved detailed drawings.

8.7.2.2. During erection, ETP must be transversely braced to provide stability in accordance with method statements prepared by the Contractor and approved by S.O.. All other bracings shall be provided for this purpose. ETP gable ends shall be braced before installation of other internal frames.

8.7.2.3. The engagement of a licensed surveyor to determine the accuracy of base plate and position of ETP structure shall be under the scope of work of the Contractor.

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8.7.2.4. The Contractor shall inspect the prepared foundations and holding down bolts for position and level not less than seven (7) days before erection of ETP work starts. He shall then inform the S.O., if he finds any discrepancies which are outside the deviations specified in the Drawings requesting that remedial work be carried out before erection commences.

8.8. Defects and Alteration

- 8.8.1. Glued laminated timber structures shall not have any debonding. Glued laminated timber structures affected by debonding shall be marked as 'Rejected' and removed from Site.
- 8.8.2. No element of the ETP roof truss, roof frames or roof ancillary members shall be cut or notched or removed or otherwise altered from its original state without the prior written approval of the S.O..
- 8.8.3. Where defects exceeding the limits or permitted tolerances are detected, rectification works shall be carried out based on the recommendations made by the P.E and to the approval of the S.O..

8.9. Warranty

- 8.9.1. The Contractor shall submit to the S.O. a performance warranty by the Contractor on the performance of the ETP member against debonding which may occur during a period of ten (10) years from the date of practical completion. The terms of the performance warranty shall be as stipulated in **APPENDIX I1** and as approved by the S.O..

9. Carpentry Works

- 9.1. All carpentry shall be accurately set out in strict accordance with the drawings and shall be framed together and securely fixed to the approval of the S.O.. Timber framing shall be properly braced and checked, halved, screwed or bolted together as required. Longitudinal joints in plates, ridge, fascias, etc. shall be formed over supports. Those timber members with lapped joints shall lap at least 150mm or twice the depth of the timber whichever is the greater. The brads, nails, screws, spikes, plugs, bolts, framing anchors and timber connectors shall be provided wherever necessary and as detailed. Other than those detailed, no joints are permitted in structural work unless prior permission is obtained from the S.O.. No structural member shall be notched unless instructed by the S.O..
- 9.2. For the carpentry works, timbers shall as far as possible be in piece between continuing lengths. At corners, timbers shall be halved for materials of the same thickness and sufficiently lapped for materials of different thicknesses.

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10. Joinery Works

- 10.1. All doors, windows, louvres, screens and the like shall be constructed as shown on the Drawings. Frames shall be assembled at the commencement of the work and all members shall be carefully mortised and tenoned together but no wedging, pinning or glueing shall be done until the framing is prepared in readiness for immediate fixing. All doors, windows, louvres, screens and the like shall be properly stored on Site.
- 10.2. Immediately before fixing in its final position, joinery shall be wedged and pinned by drawn hole pinning with 10mm diameter Strength Group 1 and 2 timber dowels pins. The pins shall be left projecting until permission is given for flushing off. The methods of framing and putting together all works shall be approved by the S.O. before being executed. Any portions that warp, twist or develop any other defects shall be replaced before wedging up. All framed work shall be pinned before being framed together.
- 10.3. The choice of species for joinery should be based on working properties of timbers that is the maximum percentage of shrinkage.
- 10.4. Jointing or connection for joinery that is nailed joint, screwed joint, coach screwed joint or bolted joint shall comply with MS 544: Part 5.

11. Timber Floor Finish

- 11.1. Unless otherwise shown on the Drawings, timber floors shall be constructed using 100mm x 38mm wrot, tongued and grooved boarding, well cramped up and secretly nailed to each joist or batten with 62mm wire nails. Floor boarding shall be in long lengths with splayed heading joints and no two adjacent joints shall occur over the same joist. On completion, the flooring shall be planed, sanded and all gaps sealed with an approved sealer. The floor shall then be cleaned off and unless otherwise specified, it shall be finished with three (3) coats of approved polyurethane paint applied strictly in accordance with the manufacturer's instructions.
- 11.2. Wrot timber skirting shall be provided where shown and as detailed on the Drawings. Skirting shall be in long lengths with splayed heading joints and with mitres, returns and ends neatly cut and fitted and fixed to grounds.
- 11.3. Where engineered timber floorings are specified or shown on the Drawings, it shall be finished with high abrasive protective overlay and a moisture barrier balancing film to be applied on timber flooring backing in accordance with the manufacturer's recommendations and S.O.'s approval.
- 11.4. Timber strip and parquet flooring shall be as specified in SECTION K: PLASTERING, PAVING AND FLOOR FINISH.

12. Ceiling Timber Battens

Where ceiling battens are used for ceilings, it shall be fixed to the frames with butt 'V' joint using nails or screws. Asbestos-free cement flat sheets for ceiling shall be 5mm thick fixed to frames using mitred profiled timber cover battens and brass screws with rounded edge beading. Ceiling panels shall be set out symmetrically from the centre line of the ceiling. Suspended ceiling systems shall be as specified in SECTION L: CEILING.

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13. Timber Partitions

Non-structural timber partitions shall be as specified in SECTION F: WALL SYSTEM.

14. Fascia And Barge Boards

Unless otherwise shown on the drawings, fascia and barge boards shall be 25mm thick wrot timber and supplied in long lengths. The boards shall be fixed in whole lengths and where joints are necessary, they shall be scarfed jointed and the joints shall occur only over the ends of roof framing members and mitred corners. Boards, 250mm wide and less shall be in one width and those deeper shall be formed by multiple boards joined together by tongue and groove and 'V' joint.

15. External Boarding

- 15.1. Unless otherwise shown on the drawings, all external boarding shall be formed with 150mm x 19mm horizontal, vertical or diagonal boarding in wrot pressure-treated timber in long lengths and to the sectional profile as detailed in the drawings.
- 15.2. Unless otherwise shown, lapping for plain weather boarding shall be 38mm. Boarding shall be secured to the frames using 75mm galvanized steel nails and in the case of plain weather boarding, nails shall not be driven through the lapped portions. The exposed bottom ends of all external vertical boarding shall be splayed inward at an angle of 30° and treated with preservatives.
- 15.3. The timber boarding shall be cleaned off and unless otherwise specified, it shall be finished with approved polyurethane base paint with UV protection applied strictly in accordance with the manufacturer's recommendations. The strength grouping for external timber flooring shall be in accordance with the Properties of Malaysian Timber as shown hereinafter in **TABLE I8**.
- 15.4. For coastal environments and exposed weather applications subjected to airborne salts deposition, metal connectors and fasteners used shall comply with AS 3566 Class 4 and be certified as such by the supplier of fasteners and to the approval of the S.O..
- 15.5. All fixings and associated components shall be manufactured from compatible metals and coated conforming to ISO 9223 Category 4 (C4) and Category 5 (C5) environment. Flashings shall be made from the same material as the roofing sheets.

16. Staircase And Balustrades

- 16.1. Unless otherwise shown on the Drawings, the Contractor shall prepare Shop Drawings as required for the Works. Prior to the fabrication and installation works, the Contractor shall submit the Shop Drawings to the S.O.'s for approval.
- 16.2. The preferred sizes for modular staircase and stair openings shall comply with MS 1064: Part 3.

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17. Timber Solid Panel Doors

- 17.1. All fire doors shall be of the appropriate Fire Resistance Period (FRP) in accordance with the Ninth Schedule of the Uniform Building By-Laws.
- 17.2. All fire doors including frames shall be constructed to a specification of the relevant FRP in accordance with MS 1073 and shall be tested by a laboratory, approved and certified by JBPM and have obtained a Product Certification Scheme from an accredited certification body.
- 17.3. All double leaf doors with rebated meeting stiles shall be provided with coordinating device fully fitted within the door openings with a gap of not more than 3mm between the frame and the edge of the door when closed
- 17.4. Where shown on the Drawings, approved vision panels of suitable size shall be incorporated in the Fire Rated Door.
- 17.5. Flush doors shall generally comply with MS 1506: Specification for Wooden Door with plywood facing and strength group 1 and strength group 2 timber lipping, mitred around all edges. The plywood and strength group 1-4 shall in all respects with the Specifications mentioned hereinbefore.
- 17.6. The preferred sizes for modular door sets shall comply with MS 1064: Part 4 and for modular windows shall comply with MS 1064: Part 5.

18. PVC Doors

- 18.1. Unless otherwise specified in the drawings, PVC doors shall be of strong impact resistance and waterproof/moisture resistant laminated timber finish on both sides. Unless otherwise shown on the Drawings, the door shall be 38mm thick.
- 18.2. PVC toilet doors shall be of full single panel of flush type. It shall be 100% waterproof, strong impact resistance and not be discoloured easily. Unless otherwise shown on the Drawings, the door shall be 38mm thick. PVC door shall be delivered to the Site complete with ironmongery as listed in the **TABLE 19**: Schedule of Ironmongery.

19. Products And Materials

19.1. Plywood

- 19.1.1. Unless otherwise specified, plywood used for interior and exterior purposes other than for formworks and temporary works shall be manufactured with Moisture Resistant (MR) bond and Weather and Boil Proof (WBP) bond respectively in compliance with MS 228. Boards which are to be painted or varnished shall be properly sanded down and holes and crevices filled with approved wood putty or filler.
- 19.1.2. Plywood intended for use as a shuttering board shall be of the Weather and Boil Proof (WBP) type.
- 19.1.3. Plywood intended for structural use, shall be of Malaysian Basic Structural Grade (MBSG) rated or equivalent and shall comply with MS 544: Part 4.

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19.1.4. Plywood to be used in marine environments or severe wet conditions shall be in accordance with MS 544: Part 4.

19.2. Blockboard

19.2.1. Fixing of blockboards shall generally be in accordance with the manufacturer's instructions.

19.2.2. Boards which are to be painted or varnished shall be properly sanded down and holes and crevices filled with approved wood putty or filler to the approval of the S.O..

19.3. Chipboards

19.3.1. Chipboards shall be of the type manufactured from wood chips or shavings combined with a thermosetting synthetic resin glue binder bonded and hot-pressed together and complying with MS 1036 for medium density chipboard. The type and quality of boards shall be approved by the S.O.. The boards shall be fixed as detailed in the drawings with a minimum edge distance of 12mm for nailing. All edges must be properly sealed, not exposed.

19.3.2. Boards which are to be painted or varnished shall be properly sanded down and holes and crevices filled with approved wood putty or filler to the approval of the S.O..

19.4. Fibre Building Boards

19.4.1. All fibre building boards namely, Hard Board, Medium Board and Medium Density Fibre Board (MDF) shall comply with MS 1429 and MS 1912. The type and quality of Fibre building boards shall be as approved by the S.O.. Perforated hardboards shall be not less than 3.2mm thick with maximum of 4.8mm perforation at 19mm centres unless otherwise stated in the Drawings.

19.4.2. All fibre building boards shall be fixed strictly in accordance with the manufacturer's instruction. Unless otherwise detailed in the Drawings, the ceiling boards shall be butt and 'V' jointed.

19.5. Composite Boards

19.5.1. The type and quality of composite boards shall be as approved by the S.O. and shall be fixed strictly in accordance with the manufacturer's instruction. All edges must be properly sealed, not exposed.

19.5.2. Fixing of timber based composite boards shall comply with the manufacturer's instructions. Panels which are to be painted or varnished shall be properly sanded down and holes and crevices filled with approved wood putty or filler to the satisfaction of the S.O. Panels which are for wet prone areas, shall comply with MS 1787.

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19.6. Woodwool Slabs

- 19.6.1. Woodwool slab shall comply with MS 1036 and shall be of the type and quality as approved by the S.O.. Unless otherwise specified in the Drawings, the slab shall be laid with its length at right angles to support, fixed strictly in accordance with the manufacturer's instruction.

19.7. Wood Cement Boards

- 19.7.1. Wood cement boards shall comply with the requirements of MS 934 or MS 544: Part 4. In fixing, the board must be supported on all four edges and at immediate positions at centres not exceeding 610mm. Joints between boards shall occur on centres of supports. Minimum edge distance shall be 20mm.
- 19.7.2. Boards which are to be painted shall be lightly sanded and any dust shall be removed from the surface with a piece of clean coarse cloth. Any filling compounds used shall be alkali-resistant. Fixing of the board shall be in accordance with the manufacturer's instructions.

19.8. High Pressure Laminate (HPL)

High Pressure Laminate is a thermoset paper/plastic composite, where decorative papers impregnated with melamine are consolidated over phenolic-impregnated craft papers at high temperature and pressure to form a homogenous laminate. Unless otherwise specified, HPL shall comply with MS 1787: Part 1-15 for durability. All edges must be properly sealed and shall not be exposed.

19.9. Wood Plastic Composite (WPC)

WPC shall be made from minimum 70% rice husk and balance recycled HDPE. WPC solid decking system shall be of 145mm (w) x 25mm (t) fixed onto 300mm c/c on Suspended Levelling System with hot dipped zinc-aluminium alloy coated steel with a minimum coating mass of AZ150 to AS/NZS 1397-2002 steel sheet grade G300 on to flat concrete slab with ENSS03 stainless steel clip, all in accordance with manufacturer's recommendation and S.O.'s approval.

20. Ironmongery

- 20.1. Unless otherwise shown on the Drawings, the Contractor shall supply and fix all ironmongery as listed in the **TABLE 19: Schedule of Ironmongery** attached hereinafter, complete with fixing screws of the same material and finish. All ironmongery set such as internal lock set shall come from the same brand with lever handle/cylindrical set.
- 20.2. Proper sockets shall be provided for all bolts to fix flush in floors, cills and door and window frames. Each lock shall be provided with three keys, and no locks shall have identical keys, unless specifically required by the S.O.
- 20.3. All doors, windows, gates, joinery, etc., shall be provided with anti-rust heavy duty ironmongery appropriate for its function, complete with fixing screws of the same material and finish.
- 20.4. All doors shall be provided with door-stops, door-closers and other appropriate ironmongery where applicable or as shown on the Drawings.

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- 20.5. The submission of the ironmongery set shall have been tested and certified by SIRIM QAS International Sdn. Bhd. or approved equivalent.
- 20.6. Installations of ironmongery for coastal areas must be of brass, chromium or bronze that can withstand rust and weather. All locksets to be of stainless steel of SUS 304SS. SUS201 SS and zincalume within the lockset accessories are to be avoided.
- 20.7. Construction key, master key and grand master key are to be provided by the suppliers in accordance with the project needs.

21. Built-in Furniture

21.1. General

- 21.1.1. Built-in furniture shall be constructed and properly framed in wrot timber as shown on the Drawings. Where fittings are not to be painted, unless otherwise specified, they shall be stained and varnished as described in SECTION N: PAINTING.
- 21.1.2. All interior furniture works shall be coordinated with mechanical and electrical works and as approved by the S.O.
- 21.1.3. All built-in furniture materials shall be protected wrapped in strong waterproof paper or polythene/polyethylene (PE) sheeting to protect against damp and scratching during transportation from the factory. The wrapping shall not be removed until installation starts.
- 21.1.4. Built-in furniture materials shall be unloaded and handled in a manner which will not result in damage, deformation or contamination to the built-in furniture materials.
- 21.1.5. Built-in furniture materials and loose furniture delivered to the Site shall be properly stored by arranging them in stacks, keeping them properly wrapped and stored under cover if they are not used or assembled immediately.

21.2. Materials

- 21.2.1. All composite wood products, such as Medium Density Fibreboard (MDF) shall comply with MS 1429 and the use of Particleboards shall comply with MS 1912.
- 21.2.2. The formaldehyde emission for all composite wood products and wood-based panels shall comply with MS 1787.
- 21.2.3. Laminates used in composite wood products shall comply with MS ISO 4586.
- 21.2.4. Unless otherwise specified in the drawings or Specification the resin used in composite wood products shall be phenol-formaldehyde (PF), melamine-urea-formaldehyde (MUF), melamine-urea-phenol formaldehyde (MUPF), polymeric diphenyl methane diisocyanate (PMDI) or polyurethane (PU).
- 21.2.5. Adhesive for wood and composite wood products shall be phenol-formaldehyde resin adhesive classified as weather-proof and boil-proof, in accordance with MS 908.

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21.2.6. Thermoplastic fittings, such as handles and accessories, where applicable, shall be polyamide (PA) or polypropylene (PP). Thermoplastics shall comply with MS 2324.

21.2.7. Solid surface shall be non-porous, homogenous, stain and chemical resistant, fire resistant and with a composition of acrylic polymer, aluminium trihydrate filler and pigment.

21.2.8. Where timber species are used it shall be constructed and properly framed in wrot timber as detailed in the Drawings.

21.2.9. All composite wood products to be used in air-conditioned areas must be of 100% waterproof material with mold and mildew resistant.

21.3. Component Assemblies

21.3.1. Unless otherwise stated in the Drawings, steel frames, where applicable, shall be square and flat with mitred, welded corners.

21.3.2. Screws shall have countersunk heads which shall comply with MS ISO 1482.

21.3.3. Hinges shall have a spring mechanism to lock the door in a close or open position, remain completely hidden behind the door and enable the door to open to 120°.

21.3.4. Drawer slides shall be of epoxy powder coated metal, mounted from the bottom and provided with friction bearing-mounted nylon rollers.

21.3.5. Unless otherwise specified, drawers shall have the 'soft-close' and/or 'positive-close' functions, which are mechanisms enabling drawers to quietly shut, or which fully shut after being only partially pushed. Drawers can be lifted up and removed easily for cleaning purposes.

21.3.6. All drawers, unless otherwise specified, shall have $\frac{3}{4}$ extension and be able to sustain up to 25kg. Kitchen cabinet drawers shall have full extension and be able to sustain up to 45kg, which is suitable for large pots, pans and/or woks.

21.3.7. Drawers for storing small kitchen cutlery shall have thermoplastic inserts with subdivided compartments.

21.3.8. Drawer handles and cabinet pulls shall be ergonomic. Thermoplastic handles and pulls shall recess into the door panels. Metal handles and pulls that extrude shall either be epoxy powder coated and/or anodized aluminium.

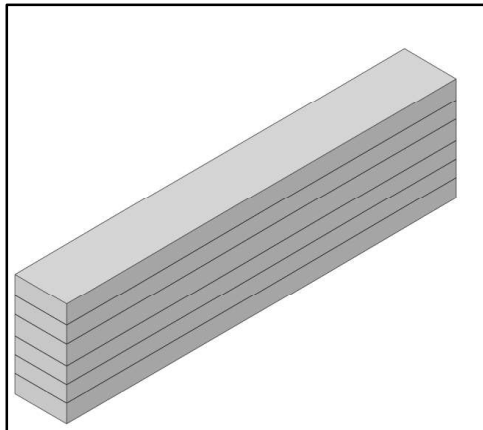
21.3.9. Solid surface worktops and countertops shall be 12mm thick, 600mm deep with backsplash 100mm high, with integral bowl, where applicable. Actual dimension of solid surface worktops shall be measured at Site. Upon installation of the solid surface worktops, it shall be polished and set level to S.O.'s approval.

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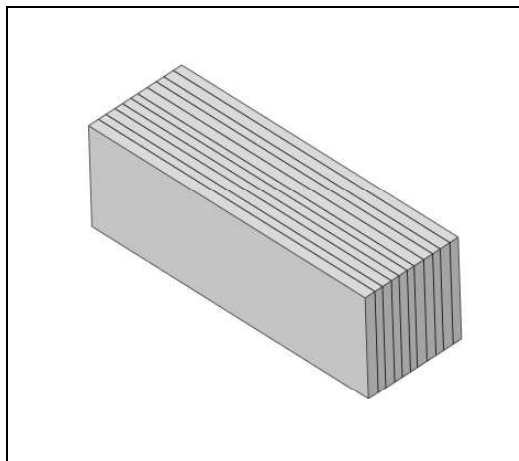
- 21.3.10. Unless otherwise specified, worktops and countertops shall have a flat edge finishing at the perimeter. Worktops and countertops shall be provided with holes and cut-outs for plumbing components, where applicable. All joints shall be inconspicuous and use the manufacturer's recommended adhesive and silicone sealant.
- 21.3.11. Built-in furniture sliding doors shall be fitted with guides or similar fittings, rollers or ball bearings, pull handles, stops and locking mechanisms.
- 21.3.12. Cabinet doors with glass inserts and/or panels shall be constructed with proper support to ensure that the glass remains securely fixed. Support shall be bedded in mastic with all interstices completely filled.
- 21.3.13. Glass inserts and/or panels and glass shelves, where applicable, which needs to be structurally strong and shall be tempered glass. Tempered glass shall comply with MS 1498.
- 21.3.14. Cupboards, wardrobes, cabinets and shelves shall have peg-holes on either side internally, allowing for adjustable shelf height. Adjustable legs, if applicable, shall be of a proprietary system type as approved by the S.O..

FIGURE I1: ENGINEERED TIMBER PRODUCTS:

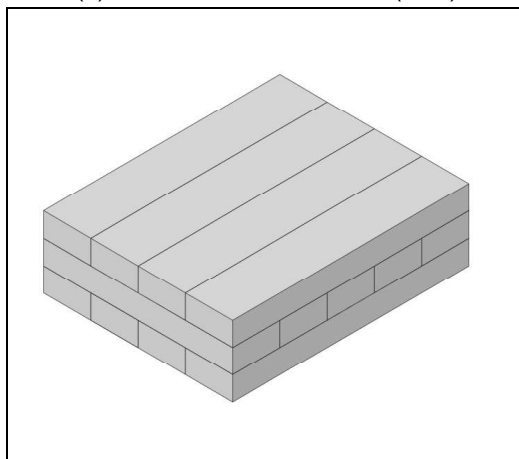
(a) Glued Laminated (Glulam) Timber



(b) Laminated Veneer Lumber (LVL)



(c) Cross Laminated Timber (CLT)



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TABLE I1: SCHEDULE OF TIMBER GROUPING AND USAGE

No	Typical Usage	Species
1.	Structural frames 1.1 All columns, stilts and beams	SG4
2.	Bearer to water tank	SG5
3.	Staircase and component elements	
	3.1 Stinger & treads/Riser	SG5
	3.2 Trimmer beams	SG5
	3.3 Balustrades, nosing and handrails	SG5
4.	Flooring	
	4.1 Floor bearers, joists and strutting for joists	SG5
	4.2 Floor boardings	SG5
	4.3 Gymnasium floor boarding	SG4
	4.4 Parquet flooring	SG5
	4.5 Skirtings	SG5
5.	Walling	
	5.1 Wall and partition framings	SG5
	5.2 External wall boardings	SG5
	5.3 Internal wall boardings	SG7
6.	Roof structures	
	6.1 Roof trusses, rafters, purlins, wall plates and other roof members	SG1 - SG4
	6.2 Fascia boards	SG5
7.	Ceiling frames	
	7.1 Ceiling joists and spacers	SG5
	7.2 Cover battens to joints of ceiling sheets	SG7
	7.3 Ceiling strips and soffit battens	SG7
8.	Door and window frames	
	8.1 All doors, windows, vent frames, grounds, stops and architraves	
	8.1.1 External usage	SG5
	8.1.2 Internal usage	SG7
9.	Furniture fitting	
	9.1 Built-in fittings and furniture in general	
	9.1.1 Carcassing	SG5
	9.1.2 Lining/Panelling	SG7
	9.1.3 Top	SG5
	9.2 Workshop furniture top	SG5
10.	Beading fillets and edgings in general	SG5

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**TABLE I2: SCHEDULE OF TIMBER SPECIES IN ACCORDANCE WITH STRENGTH
GROUPING (S.G)**

S.G 1	S.G 2	S.G 3	S.G 4	S.G 5	S.G 6	S.G 7
A) Naturally Durable						
Balau	Belian	Bekak	Giam	Jati		
Bitis	Mata Ulat	Delek	Malabera	Tembusu		
Cengal	Kekatong	KerANJI	Merbau			
Penaga			Resak			
B) Requiring Treatment						
	Dedaru	Agoho	Berangan	Alan Bunga	Bayur	Ara
	Kempas	Balau Merah	Dedali	Babai	Damar Minyak	Batai
	Merbatu	Kelat	Derum	Balik Angin Bopeng	Durian	Geronggang
	Mertas	Kembang Semangkuk	Kapur	Bintangor	Jelutung	Laran
		Kulim	Kasai	Brazil Nut	Jenitri	Pelajau
		Pauh Kijang	Keruntum	Gerutu	Jongkong	Pulai
		Penyau	Mempening	Kundur	Kasah	Sesenduk
		Perah	Meransi	Kedondong	Macang	Terentang
		Petaling	Meranti Bakau	Keledang	Medang	
		Ranggu	Merawan	Keruing	Melantai/ Kawang	
		Ru	Merpauh	Ketapang	Meranti Merah Muda	
		Surian Batu	Nyalin	Kungkur	Meranti kuning	
		Tualang	Perupuk	Melunak	Mersawa	
			Punah	Mempisang	Sengkurat	
			Rengas	Mengkulang	Terap	
			Simpoh	Meranti Merah Tua		
				Meranti Putih		
				Nyatuh		
				Penarahan		
				Petai		
				Ramin		
				Kayu Getah		
				Sengkuang		
				Sepetir		
				Tetebu		

Notes :

- For naturally durable timbers, sapwood should be excluded. If sapwood is included, preservative treatment is necessary. (Source: MS 360:1986)
- For timber requiring treatment, they should be amenable to preservative treatment.

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TABLE I3: SCHEDULE OF MOISTURE CONTENTS (M.C) OF TIMBER FOR VARIOUS POSITIONS IN BUILDING

Application	Maximum M.C. At Time Of Installation For Non Air-Conditioned Application	Maximum M.C. At Time Of Installation For Airconditioned Application (Kiln-Dried Timber)
Structural Components Columns, beams, bearer, studs, joists, ties and struts	30% (Thickness >100mm) 25% (Thickness <100mm)	Not applicable Not applicable
Roofing - Rafters, ties, struts, purlins and bracing - battens	25% 25%	Not applicable Not applicable
Staircase - stringers, treads, trimmer beam and handrail - balustrades	19% 19%	12% 12%
Flooring - floor boarding and parquetry - skirtings	19% 19%	12% 12%
Walling - wall, partition framing - external wall boardings - internal wall boardings - fascia boards	19% 19% 19% 19%	12% Not applicable 12% Not applicable
Ceiling Frames - cover battens to joints of ceiling sheets - ceiling strips and soffit battens Door & Window Frames - door, window and vent frames including their stops and grounds - door leaves, window and vent sashes	25% 19% 19% 19%	Not applicable 12% 12% 12%
Furniture - built in fittings, furniture generally - workshop furniture - science laboratory tops Beading fillets and edgings generally	19% 19% 19%	12% 12% 12% 12%

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TABLE I4: NATURAL DURABILITY¹ CLASSIFICATION OF PENINSULAR MALAYSIA TIMBERS FOR GROUND CONTACT

Class 1	Class 2	Class 3		Class 4	
Very durable (More than 10 years)	Durable (5 to 10 years)	Moderately durable (2 to 5 years)		Not durable (Less than 2 years)	
Chengal	Balau	Agoho ²	Rengas	Api-api	Nyato ^{6c}
Giam	Bekak	Balau, red	Sepetir	Ara	Perapat
Penyau	Bitis	Bakau	Tumu	Berangan	Perah
Resak	Kasai	Bungor	Tualang	Balek angin	Perupok
Tempinis	Kapur ^{4a}	Derum	Telor buaya	Bintangor	Petai
	Nyato ^{6a}	Dedali	Pelong	Batai	Podo
	Merbau	Dedaru	Kerukup	Bayur	Pulai
	Mersawa	Delek	Brazil nut ²	Damar minyak	Putat
	Merbau lalat	Dungun	Keruntum	Dungun paya	Ramin
	Delinsem ²	Acacia ³	Keruing ^{8a,b,c}	Durian	Samak
	Malabera	Pauh kijang	Keledang ^{9a,b}	Engkabang	Sena
	Medang ^{5a,b}	Kapur ^{4b}	Mata ulat	Jelutong	Sawa luka
	Penaga	Kelat	Medang ^{6c}	Gaham badak	Sepul
	Pelajau	Kembang semangkok	Meranti, ^{7a,b,c,d,e} dark red	Geronggang	Sesenduk
	Pelawan	Kempas	Mempening	Gerutu	Sentang ³
	Ranggu	Kerangi	Mengkulang	Gading	Simpoh
	Surian batu	Gegatal	Meransi	Gapis	Sempilor
	Teak	Kulim	Merbatu	Meranti bakau	Terentang
	Tembusu	Kungkur	Merawan	Meranti, light red	Tapus
		Leban	Merbau kera	Jenitri	Terap
		Nyalas	Meranti, white	Jongkong	Tuai
		Pauh kijang	Mertas	Kasah	Tulang daing
		Petaling	Nyato ^{6b}	Kekabu	Ketapang
		Punah	Nyireh	Kawang	Rubberwood
			Nipis kulit	Keledang ^{9c,d,e}	Pine ³
				Kapur ^{4c}	Yemane ³
				Kayu malam	Coconut
				Kedondong	Tengkuring
				Kungkur	Penarahan
				Meranti, yellow	Keruing ^{8d,e}
				Laran	Meranti tembaga
				Lelayang	Machang
				Lilin	Medang ^{5d,e}
				Limpaga ²	Mempisang
				Ludai	Merbatu
				Merpauh	Melantai
					Minyak berok

NOTE:

For reference to source of data see Bibliography.

The results were obtained from the graveyard test from the Forest Research Institute Malaysia test site.

¹ All samples taken from heartwood area except for the timber which their sapwood and heartwood cannot be differentiated. Timber of the same species but from different regions in Malaysia may have different durability classifications.

² The timber is not Peninsular Malaysia origin.

³ Plantation timber, originally from other countries.

^{4a} *Dryobalanops aromatica*

^{4b} *Dryobalanops rappa*

^{4c} *Dryobalanops oblongifolia*

^{5a} *Alseodaphne insignis*

^{5b} *Dehaasia nigrescens*

^{5c} *Cinnamomum porrectum*

^{5d} *Litsea firma*

^{5e} *Litsea megacarpa*

^{6a} *Palaquium impressinervium*

^{6b} *Palaquium maingayi*

^{6c} *Palaquium gutta*

^{7a} *Shorea uliginosa*

^{7b} *Shorea platyclados*

^{7c} *Shorea pauciflora*

^{7d} *Shorea singkawang*

^{7e} *Shorea curtisii*

^{8a} *Dipterocarpus sublamellatus*

^{8b} *Dipterocarpus crinitus*

^{8c} *Dipterocarpus verrucosus*

^{8d} *Dipterocarpus kerrii*

^{8e} *Dipterocarpus lowii*

^{9a} *Artocarpus interger*

^{9b} *Artocarpus lanceifolius*

^{9c} *Artocarpus dadah*

^{9d} *Artocarpus rigidus*

^{9e} *Artocarpus heterophyllus*

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**TABLE I5: NATURAL DURABILITY CLASSIFICATION OF SARAWAK TIMBERS FOR
GROUND CONTACT**

Class 1	Class 2	Class 3		Class 4	
Very durable (More than 10 years)	Durable (5 to 10 years)	Moderately durable (2 to 5 years)		Not durable (Less than 2 years)	
Belian	Kapur bukit	Baru	Kapur paji	Acacia	Bindang
Penyau	Kapur kelansau	Bedaru	Kapur paya	Alan	Geronggang
Selangan batu ²	Kawi	Kandis	Luis/Chengal pasir	Asam	Jadap
	Luis	Kasai	Medang luis kasar	Bajan	Jelawai
	Lun runcing	Leban	Mengkulang	Bayur	Jelutong
	Mertama	Nyireh	Mersawa kunyit	Bengang	Kayu cina
	Nyato ³	Pelajau	Petai belalang	Benuah	Kayu malam
	Rhu	Resak membangun	Sempilor	Binuang	Kelampayan
	Selangan batu ^{4a}	Seladah ^{4b, c}		Bintangor	Kembang semangkok
		Selumar		Bintawak	Kepayang babi
		Selunsur		Dungun	KerANJI
		Tapang		Durian	Keruing
		Urat mata		Empenit	Ketiau
				Entuyut	Kumpang
				Litoh	Legai
				Medang	Meranti, light red
				Menggris	Yellow flame
				Mersawa paya	Meranti, yellow
				Minggi	Mergasing
				Ngilas	Peran/bilat
				Nyato ^{5a, b}	Segera
				Pelai	Seladah ^{6a, b}
				Perah	Sentang
				Perupok	Simpoh Tampoi
				Petai	Tekalong
				Pitoh	Teruntum Ubah
				Ramin	Upi
				Resak paya	
				Sawih	

¹ The results were obtained from the graveyard test from Oya Road, Sibu test site. All samples taken from heartwood area except for the timber which their sapwood and heartwood cannot be differentiated. Timber of the same species but from different regions in Malaysia may have different durability classifications.

² *Shorea pulricostata*

³ *Palaquium rivulare*

^{4a,b,c} *Shorea flava*, *S. laecis*, *S. spp*

^{5a,b} *Dacryodes incurvata*, *Santira laevigata*

^{6a,b} *Palaquium pseudorostratum*, *Ganua motleyana*

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TABLE I6: COMMON COMMERCIAL TIMBER SIZES

Sizes and geometrical properties of Malaysian structural timbers

Shape	Nominal Size (mm x mm)	Minimum timber sizes (mm)		
		Fullsawn	Baresawn	Dressed Timber
Square	25 x 25 (1" x 1")	28 x 28	25 x 25	20 x 20
	50 x 50 (2" x 2")	55 x 56	50 x 50	45 x 45
	75 x 75 (3" x 3")	80 x 81	75 x 75	70 x 70
	100 x 100 (4" x 4")	106 x 106	100 x 100	90 x 90
	125 x 125 (5" x 5")	131 x 131	125 x 125	115 x 115
	150 x 150 (6" x 6")	159 x 159	150 x 150	140 x 140
Rectangle	25 x 50 (1" x 2")	28 x 56	25 x 50	20 x 45
	25 x 75 (1" x 3")	28 x 81	25 x 75	20 x 70
	25 x 100 (1" x 4")	28 x 106	25 x 100	20 x 90
	25 x 125 (1" x 5")	28 x 131	25 x 125	20 x 115
	25 x 150 (1" x 6")	28 x 159	25 x 150	20 x 140
	25 x 175 (1" x 7")	28 x 184	25 x 175	20 x 165
	25 x 200 (1" x 8")	28 x 212	25 x 200	20 x 190
	38 x 50 (1½" x 2")	41 x 56	38 x 50	33 x 45
	38 x 75 (1½" x 3")	41 x 81	38 x 75	33 x 70
	38 x 100 (1½" x 4")	41 x 106	38 x 100	33 x 90
	38 x 125 (1½" x 5")	41 x 131	38 x 125	33 x 115
	38 x 150 (1½" x 6")	41 x 159	38 x 150	33 x 140
	38 x 175 (1½" x 7")	41 x 184	38 x 175	33 x 165
	38 x 200 (1½" x 8")	41 x 212	38 x 200	33 x 190
	50 x 75 (2" x 3")	55 x 81	50 x 75	45 x 70
	50 x 100 (2" x 4")	55 x 106	50 x 100	45 x 90
	50 x 125 (2" x 5")	55 x 131	50 x 125	45 x 115
	50 x 150 (2" x 6")	55 x 159	50 x 150	45 x 140
	50 x 175 (2" x 7")	55 x 184	50 x 175	45 x 165
	50 x 200 (2" x 8")	55 x 212	50 x 200	45 x 190
	63 x 100 (2½" x 4")	68 x 106	63 x 100	58 x 90
	63 x 125 (2½" x 5")	68 x 131	63 x 125	58 x 115
	63 x 150 (2½" x 6")	68 x 159	63 x 163	58 x 140
	63 x 175 (2½" x 7")	68 x 184	63 x 175	58 x 165
	63 x 200 (2½" x 8")	68 x 212	63 x 200	58 x 190
	75 x 100 (3" x 4")	80 x 106	75 x 100	70 x 90
	75 x 125 (3" x 5")	80 x 131	75 x 125	70 x 115
	75 x 150 (3" x 6")	80 x 159	75 x 175	70 x 140

(Source : MS 544: Part 2)

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TABLE I7: MINIMUM REQUIRED SIZE OF WASHERS FOR STRUCTURAL BOLTED JOINTS

Bolt diameter (mm)	Washer size (mm)		
	Thickness	Minimum diameter for round washers	Minimum side length for square washers
M6	1.6	30	25
M8	2.0	36	32
M10	2.5	45	40
M12	3.0	55	50
M16	4.0	65	57
M20	5.0	75	65
>M20	6.0	85	75

(Source: MS 544: Part 6)

TABLE I8: PROPERTIES OF MALAYSIAN TIMBER

Heavy Hardwoods				
No	Species	Strength	Tangential Movement	Air-dry density (kg/m ³)
1	Balau	Very strong	2.1 – 2.5%	850-1155
2	Merbau	Strong	2.1 – 2.5%	515-1040
3	Red Balau	Strong	2.1 – 2.5%	800-880
Medium Hardwoods				
1	Kelat	Strong	2.1 – 2.5%	495-1010
2	Kempas	Very strong	> 3.1%	770-1120
3	Keruing	Strong	2.6 – 3.0% 3.1%	690-945
4	Mengkulang	Strong	2.1 – 2.5%	625-895
5	Merpauh	Strong	1.5 – 2.0%	640-880
Light Hardwoods				
1	Bintagor	Moderately strong	1.5 – 2.0%	495-865
2	Dark Red Meranti	Moderately strong	< 1.5% 1.5 – 2.0%	560-865
3	Gerutu	Moderately strong	2.6 – 3.0%	575-880
4	Mersawa	Moderately strong	2.1 – 2.5%	515-735
5	Yellow Meranti	Moderately strong	1.5 – 2.0%	575-735

(Source: Choo KT, Gan KS & Lim SC, Movement of Seasoned Timber in Service, FRIM Technical Information Handbook No. 18)

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TABLE I9: SCHEDULE OF IRONMONGERY

Type of Doors, Windows etc.	Ironmongery for each type of doors, windows etc.
1. Single Leaf Door 1.1. Plywood Flush Door 1.2. Timber Panelled Door 2. Double Leaf Door 2.1. Plywood Flush Door 2.2. Timber Panelled Door 3. PVC Door To Toilet /Bathroom Cubicles 4. Single Leaf Fire Rated Door 4.1. Standard size of 800 mm x 2100 mm ½ hr & 1 hr fire rated door (Metal Frame & Timber Door) 4.2 Standard size of 900 mm x 2100 mm ½ hr & 1hr fire rated door (Metal Frame & Timber Door) 4.3 Standard size of 900mm x 2100mm 2 hr fire rated door (Metal Frame & Timber Door)	a) 3 Nos. of 102mm x 76mm x 2mm galvanised steel hinges with nylon rings. b) 1 No. upright 3 lever mortice lockset with satin chrome lever handle furniture of approved manufacture with 2 Nos. chrome plated keys of different serial number for each building. c) 1 No. stainless steel door stopper. a) 3 Nos. of 102mm x76 mm x 2mm stainless steel hinges with nylon ring. b) 1 No. medium duty cylindrical lockset, 5 pin tumbler with knob and rose of stainless steel with hairline finish complete with 3 Nos. nickle-plated brass keys of different serial number for each building. c) 1 No. stainless steel door stopper. a) 6 Nos. 102mm x 76mm x 2mm stainless steel hinges with nylon rings. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body with single key thumb turn cylinder. c) 1 No. solid brass mortice lock rebated part. d) 1 Set of 150mm and 300mm Flush Bolt Lever Type Stainless Steel. e) 1 No. dust socket medium. f) 2 Nos. stainless steel door stopper. a) 6 Nos. 102mm x 76mm x 2mm stainless steel hinges with nylon rings. b) 1 No. cylindrical lock stainless steel, 5 pin tumbler with knob and rose of stainless steel with 3 nos nickel-plated brass keys c) 1 No. solid brass mortice lock rebated part. d) 1 Set of 150mm and 300mm Flush Bolt Lever Type Stainless Steel. e) 1 No. dust socket medium. f) 2 Nos. stainless steel door stopper. a) 3 Nos. 102mm x 76mm x 2mm stainless steel hinges with nylon rings. b) i) Residential Quarters - 1 No. stainless steel cylindrical lock with privacy locking device operated by turn from inside and knob handle. ii) Non-residential buildings - 1 No. stainless steel indicator bolt toilet. c) 1 No. hat & coat hook stainless steel. a) 3 Nos. 127mm x 89mm x 2.5mm heavy duty stainless steel hinges. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body with single key thumb turn cylinder approved by JBPM. c) 1 No. stainless steel door stopper. d) 1 No. door closer. e) 1 No. floor spring for double swing door. a) 3 Nos. 12mm x 89mm x 2.5mm heavy duty stainless steel hinges. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body with single key thumb turn cylinder approved by JBPM. c) 1 No. stainless steel door stopper. d) 1 No. door closer. e) 1 No. floor spring for double swing door. a) 4 Nos. 127mm x 89mm x 2.5mm heavy duty stainless steel hinges. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body with single key thumb turn cylinder approved by JBPM. c) 1 No. stainless steel door stopper. d) 1 No. door closer. e) 1 No. floor spring for double swing door. f) 2 Nos. of ball bearings. g) 1 No. of heavy duty stainless steel latch with 75 mm long backset.

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Type of Doors, Windows etc.	Ironmongery for each type of doors, windows etc.
5. Double Leaf Fire Rated Door 5.1. Standard size of 1200mm x 2100mm	a) 4 Nos. 127mm x 89mm x 2.5mm heavy duty stainless steel hinges. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body with single key thumb turn cylinder approved by JBPM. c) 1 No. solid brass mortice lock rebated part. d) 1 Set of 150 mm and 300 mm Flush Bolt Lever Type Stainless Steel. e) 1 No. dust socket medium. f) 2 Nos. stainless steel door stopper. g) 2 Nos. automatic door closer of hydraulically spring operated type (for swing doors) or of wire rope and weight type (for sliding doors). h) 2 Nos. floor spring for double swing door.
5.2 Standard size of 1800mm x 2100mm 5.3 Standard size of 2400mm x 2100mm	a) 6 Nos. 127 mm x 89 mm x 2.5 mm heavy duty stainless steel hinges. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body with single key thumb turn cylinder approved by JBPM. c) 1 No. solid brass mortice lock rebated part. d) 1 Set of 150 mm and 300 mm Flush Bolt Lever Type Stainless Steel. e) 1 No. dust socket medium. f) 2 Nos. stainless steel door stopper. g) 2 Nos. automatic door closer of hydraulically spring operated type (for swing doors) or of wire rope and weight type (for sliding doors). h) 2 Nos. floor spring for double swing door. a) 8 Nos. 127 mm x 89 mm x 2.5 mm heavy duty stainless steel hinges. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body with single key thumb turn cylinder approved by JBPM. c) 1 No. solid brass mortice lock rebated part. d) 1 Set of 150 mm and 300 mm Flush Bolt Lever Type Stainless Steel. e) 1 No. dust socket medium. f) 2 Nos. stainless steel door stopper. g) 2 Nos. automatic door closer of hydraulically spring operated type (for swing doors) or of wire rope and weight type (for sliding doors). h) 2 Nos. floor spring for double swing door.
6. Single Leaf Fire Escape Door	a) 3 Nos. of 127mm x 89mm x 2.5mm thick heavy duty stainless steel hinges. b) 1 complete set of approved make fire rated panic bolts.
7. Double Leaf Fire Escape Door	a) 6 Nos. of 127mm x 89mm x 2.5mm thick heavy duty stainless steel butt hinges. b) 1 complete set of approved make fire rated panic bolts.
8. Glass Door	a) 1 Set Floor Spring. b) 1 Set Patch Fitting, door bottom, door top, lock clamp, over panel. c) 1 pair Pull handle 600 mm.
9. Aluminium Door	a) 3 Nos. 102mm x 76mm x 2mm stainless steel hinges with nylon rings. b) 1 Set Hollow Lever Handle Stainless Steel Mortice Lock Body deadlock with a single key thumb turn cylinder.
10. Kitchen Cabinet Door / Workbench	a) Galvanised steel continuous 'piano' butt hinges. b) 1 No. 100mm aluminium 'D' handle. c) 1 No. bales catch. d) 1 No. galvanised steel cupboard lock in satin chrome finish.
11. Wardrobe	a) 3 Nos. of 75mm brass butt hinges (per door leaf). b) 2 Nos. 100mm anodised aluminium barrel bolt (for double leaf doors) c) 1 No. 100mm aluminium 'D' handle. d) Chromium plated steel clothes hanger rail. e) Steel cylinder cupboard lock in satin chrome finish.
12. Drawer	a) 1 No. steel cylinder drawer lock in satin chrome finish. b) 1 No. 100mm aluminium 'D' handle.

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Type of Doors, Windows etc.	Ironmongery for each type of doors, windows etc.
13. Sliding and Folding Door/ Partition	a) Top or bottom running set sliding and folding door gear, complete with tracks, channel, brackets, roller guides, hangers and all necessary butt hinges, flush bolts and flush door pulls, etc. as recommended by the manufacturer. b) 1 No. upright 3 lever rebated mortice lockset for sliding and folding door with satin chrome lever handle furniture with 2 Nos. keys of different serial numbers for each building.
14. Straight Sliding Door	a) Top or bottom running set straight sliding door gear complete with tracks, brackets, hangers, roller guides, channels, door stops, flush brass bolts, brass flush pull etc. as recommended by the manufacturer. b) 1 No. upright 3 lever mortice lockset with satin chrome finish for straight sliding door with 2 Nos. keys of different serial numbers for each building.
15. Timber Casement Window	a) 2 Nos. 400mm long approved electro-galvanised steel friction hinges. b) 1 No. approved brass with satin chrome finish combination handle and fastener.
16. Top Hung Casement Timber Window.	a) 2 Nos. 750mm long approved electro-galvanised steel friction hinges. b) 1 No. approved brass with satin chrome finish automatic locking fastener.
17. Top Hung Vent/Sashes	a) 2 Nos. 400mm long approved electro-galvanised steel friction hinges. b) 1 No. approved brass with satin chrome finish automatic locking fastener

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APPENDIX H/1

GLUED LAMINATED TIMBER PERFORMANCE WARRANTY (SPECIMEN)

1.0 Coverage of Performance Warranty

We the glued laminated timber Manufacturer hereby warrant that for a period of **ten (10) years** from the date of Practical Completion, the glued laminated timber system shall not be affected by the following defect:

a) Debonding

This condition occurs when the individual laminations of a glued laminated timber member become separated.

2.0 Procedure for Claims

- i) Any defect claims shall be made in writing and delivered by post or by hand to the Manufacturer.
- ii) A technical team from the Manufacturer will be dispatched to evaluate the nature of the claim. Should our findings conclude the defects as within the scope of warranty, then the Manufacturer shall make good such defects.
- iii) Should the Manufacturer's technical team conclude that the defects fall outside the scope of the warranty, the Manufacturer shall not be held responsible for the claim.
- iv) Should the Government disagree with the conclusion of the technical team pertaining to the defects in particular, then an independent third party competent in such technical evaluation shall be appointed to investigate the disputed defects.
- v) The appointment of independent third party competent in such technical evaluation shall only be appointed upon the mutual agreement between the Government and the Manufacturer.
- vi) The findings of the third party shall be conclusive and mutually accepted by the Government and the Manufacturer.
- vii) If the findings of the independent third party are within the coverage of this performance warranty, all cost shall be borne by the Manufacturer or otherwise such cost shall be borne by the Contractor.
- viii) All claims for the defects must be received by the Manufacturer not later than fourteen (14) days from the expiry of the warranty period.

MANUFACTURER

.....
.....

.....
Company Stamp

.....
Signature

Name:
Date:

WITNESS

.....
.....

.....
Company Stamp

.....
Signature

Name:
Date:

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APPENDIX I2:

SAMPLE CERTIFICATE OF COMPLIANCE

CERTIFICATE OF COMPLIANCE

Certificate of Compliance

Certificate No.

This is to certify that the sawn timber below which is consigned to (name and address of consignee).....

under purchase order number has been graded by a qualified Timber Grader in accordance with the Malaysian Standard (MS XXX) that the timber is of the kind/strength group of timber and grade(s) shown in the summary below; and that the appropriate grade and other marks have been placed on the timber.

Descriptions

Cross section (Size)	Timber name/strength group of timber, grade, number of pieces and length	Pieces	Volume

Total number of pieces KD/AD/SD

Total volume of timber m³

THIS HARDWOOD WAS GRADED IN ACCORDANCE WITH REQUIREMENTS

OF MS

.....

Name & Signature of Timber Grader and C.O.C.
number

Date:

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1. General

This section provides the generally applicable requirements for steel and metal for the construction of structures, building components and other related works. All materials shall conform to the relevant Malaysian or British or European Standards or other internationally recognised standards with the approval of the S.O..

2. Hot Rolled Structural Steelworks

- 2.1. All hot rolled structural steelworks design, materials, drawings, workmanship (welding, bolting, fabrication and erection), protective treatment (corrosion and fire), Quality Assurance and Quality Control shall be in accordance with the JKR Specification for Structural Steelworks (No. JKR 20601-0272-22) or its latest edition.
- 2.2. The Contractor shall procure all steel products or components from manufacturers/suppliers with *Perakuan Pematuhan Standard* (PPS) as specified in SECTION A: PRELIMINARIES AND GENERAL CONDITIONS.
- 2.3. The Contractor is reminded to employ certified skilled construction workers with *Sijil Kemahiran Kompetensi Pembinaan* (SKKP) as specified in SECTION A: PRELIMINARIES AND GENERAL CONDITIONS.
- 2.4. Quality Assurance and Quality Control (QA & QC)

The Contractor shall submit a Quality Assurance and Quality Control programme as specified in the JKR Specification for Structural Steelworks (No. JKR 20601-0272-22) or its latest edition.

2.5. Drawings and Design Reports

2.5.1. The Drawings to be submitted by the Contractor shall be endorsed by Professional Engineer with Practicing Certificate (P.E.P.C.) based on construction drawings are as follows:

- 2.5.1.1. Shop drawings:
 - Fabrication drawings;
 - Erection drawings.

2.5.1.2. As-built drawings.

2.5.2. Where the Contractor provides the design, the Contractor shall prepare design reports and Drawings with details in accordance with *MS EN 1993* or other relevant standards. The Drawings and design reports shall be endorsed by a P.E.P.C.. The Contractor shall also prepare Drawings of temporary restraints and/ or works for all construction stages in compliance with the requirements specified in the JKR Specification for Structural Steelworks (No. JKR 20601-0272-22) or its latest edition.

- 2.6. The Contractor shall refer to the list provided in the JKR Specification for Structural Steelworks (No. JKR 20601-0272-22) or its latest edition as in **Appendix 1** (but not limited) for design, workmanship, erection, protective treatment and construction work programme.

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2.7. Records

- 2.7.1. All records related to the works shall be made available to the S.O. throughout the contract period.
- 2.7.2. The Contractor shall submit to the S.O. document and records for approval which shall include but not limited to:
 - 2.7.2.1. Drawings as in Item 2.5. and documentation register;
 - 2.7.2.2. Mill certificates for materials and certification for welding consumables;
 - 2.7.2.3. Calibration of equipment;
 - 2.7.2.4. Welding Procedure Specification (WPS);
 - 2.7.2.5. Inspection, laboratory test reports and valid test certificates;
 - 2.7.2.6. Type of protective treatment system for corrosion and fire including technical data sheet and method statement;
 - 2.7.2.7. Delivery schedules and method statements for fabrication, erection and installation;
 - 2.7.2.8. Construction works sequences;
 - 2.7.2.9. Surveys and final inspection results;
 - 2.7.2.10. Completion of erection and hand over certification.

3. Prefabricated Cold Formed Steel Roof Trusses

- 3.1. All prefabricated components shall be manufactured only by reputable licensed truss suppliers listed in J-TRUSS system online (Application and Approval of Truss System Provider) and approved by the S.O.. This supplier duly termed as 'System Provider' is responsible for the analysis, design, detailing, drawing, manufacture, material, handling and erection of the roof members, and their ancillary fixing components. The full requirement is outlined in the JKR Specification for Prefabricated Cold Formed Steel Roof Trusses (No. JKR 20601-0270-22 or its latest edition).
- 3.2. System Provider (S.P.)

The System Provider (S.P.) is a manufacturer and a supplier of a proprietary roof truss system, approved by JKR which employs quality assurance procedures in the supply of material, design with detailing and trusses component manufacturing. The S.P. shall be responsible to fabricate, deliver and install the cold formed steel roof trusses system. The S.P. shall guarantee the due performance of the entire roofing system.
- 3.3. Duties of P.E.P.C.
 - 3.3.1. The P.E.P.C. shall sign-off and endorse every process of the truss system delivery that includes:
 - 3.3.1.1. Roof truss analysis and design;

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- 3.3.1.2. Construction drawings;
- 3.3.1.3. Fabrication drawings;
- 3.3.1.4. Design changes document in every stage of works;
- 3.3.1.5. Roof truss installation completion document, prior to issuance of Certificate of Practical Completion (CPC) by the S.O.;
- 3.3.1.6. As Built Drawings; and
- 3.3.1.7. Defect report prior to issuance of Certificate of Making Good Defect (CMGD) by the S.O..

3.4. Fabricator

All trusses may be assembled and installed either by S.P. or licensed company appointed by the S.P. and registered with CIDB under Class B02 IBS: *Sistem Kerangka Keluli*. A copy of CIDB registration certificate shall be submitted to the S.O. for verification.

3.5. Installer

All fabrication and installation works shall be executed and supervised by skilled construction worker accredited and certified by CIDB. The S.O. may verify the identification and qualification of the installer prior to the installation.

3.6. General Truss Limitation

- 3.6.1. Prior to any prefabricated cold formed steel roof trusses works, the following general limitation shall be applied:
 - 3.6.1.1. Maximum truss span or unsupported truss length 12.00 metres with permitted deviation of ± 0.05 metres unless otherwise instructed by the S.O.;
 - 3.6.1.2. Maximum truss spacing of 1.20 metres with permitted deviation of +0.025 metres;
 - 3.6.1.3. The minimum basic wind speed shall be 35.0 m/s;
 - 3.6.1.4. Minimum base steel thickness for main truss member shall be;
 - a) 1.0mm for unsymmetrical section or open cross section; or
 - b) 0.6mm for symmetrical machine-manufactured box or closed cross section.
 - 3.6.1.5. Minimum base steel thickness for other truss element shall be;
 - a) 0.5mm for batten or purlin;
 - b) 1.2mm for wall plate; and
 - c) 1.0mm for bracing.
 - 3.6.1.6. Minimum section depth shall be 75.0mm in the direction of local major axis of truss member section;

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- 3.6.1.7. Minimum section flange shall be 35.0mm in the direction of local minor axis of truss member section;
- 3.6.1.8. Minimum section lip shall be 7.0mm in the direction of local major axis of truss member section;
- 3.6.1.9. Minimum section batten or purlin shall be proposed and endorsed by P.E.P.C. according to the design; and
- 3.6.1.10. Connector shall only be of hexagon head/wafer-head self-drilling screw or bolt. Welding is not allowed as fastener.

3.7. Analysis, Design Report and Drawings Submission

- 3.7.1. The S.P. shall propose a roof truss system which is safe, functional and conforming to design standard. Submission of proposal shall include truss analysis, design report, and construction drawings. The truss analysis and design shall indicate all design parameters including but not limited to loads, load combinations, connections criteria, bracings and tie-downs of the truss. Design output of the truss members, battens, connections, tie-downs and wall plates, anchors, bracings, truss accessories, splicing and stiffeners whereby related to the analysis shall be included in the design report. Refer to **Appendix 3** of JKR Specification for Prefabricated Cold Formed Steel Roof Trusses (No. JKR 20601-0270-22) or its latest edition.
- 3.7.2. All details in the construction drawing shall be sufficient as such to enable checking against the analysis and design report, by specifying and providing not limited to; the truss layout and configuration, steel grades, section properties of members, length of members in each truss configuration, properties of truss accessories, specification of corrosion protection, specification of fastener and anchor, tie-down and anchoring details and all type of connection details including the connection of all attachments to the trusses.
- 3.7.3. Technical specifications or mill certificates for base steel, fastener and anchor of which the designs refer to shall also be included in the submission. Verification test certificate from an approved accredited laboratory on the technical parameter specified in the technical specifications or mill certificates shall be submitted upon request by the S.O..

3.8. Warranty

- 3.8.1. When a prefabricated cold formed steel roof truss system is used, the Contractor shall submit to the S.O. a warranty from the S.P. with the following provisions:
 - 3.8.1.1. The products used are genuine and free from manufacturing defects;
 - 3.8.1.2. The prefabricated cold formed steel roof truss system is installed in accordance with the S.P.'s instructions, guidance and specifications that will deliver the specified level of performance; and
 - 3.8.1.3. The warranty certificate shall cover a period of ten (10) years from the date of Certificate of Practical Completion against any defect or failure due to the installation and workmanship by the S.P.'s registered panel installer.

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4. Metal Frames for Doors and Windows

4.1. Steel Frames

- 4.1.1. The Contractor shall supply, assemble and fix steel frames for doors and windows as shown on the Drawings. The steel frames shall comply with BS 6510 and shall be from an approved source and shop-primed with two (2) coats of red lead oxide or other approved rust resisting primer.
- 4.1.2. The steel frames shall be manufactured from sections rolled from good commercial grade galvanized mild steel in single sections, mechanically straightened with all corners pre-cut with a 45 degrees mitre joint giving a snug and accurate fit, fully electrically welded, and carefully ground and cleaned, or shall be mechanically jointed by an approved method.
- 4.1.3. All screws, nuts, bolts and washers shall be of stainless steel.
- 4.1.4. Steel frames shall be painted as specified in SECTION N: PAINTING.

4.2. Aluminium Frames

- 4.2.1. The Contractor shall supply, assemble and fix aluminium frames for doors and windows as shown on the Drawings. Unless otherwise specified, all aluminium frames for windows shall be fabricated from sections extruded from aluminium alloy conforming to MS 832. All aluminium frames for glass sliding doors shall be fabricated from sections extruded from aluminium alloy and in compliance with MS 1017.
- 4.2.2. Unless otherwise shown on the Drawings, aluminium surfaces shall be natural anodised finish, free from alloy defects, dye marks, scratches and other surface blemishes in accordance with BS 3987 with an anodic coating of 15µ minimum thickness complying with BS EN 12373-1.
- 4.2.3. All coloured anodized finish to aluminium exposed surfaces shall be subject to the S.O.'s approval.
- 4.2.4. All aluminium extrusion or sheet exposed surfaces after anodizing and after colouring, if required by the S.O., shall be sealed, and the adequacy of the sealing shall be given special emphasis.
- 4.2.5. All fasteners such as bolts and screws shall be of stainless steel type A2-70 (minimum) in compliance with ISO 3506 or other suitable materials as specified in the Drawings. Rivets shall be stainless steel or aluminium alloy appropriate to the applications.
- 4.2.6. Extruded aluminium framing members shall be fabricated from designated alloys complying with MS 2289. Ancillary members such as sills, couplings and the like formed from sheet materials, they shall be fabricated from designated alloys complying with MS 2040.
- 4.2.7. Where friction stays and hinges are fastened onto the framing section, the portion that receives the fastener shall not be less than 2.5mm thick.

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4.3. Frames for Adjustable Louvre Windows

- 4.3.1. The Contractor shall supply, assemble and fix frames for adjustable louvre windows as shown on the Drawings in compliance with MS 1057.
- 4.3.2. Unless otherwise specified, the frames shall be of approved manufacture. The frames shall be supplied complete with weather seal and non-ferrous bearings, spring clips, locking device and weather stripping with all necessary spacing pieces. The frames, coupling mullions and spacer brackets shall be minimum 1.2mm thick (18 SWG) or otherwise specified cold-rolled steel strip galvanised with hot-dipped process. Unless otherwise specified in the Drawings, the clips and pivots to receive the louvres shall be of durable nylon material and sample submitted shall be to S.O.'s approval.
- 4.3.3. The operating rods shall be 2.13mm thick (14 SWG). The handle and lock shall be 2.642mm thick (12 SWG) steel.
- 4.3.4. Unless otherwise specified, the finish shall be anodized coating of 15µ (average) minimum complying with BS EN 12373-1.

4.4. Accessories

- 4.4.1. Accessories for each steel or aluminium frame for doors and windows shall be supplied complete with:
 - 4.4.1.1. Sufficient number of built-in stainless steel hinges as per Schedule of Ironmongery under SECTION I: TIMBER, JOINERY AND IRONMONGERY;
 - 4.4.1.2. Two (2) rubber buffers per closing jamb, to reduce noise and vibration;
 - 4.4.1.3. Welded mortar guard; Adjustable stainless steel striker plate with a gently curved lead-in edge;
 - 4.4.1.4. Removable spreader bars, to ensure a perfect square during transportation and installation; and
 - 4.4.1.5. Minimum of eight (8) pieces of 4mm brick ties, to ensure a tight permanent fit.

4.5. Samples

Samples of steel or aluminium sections with complete accessories for the doors and windows, together with complete set of shop drawings of all works shall be submitted to the S.O.'s for approval prior to the commencement of any work.

4.6. Installation

- 4.6.1. Unless otherwise specified or shown on the Drawings, all types of window and door frames shall be fixed or installed using the sub-frame method in accordance with the manufacturer's recommendation and to the S.O.'s approval.
- 4.6.2. All joints on the window and door frames shall be sealed using polyurethane (PU) type joint sealant.

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4.6.3. Where buildings are located near to the coastal area, the bolts, nuts and screws used shall be of stainless steel unless otherwise specified.

4.6.4. Unless otherwise specified in the Drawings, the adjustable louvre side frames shall fix to the aluminium frames and shall be installed using the sub-frame method in accordance with the manufacturer's recommendation and to the S.O.'s approval.

5. Collapsible Gates, Roller Shutters Etc.

The Contractor shall provide and fix approved collapsible steel gates, folding shutters, roller shutters etc. complete with all necessary accessories as approved by the S.O. to the sizes and positions as shown on the Drawings. Unless otherwise specified in the Drawings, they shall be galvanised and fixed in accordance with the manufacturer's instructions.

6. Sundries

- 6.1. Unless otherwise specified in the Drawings, mild steel shall be used for balustrades to staircases, verandahs, balconies, etc. shall be fixed as shown on the Drawings.
- 6.2. All iron and steel for the sundries shall be of the quality approved by the S.O.. Screws and bolts shall have washers where appropriate. Hooks for carrying ceiling fans shall be formed from 13mm diameter mild steel rods bolted to timber ceiling members or ragged into concrete.
- 6.3. Welded mesh, expanded metal, aluminium sheets etc. shall be provided and fixed as shown on the Drawings.
- 6.4. Mild steel grilles, drain cover gratings shall be provided and fixed as shown on the Drawings. Unless otherwise stated, all steelworks shall be joined by continuous welding.
- 6.5. Ant caps shall be of 16 gauge galvanised iron sheets formed to shape as shown on the Drawing. The caps shall be fixed between concrete stumps/brick piers or walls and timber posts or plates as required. The caps shall project 60mm and inclined at 45° from the surface.

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1. General

1.1. Cement

1.1.1. The cement, unless otherwise described shall be Ordinary Portland Cement, complying with MS EN 197-1 as specified in SECTION E: CONCRETING or Masonry Cement complying with MS EN 413-1.

1.1.2. White and coloured cement shall be of approved manufacture.

1.2. Plasticiser

The plasticiser shall be of approved manufacture and used strictly in accordance with the manufacturer's recommendation.

1.3. Plasterlime

The plasterlime shall be of approved manufacture and shall comply with BS 890 and shall be applied strictly in accordance with the manufacturer's recommendation.

1.4. Sand

The sand for external rendering, internal plastering and floor screeding shall comply with MS 30 for fine aggregates. Sand for plastering using gypsum shall comply with MS 701.

1.5. Water

Water for mixing shall be clear and free from harmful matter as specified in SECTION E: CONCRETING.

1.6. Mixing

1.6.1. All mixing of mortar for plaster and screed shall be done by machine. Hand mixing shall only be allowed for small quantities and with the approval of the S.O.. Hand mixing shall be done on a clean platform. The water content of the mix shall be only the minimum required to give a workable mix.

1.6.2. Mortar for plaster and screed shall be used up within 45 minutes after mixing.

1.6.3. For gypsum plaster, mixes shall be used up within 1 hour after mixing.

1.6.4. No remaking of the mix shall be permitted thereafter.

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1.7. Surface Preparation

- 1.7.1. Where possible cement paving, screeding and rendering on concrete surface shall be laid while the concrete is still green, that is after the final set but not later than 24 hours of laying concrete. The concrete surfaces shall be brushed with a stiff broom before it has hardened to remove laitance and give a roughened surface. Hardened concrete surfaces shall be thoroughly hacked to form a key to the approval of the S.O..
- 1.7.2. Before any paving, screeding or rendering is applied, all surfaces shall be thoroughly cleaned and wetted and be in damp state at the time the paving, screeding or rendering is applied.
- 1.7.3. Where plastering and rendering are to be applied in several coats, the surface of each preceding coat shall be scratched while still green to form a key for the subsequent coat.

1.8. Bay

Paving and screeding shall be laid in alternate bays. On hardened concrete bases, each bay shall not exceed 15m². On the surface where the concrete is still green, each bay shall not exceed 30m². Where bays are not square, the ratio of the length between adjacent sides of each bay shall be approximately 1:1.5. The joints in paving screed shall coincide as nearly as possible with joints in the base.

1.9. Curing and Protection

Unless otherwise specified hereinafter, the screeds shall be cured for three (3) to seven (7) days after laying and protected from rapid drying by covering with polyethylene sheets or tarpaulins and shall also be protected from any damage.

1.10. Making Good

- 1.10.1. Defective screeds shall be cut out and made good with fresh screed and sufficient time shall be allowed for the screed to dry prior to the laying of the floor finish.
- 1.10.2. Defective plastering and rendering shall be made good by cutting out the defective part to a rectangular shape, and the edges shall be undercut to form dovetail-key and finished flush with the surrounding work.

1.11. Samples

The Contractor shall supply the S.O. with samples of materials and/or sample of finished work for approval. Approved samples shall be kept at Site for reference.

1.12. Tools

Proper tools shall be used for all scribing, scoring, splicing, smoothing edges, making angles etc. of tiles, bricks and others so as to produce neat and fit joints.

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1.13. Types of Finishes

The appropriate type of finishes to be used in the various locations of the works shall be as shown on the Drawings or as tabulated in the Schedule of Finishes. Unless otherwise shown on the Drawings, the finishes and their dimensions shall be as specified hereinafter.

1.14. Cornices and Angles

- 1.14.1. The cornices and moulded work shall be clean and accurately formed to the section shown on the Drawings. All mitres, stops and enrichments and moulding shall follow the details as shown on the Drawings, all to the approval of the S.O..
- 1.14.2. All rounded and moulded angles shall be of the same material mix as the adjacent finish. For narrow reveal, splays and returns under 30mm wide, Class D plaster to BS 1991 shall be used.

1.15 Water proofing

The full requirements are specified under SECTION F: WALL SYSTEM of this Specification.

2. Plaster Work

2.1. Plain Plaster

- 2.1.1. Plain plaster shall consist of one (1) part masonry cement to six (6) parts sand by volume. Where CEM 1 is used, plasticiser or plaster lime shall be added to the mix in accordance with the manufacturer's instruction.
- 2.1.2. The plaster shall be applied in two (2) coats generally to a total thickness of 20mm to brickwall up to wall height and 12mm to soffits, beams, columns, concrete-walls and other smooth surfaces.
- 2.1.3. The first coat shall consist of rough plastering to a thickness of 10mm for 20mm plainface, and 6mm for 12mm plainface. The second coat shall be finished with a steel trowel for internal surfaces and with a straight-edged wood float for external surfaces.
- 2.1.4. All external walls, unless otherwise specified, shall be finished with rough surface cement plastering.
- 2.1.5. All internal walls, unless otherwise specified, shall be finished with smooth skimmed surface cement plastering.
- 2.1.6. The Autoclaved Aerated Concrete (AAC) blocks wall with compatible plaster thickness shall be as follows:
 - i. Internal wall (general area): minimum 125mm thick.
 - ii. Internal wall (clinical area): minimum 150mm thick.

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iii. Internal wall at 24 hours air-conditioned room: minimum 150mm thick for both sides of walls with minimum 25mm gap (infill with PUR/PIR insulation) in between the walls or 200mm thick of wall.

iv. Party wall: 200mm thick, shall be classified of Class O building material in accordance with BS 476 Part 4 (non-combustible) or Part 6 & 7 (limited combustible), or at least has an A2 rating in accordance with EN 13501 Part 1.

v. Auditorium wall: minimum 200mm thick.

2.2. Granolithic Plaster

2.2.1. Granolithic plaster shall consist of by volume, two (2) parts cement, one (1) part sand, five (5) parts granite chipping passing 6mm mesh and retaining upon 3mm mesh, applied in two (2) coats to a total thickness of 10mm to a backing coat, finished smooth with wood float.

2.2.2. The backing coat shall consist of 12mm thick plain plaster as described herein before. The finished surface shall be brushed lightly to achieve the required texture after it has reached the initial set.

2.2.3. Shanghai plaster shall consist of two (2) parts approved coloured cement, one (1) part sand and five (5) parts of selected lime-stone chipping passing 6mm mesh and retaining upon 3mm mesh by volume applied in two (2) coats to a total thickness of 10mm to the backing coat, finished smooth with wood float.

2.2.4. The backing coat shall consist of 12mm thick plain plaster as described hereinbefore. The finished surface shall be brushed lightly to achieve the required texture after it has reached the initial set.

2.3. Shanghai Plaster

2.3.1. Shanghai plaster shall consist of two (2) parts approved coloured cement, one (1) part sand and five (5) parts of selected lime-stone chipping passing 6mm mesh and retaining upon 3mm mesh by volume applied in two (2) coats to a total thickness of 10mm to the backing coat, finished smooth with wood float.

2.3.2. The backing coat shall consist of 12mm thick plain plaster as described hereinbefore. The finished surface shall be brushed lightly to achieve the required texture after it has reached the initial set.

2.4. Textured Finish Plaster

2.4.1. Textured finish plaster shall consist of a 20mm thick backing coat of plain plaster as described hereinbefore ruled into a plain and even surface and a finishing coat as on the Drawings and described hereinafter.

2.4.2. For rough cast finish, the mix shall consist of selected cement, sand and aggregate in the proportion to give the required finish to the approval of the S.O..

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- 2.4.3. For Tyrolean finish, the mix shall consist of one (1) part selected coloured cement, and two (2) parts sand by volume applied to the backing coat by means of a Tyrolean machine in accordance with the manufacturer's recommendation. The finish shall be built up in three (3) layers to a total thickness of not exceeding 6mm. Each coat shall be allowed to dry before the application of a subsequent coat.
- 2.4.4. For pebble-dash finish, the dry pebble for the finish shall be thrown onto the backing coat while the latter is still wet. The pebbles to be used shall be clean and of size and quality approved by the S.O..
- 2.4.5. For pebble-wash finish, the selection of pebbles shall be clean and of size, colour and quality approved by the S.O.. The selected pebbles shall be mixed with plain plaster and applied while it is still wet in a single coat generally to a total thickness of 12mm to a backing coat. The applied surface is tapped to set the pebbles in position. The pebbles shall be brushed and washed lightly to achieve the required texture after it has reached the initial set. Loose pebbles shall be placed back in position and by tapping the surface to set.
- 2.5. Gypsum Plaster
- 2.5.1. Gypsum plaster, or plaster of Paris, is produced as a proprietary dry plaster powder and when it is mixed with water, it re-forms into gypsum. The ratio of the gypsum powder mix to the amount of water shall be as recommended by the manufacturer.
- 2.5.2. The setting of unmodified plaster starts about 10 minutes after mixing and is complete in about 45 minutes; but not fully set for 72 hours. The total gypsum plaster thickness for vertical and horizontal masonry and concrete surfaces shall be 16mm.
- 2.5.3. The resulting paste hardens as it cools, forming a relatively soft, pliable finished product. Unlike mortar or cement, which dries much harder, gypsum plaster can be sanded or otherwise manipulated once cured, making it a good option for aesthetic, non-load bearing purposes.
- 2.5.4. Gypsum plaster is renowned for its use as an art medium and is often use in conservation works especially for decorative embellishment. It is also used to simulate the appearance of surfaces of wood, stone or metal.
- 2.6. Lime Plaster
- 2.6.1. Typical lime plaster mix shall consist of one (1) part lime putty to three (3) parts of washed, well graded sand. The lime putty is mixed at one (1) to three (3) ratios, creating a compact plaster.
- 2.6.2. Water is added to produce slaked lime (calcium hydroxide), which is sold as a wet putty or white powder. Water is added to the white powder mix as per the manufacturer's recommendation.

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2.6.3. Water is added to the proprietary lime plaster mix as per the manufacturer's recommendation to form a workable paste prior to use. Lime plaster is used as an alternative to or in combination with ordinary Portland cement. It is commonly used for decorative works such as mural paintings on walls, ceilings or any type of flat surface.

2.6.4. Once the water is mixed it shall be stored in an air-tight container. Once exposed to the atmosphere, the calcium hydroxide turns back into calcium carbonate, causing the plaster to set.

2.7. Barium Plaster

The plastering of internal surfaces of X-Ray room walls shall be of barium plaster consisting of one (1) part cement, one (1) part barytes (barium sulphate) fines and three (3) parts barytes sand by volume.

2.8. Plaster to Sides of Manholes, Inspection Chambers and Septic Tanks

Plastering to sides of manholes, inspection chambers and septic tanks shall be as specified under SECTION V: SEWERAGE.

3. Paving Work

3.1. Cement Paving

3.1.1. Unless otherwise shown on the Drawings, cement paving shall be 20mm thick consisting of one part cement to three parts sand by volume. The paving shall be thoroughly rammed within 30 minutes of laying and trowelled smooth after it has stiffened sufficiently to prevent laitance being brought to the surface. Paving to the apron shall finish to a slight fall towards surface drains.

3.1.2. Unless otherwise shown on the Drawings skirtings shall be formed to a height of 150mm and thickness of 20mm, covered at bottom and rounded at top.

3.2. Granolithic Paving

3.2.1. Granolithic paving shall be 20mm thick, consisting of two (2) parts cement and five (5) parts granite chipping passing 6mm mesh and retained upon 3mm mesh by volume.

3.2.2. The chipping shall be washed and free from dust. The paving shall be trowelled smooth to proper level or fall where appropriate. After initial set the surface shall be brushed lightly to achieve the required textured finish.

3.2.3. Unless otherwise shown on the Drawings, granolithic skirting shall be 100mm high and 20mm thick, coved at bottom and slightly rounded at top.

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- 3.2.4. Unless otherwise shown on the Drawings, the edge of threshold and treads of concrete stairs shall be finished with 150mm x 75mm x 12mm thick vitreous non-slip nosing tiles laid lengthwise bedded and pointed in 1:3 cement and sand mortar. The sides of open stringers shall be finished with granolithic plaster worked to profile the treads and risers to the approval of the S.O..

3.3. In-situ Terrazzo

- 3.3.1. In-situ terrazzo shall consist of one (1) part approved coloured cement and three (3) parts selected limestone chipping passing through 12mm mesh and retained upon 3mm mesh by volume.
- 3.3.2. The terrazzo topping shall be 20mm thick laid on 20mm thick cement and sand (1:3) screed. The concrete base to receive the screed shall be thoroughly cleaned and wetted.
- 3.3.3. While laying the screed, aluminium or brass strips of size 32mm wide x 3mm thick shall be set vertically on edge into the screed to form panels. Each panel shall not exceed 4m² with top edges of the strips standing sufficiently high to finish flush with the finished terrazzo floor level. The terrazzo shall be trowelled to a dense even finish.
- 3.3.4. When sufficiently hard but not less than two (2) days after being laid it shall be rubbed down to a smooth surface by means of carborundum stone.
- 3.3.5. Tile impregnator then shall be applied strictly in accordance with the manufacturer's recommendation onto the terrazzo surface to prevent future staining.
- 3.3.6. Unless otherwise shown on the Drawings, the edge of the threshold and treads of concrete stairs shall be finished with 150mm x 76mm x 12mm vitreous non-slip nosing tiles of approved colour laid lengthwise bedded and pointed. The sides of open stringers shall be finished with in-situ terrazzo working to profile the treads and risers to the approval of the SO..

3.4. Waterproof Paving to Roof Slabs

Waterproof paving to roof slabs shall be as specified under SECTION E: CONCRETING.

3.5. Precast Concrete Paving

- 3.5.1. Unless otherwise shown on the Drawings, precast concrete paving slabs shall be of size 600mm x 600mm x 50mm thick each and made of 1:2:4-20mm concrete reinforced with 'A6' fabric reinforcement to MS 145. The top surfaces of slab shall be brushed with stiff broom or wire brush after the initial set to give a rough finish.
- 3.5.2. Paving slabs shall be laid to the pattern as shown on the Drawings or approved by the S.O.. The slabs shall be bedded on 25mm thick semi-dry cement and sand (1:3) screed laid on 100mm thick properly compacted and blinded hardcore.

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3.5.3. The joints between the paving slabs shall be 20mm wide filled with cement mortar (1:3) and raked to a depth of 6mm.

3.5.4. Pavers shall be provided to areas needed as per functional requirement:

- i. Pre-cast concrete pavers shall be a minimum of 60mm thick for light to a medium-duty application (e.g., footpaths, jogging tracks, residential driveways).
- ii. Pre-cast concrete pavers shall be a minimum of 80mm thick for heavy-duty application (e.g., roads, factory floors, container yards, aircraft parking aprons). Pavers, where specified, shall be of approved equivalent and applied strictly following the manufacturer's specification.

3.6. Interlocking Concrete Paving

- 3.6.1. Taking the existing sub-grade/soil conditions and the anticipated traffic loading into consideration, an adequate thickness of well compacted base course must be provided to ensure good pavement performance. Unless otherwise specified, existing bitumen or concrete surfaces need not be removed and can act as a good subgrade.
- 3.6.2. Interlocking concrete paving blocks shall comprise of segmental interlocking concrete paving units laid on minimum 30mm thick sand bedding course.
- 3.6.3. A layer of sand should be loosely spread and screed to a uniform thickness such that its compacted thickness would be approximately 30mm thick. It is important that the sand layer remains undisturbed prior to the laying of blocks.
- 3.6.4. The grade of the concrete and thickness of the paving blocks shall be as detailed in the Drawings.
- 3.6.5. Concrete edge restraints shall be provided at the perimeter of the pavement to ensure the paving blocks are tightly abutted and to separate areas of different laying pattern.
- 3.6.6. The paving blocks are placed side by side on the sand bed with gaps of approximately 2mm between adjoining blocks. The gap between the paving blocks shall be filled with fine sand of different grading to that required for the bedding sand.
- 3.6.7. The paving blocks can be cut to fit edges and awkward corners. The pavement which has been laid shall be compacted with a hand-guided plate vibrator until it is firmly embedded in the sand layer.
- 3.6.8. The general specification of the precast concrete paving blocks shall comply with MS 1380.

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3.7. In-situ Concrete Paving Footpath

- 3.7.1. In-situ concrete paving shall consist of 75mm thick concrete of 1:3:6-20mm mix by volume as specified in SECTION E: CONCRETING, laid on 100mm thick properly compacted and blinded hardcore to panels as shown on the Drawings or as approved by the S.O..
- 3.7.2. The concrete shall be well compacted and floated with a wooden float to smooth and even finish. After the concrete has achieved the initial set, the surface shall be brushed with a stiff broom or wire brush to give a rough finish.
- 3.7.3. The joints between the panels shall be filled with approved cold-poured polyurethane joint filler.

3.8. Brick Paving

- 3.8.1. Bricks for paving shall be of semi-vitreous bricks 225mm x 75mm x 50mm thick of approved quality and colour.
- 3.8.2. The bricks shall be soaked as specified in SECTION F: WALL SYSTEM before laying and shall be laid flat on 25mm semi-dry cement and sand (1:3) screed with 6mm spacing to the pattern as shown on the Drawings or as approved by the S.O..
- 3.8.3. The screed shall be laid on 75mm thick concrete (1:3:6-19mm) base found on properly compacted and blinded 100mm thick hardcore. The joints shall be filled with cement mortar (1:2) and finish flush.

4. Tiling Works

4.1. Ceramic Tile

- 4.1.1. In general, all ceramic tiles manufactured locally are using the 'dry-pressed' manufacturing process and the ceramic tiles are categorized based on their water absorption rate as defined in the MS 1294, MS ISO 13006 or the International Standard Organization (ISO) Standards (ISO 13006).
- 4.1.2. The methods and materials used in the installation of ceramic tiles under normal internal conditions shall comply with MS 1294-1 and the installation of ceramic tiles under normal external conditions shall comply with MS 1294-2.
- 4.1.3. The installation of tiling works requires skilled operatives working safely using protective clothing and equipment where appropriate; workmanship shall comply with BS 8000-11 for ceramic tiles.
- 4.1.4. Unless otherwise shown on the Drawings, ceramic tiles to internal and external floor for heavy duty areas shall be vitrified with water absorption less than 0.5% [Classification Group Bla] also referred to as heavy duty tiles shall comply with MS ISO 13006 and the size shall be tiles of 300mm x 300mm.

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- 4.1.5. Unless otherwise shown on the Drawings, ceramic tiles to internal floor areas under normal condition shall be vitrified with water absorption less than 3% [Classification Group Bla or, Blb] shall be vitreous hard wearing non-slip glazed complying with MS ISO 13006 and the tile size shall be minimum of 300mm x 300mm.
- 4.1.6. Unless otherwise specified in the Drawings, ceramic tile skirting shall match the flooring tiles and shall be 300mm x 100mm laid lengthwise on cement and sand (1:3) screed as described. All angles to skirting shall be neatly cut to fit all abutments.
- 4.1.7. Unless otherwise specified in the Drawings, accessories such as skirting (bull nose or cove base), step tiles, step nosing, edging strips, angle tiles (internal and external), etc. shall be of an approved type of standard manufacture from the same material to match flooring. Unless specified or otherwise shown on the Drawings, skirting shall be 100mm high, stair nosing shall be minimum 20mm wide, laid full length of the treads and of bull nose profile, and edging strips 25mm wide.
- 4.1.8. Unless otherwise shown on the Drawings, ceramic tiles for internal walls shall be scuff-resistant glazed vitrified tiles with water absorption less than 6% [Classification Group Blb or Blla] shall comply with MS ISO 13006. Unless otherwise specified, the minimum tile size shall be of 300mm x 300mm.
- 4.1.9. Unless otherwise shown on the Drawings, ceramic tiles for external walls up to first floor height shall be scuff-resistant glazed vitrified tiles with water absorption less than 3% [Classification Group Bla or Blb] and shall comply with MS ISO 13006. The tiles maximum size shall be of 300mm x 300mm.
- 4.1.10. Unless otherwise shown on the Drawings, ceramic tiles for external walls used above first floor height shall be scuff-resistant glazed vitrified tiles with water absorption less than 0.5% [Classification Group Bla] shall comply with MS ISO 13006. The tiles maximum size shall be of 300mm x 300mm.
- 4.1.11. Unless otherwise specified in the Drawings, all ceramic tiles for walls and floors shall be of 1st Grade or Grade A with approved surface finish & texture, colour and manufacture.
- 4.1.12. Ceramic tiles used for walls which have high water absorption characteristics shall be bedded with approved tile adhesive to the manufacturer's specification on 20mm thick cement and sand (1:3) render which has sufficiently cured. The tiles shall be laid with 2mm to 3mm gap and all joints shall be filled with approved tile proprietary grout to match. Exposed edges of tiling shall be finished with rounded on edge tiles. Ceramic tiles of Classification Group BIII with water absorption >10% shall not be used under any conditions.

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- 4.1.13. Porous tiles shall be soaked before fixing to prevent rapid suction and subsequent failure in bonding with the mortar bed. Tiles should be removed from their cartons and completely immersed in clean water for at least 30 minutes. After soaking, they should be stacked tightly together, with the end tiles face outwards, on a clean surface and allowed to drain. Tiles classified in MS ISO 13006 in Groups BIb and BIII require this saturation treatment; soaking of tiles of Group Ia, BIb and BIIa is unnecessary, refer to MS 1294-1.
- 4.1.14. Unless otherwise instructed by the manufacturer, the tiles should be fixed dry. All tile installations shall use approved type cementitious adhesives. The selection and application of ceramic tile adhesives for internal and external tile installations on walls and floors shall comply with MS ISO 13007-1 and MS 1294.
- 4.1.15. Grouts used shall be of proprietary grout with good working characteristics, low shrinkage and good adhesion to edges of the tiles complying with MS ISO 13007-3. The selection of the type of grout shall be to the manufacturer's recommendation. Sanded grout shall be used for tile joint width of 4mm or more. Non-sanded grouts shall be used for installation in joints of 4mm width or less. The application of ceramic tile grouts for internal and external tile installations on walls and floors shall comply with MS 1294.
- 4.1.16. Tiles shall be laid with joints not exceeding 3mm wide to be filled with coloured grout. Admixtures shall be used in accordance with the manufacturer's recommendation and they shall not be added to the proprietary grout unless approved by the grout manufacturer. Admixtures are added for improving the resilience and reducing the water permeability of the hardened grout mortar.
- 4.1.17. Unless otherwise shown on the Drawings, movement joints should be located in the tiles installation to coincide and be continuous with all existing structural movement joints, although they are actually formed as separate joints isolated by suitable thickness of back-up material.
- 4.1.18. Unless otherwise shown on the Drawings,, the movement joints with consultation with the designers shall be positioned at the following locations:
- 4.1.18.1. Over existing and/or structural movement joints;
 - 4.1.18.2. Where tiling abuts other materials;
 - 4.1.18.3. Where tiling is continuous across junctions of different background materials;
 - 4.1.18.4. In large tile areas, at internal vertical corners and at 3m to 4.5m centres horizontally and vertically; and
 - 4.1.18.5. Where stresses are likely to be concentrated, for example at changes of alignment.

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- 4.1.19. Unless otherwise specified in the Drawings, joint sealant materials for movement joints shall be selected and applied in accordance with the guidance given BS 6213.
- 4.1.20. Where large format ceramic tiles are required for walls and to be fixed above first floor height, they shall be secured by mechanical means. When the thickness of tile exceeds 12.5mm and the weight of tile is more than 32kg/m², mechanical fixing is recommended. All mechanical fixing methods shall be certified by a competent Professional Engineer and to the approval of the S.O..
- 4.1.21. Pull-out test shall be carried out after twenty-eight (28) days installation for every maximum area 500m² or on the tiles that are suspected of hollowness, at the instruction of the S.O..
- 4.1.22. Adhesion strength of the pull-out test shall exceed 0.5 N/mm² for walls with cement: sand mortar bedding or 1.0N/mm² with adhesive bedding. Pull-out test shall be carried out in accordance to MS ISO 13007-2 and as recommended by the tile adhesive manufacturer. Location and number of test point for the pull-out test shall be as requested by the S.O..
- 4.1.23. Unless otherwise specified, all toilet walls, pantry, and wet areas shall be finished with glazed ceramic tiles up to the ceiling, complete with uPVC tile-trims and/or other accessories wherever required.
- 4.1.24. Cafeteria kitchen shall be finished with glazed ceramic tiles up to the ceiling, complete with uPVC tile-trims and other accessories.
- 4.1.25. Toilet, pantry, kitchen, ablution, and other wet area floors shall use non-slip tiles.
- 4.1.26. Non-slip matt finished tiles with a minimum of 300mm x 300mm shall be used for toilets, wet areas, and external corridors unless otherwise specified. Finishes for toilets in special areas (e.g., VIP areas) shall be of a higher tiles range than a standard toilet.
- 4.1.27. Glazed ceramic tiles or suitable materials to match the worktop shall be provided as a backsplash behind worktops, wash hand basins, and sinks. The length of the backsplash shall cover the overall module of the low and overhead cabinet. The height of the backsplash shall be up to the height of the bottom of overhead cabinets.
- 4.2. Precast Terrazzo Tiles
- 4.2.1. Unless otherwise shown on the Drawings, precast terrazzo tiles of an approved manufacture shall be 100mm x 300mm x 20mm thick machine-pressed tiles comprising of 6mm limestone aggregate and coloured cement.
- 4.2.2. The tiles shall be soaked prior to laying and shall be laid butt jointed on 20mm thick semi-dry cement and sand screed. The laying shall be done while the screed is still green. All joints between the tiles shall be grouted with coloured cement to match.

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- 4.2.3. The tiles shall be rubbed down to a smooth surface after a minimum of two (2) days or laying by means of Carborundum stone. Tile impregnator shall then be applied strictly in accordance with the manufacturer's recommendation on to the terrazzo surface to prevent future staining.
- 4.2.4. Unless otherwise stated in the Drawings, nosing and edging tiles to edges of flooring and treads of concrete stairs shall be of an approved type and to match with the flooring accessories such as skirting (bull nose or cove base), step tiles, step nosing, edging strips, angle tiles (internal and external), etc. shall be of an approved type from the same material to match flooring.
- 4.2.5. Unless otherwise shown on the Drawings, skirting shall be 100mm high, stair nosing shall be minimum 20mm wide laid full length of the treads and of bull nose profile and edging strips 25mm wide.
- 4.3. Mosaic
- 4.3.1. Unless otherwise shown on the Drawings, mosaic tiling to floors shall be semi-glazed tiles and shall be of an approved colour and manufacture.
- 4.3.2. Unless otherwise shown on the Drawings, mosaic tiling to walls shall be fully glazed tile and shall be of approved colour and manufacture.
- 4.3.3. Unless otherwise shown on the Drawings, all skirting shall be 100mm high to match floor tiling. The tiles at the bottom of the skirting shall be set at 45° to the horizontal and the top finished with cove tiles or edging strips to manufacturer's recommendation. The tiles required to form angles to skirting shall be neatly cut and fit to all abutments.
- 4.3.4. Mosaic tiling to floors shall be bedded on 20mm thick semi-dry cement and sand (1:3) screed, laid on the concrete base which has been thoroughly cleaned and wetted.
- 4.3.5. Mosaic tiling to walls shall be evenly buttered with cement and sand mortar before bedding on 20mm thick cement and sand (1:3) screed which has sufficiently cured. Alternatively, the tiling shall be bedded with approved proprietary adhesive to manufacturer's recommendation onto the cement screed.
- 4.3.6. During bedding, the surface of the mosaic shall be checked and any unevenness shall be made good. Any misaligned or defective tiles shall be adjusted or replaced. All joints shall be grouted with approved proprietary grout or coloured cement and sand grout to match. The tiling shall be allowed to mature under damp condition for at least four (4) days before cleaning down.
- 4.3.7. The selection and application of tile adhesives for internal and external mosaic installations on walls and floors shall comply with MS ISO 13007- The selection and application of tile grouts for mosaic installations on walls and floors shall comply with MS ISO 13007-3.

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4.4. Quarry Tiles

- 4.4.1. Quarry tiles shall be of non-slip type 150mm x 150mm x 12mm thick complying with MS 1091. The tiles shall be bedded on 20mm thick semi-dry cement and sand (1:3) screed with joints about 2mm wide, laid on the concrete base which has been thoroughly cleaned and wetted. All tiles shall be soaked overnight before laying.
- 4.4.2. All skirting shall be 100mm high with rounded top edge to match the tiles flooring. The tiles required to form angles to skirting shall be neatly cut and fit to all abutments.

4.5. PVC Tiles/Sheets

- 4.5.1. PVC tiles or sheets shall be of approved type, pattern and colour. PVC tiles or sheets are to be of non-slip type and shall comply with MS 602. Tiles shall be 250mm x 250mm x 2mm thick minimum. Sheets shall be 2m roll width x 2mm thick minimum.
- 4.5.2. Accessories such as skirting, stair nosing, edging strips etc. shall be of the same manufacture from similar material to match flooring. Unless otherwise described skirting shall be 100mm high; stair nosing shall be 60mm wide laid full length of the treads and of bullnose profiles; and edging strips shall be 25mm wide.
- 4.5.3. The final appearance and performance of the floor covering will be determined and affected, in part, by the condition of the subfloor. It is essential that all subfloors are solid, smooth, flat, even, permanently dry, clean and free from all foreign materials such as dust, paint, grease, oils, solvents, curing and hardening compounds, sealers, asphalt and old adhesive residue. The dryness of the subfloor is of the utmost importance and it must be determined by testing the moisture level in the subfloor. Enough drying time must be allowed in the building program to achieve a relative humidity (RH) reading of below 75% or in compliance to the manufacturer's RH recommendation.
- 4.5.4. Installation area for the flooring must be clean, fully enclosed, weathertight and maintained at uniform temperature at least 48 hours prior to, during and after the installation is completed.
- 4.5.5. The tiles or sheet shall be laid and jointed on 20mm thick cement and sand (1:3) screed subfloor with an approved proprietary waterproof adhesive strictly in accordance with manufacturer's recommendation. The screed shall be finished smooth with a steel trowel to an even surface and shall be dry, clean and free from dust and sand before laying the tiles and sheets. A self-levelling sub-floor smoothing compound shall be applied on uneven surfaces to provide a quality finish to receive the floor coverings or as recommended by the manufacturer.
- 4.5.6. For ground floor or basement areas, an approved damp proof membrane shall be installed prior to the application of sand/cement screeds.

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- 4.5.7. Adhesive; when not specified otherwise, type to be as recommended and approved by the PVC tile/sheet covering manufacturer. Use acrylic adhesive/solvent-based adhesive on dry, dustless sub floors in areas not subjected to spillages. Use two parts polyurethane adhesive on the sub-floors in areas subject to excessive spillage of water. Floors must be kept free of traffic until the PU adhesive is fully set, recommended minimum 8 hours.
- 4.5.8. The floor coverings should be adhered in acrylic adhesive or approved equivalent. All joints on the floor must be cut in, grooved and hot welded. Cove up skirting shall be 100mm height, to enable the self-coving of the floor covering. In areas that are not subjected to spillages of water onto the wall surfaces, the top of the covering is to be finished with a PVC capping seal. This should be adhered to the wall surface approximately 100mm-150mm high prior to self-coving floor covering. The material is then cut and fitted into the capping seal, capping seal should be adhered with contact adhesive.
- 4.5.9. In areas that are subjected to spillages of water onto the wall surfaces, the top of the covering is finished with aluminium trimming, a specially designed section for forming water-tight joints in conjunction with the surface of the wall finishes. It is recommended that the aluminium trim be screwed on the wall surface.
- 4.5.10. Where there are excessive spillages of water, it is important that a watertight joint be achieved at the junction of drains, gratings, access covers etc..
- 4.5.11. On completion, the flooring shall be well-cleaned and treated or polished in accordance with the manufacturer's recommendation.
- 4.6. Timber Strip Flooring
- 4.6.1. Unless otherwise shown on the Drawings, timber strip flooring shall be ready-made, laminated three (3) ply timber strips or floorboards of approved manufacture. The timber species for use in timber strip flooring shall be as specified in SECTION I: TIMBER, JOINERY AND IRONMONGERY.
- 4.6.2. The flooring shall be laid to the pattern as approved by the S.O., on 20mm thick cement and sand (1:3) screed with an approved waterproof adhesive applied in accordance with manufacturer's recommendation. The screed shall be finished smooth with a steel trowel to an even surface and it shall be dry, clean and dust free before laying the timber strip flooring. After the adhesive has set, the timber strip flooring shall be sanded to a true smooth and even surface using a suitable sanding machine. Any misaligned or defective timber strip shall be adjusted or replaced.
- 4.6.3. Unless otherwise shown on the Drawings, skirting to timber strip flooring shall consist of 100mm x 12mm thick wrot timber skirting rounded at the top, and fixed to the wall or column using 38mm masonry nails spaced approximately at 600mm centres in two rows 26mm away from the top and bottom edges. The nails shall be punched below the surface and the holes filled with approved putty. Any jointing of the skirting shall use splayed butt joints.

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- 4.6.4. The face edges of the flooring shall be lined with wrot timber edging to match. The edging strips shall be 38mm wide approximately x 12mm thick fixed to the base using adhesive as specified hereinbefore, projecting 12mm from the finished sides of floor slabs. Edging strips shall be jointed using glued splayed butt joints.
- 4.6.5. After sanding the flooring shall be cleaned, any gap sealed with approved sealer, stained and finished with three (3) coats of approved polyurethane paint. Each coat shall be applied strictly in accordance with the manufacturer's recommendation.
- 4.7. Parquet Tile Flooring
- 4.7.1. Unless otherwise shown on the Drawings, parquet tiles shall be ready-made 120mm x 120mm x 10mm thick consisting of 120mm x 25mm x 10mm pressure treated kempas, keruing or other approved medium hardwood timber battens. The timber species for use in parquet flooring shall be as specified in SECTION I: TIMBER, JOINERY AND IRONMONGERY WORKS.
- 4.7.2. The flooring shall be laid to the pattern as approved by the S.O., on 20mm thick cement and sand (1:3) screed with an approved waterproof adhesive applied in accordance with manufacturer's recommendation. The screed shall be finished smooth with a steel trowel to an even surface and it shall be dry, clean and dust free before laying the parquet flooring. After the adhesive has set, the parquet flooring shall be sanded to a true smooth and even surface using a suitable sanding machine. Any misaligned or defective parquet shall be adjusted or replaced.
- 4.7.3. Unless otherwise shown on the Drawings, skirting to parquet flooring shall consist of 100mm x 12mm thick wrot timber skirting rounded at the top and fixed to the wall or column using 38mm masonry nails spaced approximately at 600mm centres in two rows 26mm away from the top and bottom edges. The nails shall be punched below the surface and the holes filled with approved putty. Any jointing of the skirting shall use splayed butt joints.
- 4.7.4. The face edges of the flooring shall be lined with wrot timber edging to match. The edging strips shall be 38mm wide approximately x 12mm thick fixed to the base using adhesive as specified hereinbefore, projecting 12mm from the finished sides of floor slabs. Any edging strips shall be jointed using glued splayed butt joints.
- 4.7.5. After sanding the flooring shall be cleaned, any gap sealed with approved sealer, stained and finished with three (3) coats of approved polyurethane paint and sanding between coats. Each coat shall be applied strictly in accordance with the manufacturer's recommendation. The required type of flooring finish shall be to S.O.'s approval.

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4.8. Granite Slabs

- 4.8.1. Unless otherwise shown on the Drawings, granite slabs for flooring shall be 600mm x 600mm x 25mm thick and bedded with cement and sand mortar or alternatively with 9mm thick approved proprietary tile adhesive onto 25mm thick cement and sand (1:3) screed as described hereinbefore. The slabs shall be laid butt-joint. Any gap shall be filled with an approved mixture of adhesive and grout powder. After grouting, the surface then shall be polished, buffered and finished with a layer of impregnator.
- 4.8.2. If used in wet or exposed areas, or on ground floor, waterproofing system shall be installed prior to the laying of granite slabs. The floors or the exposed wet areas shall be applied with two coats of approved waterproof coating.
- 4.8.3. The reverse side of granite slabs in contact with the ground floor or exposed wet wall surface shall be applied with approved waterproof coating.

4.9. Marble Slab

- 4.9.1. Unless otherwise shown on the Drawings, marble slabs for flooring shall be 600mm x 600mm x 25mm thick shall be bedded with cement: sand mortar or alternatively with 9mm thick approved tile adhesive onto 25mm thick cement and sand (1:3) screed. The slabs shall be laid butt-joint. Any gap shall be filled with an approved mixture of the adhesive and grout powder. After grouting, the surface then shall be polished, buffered and finished with a layer of impregnator.
- 4.9.2. If used in wet or exposed areas, or ground floor, a waterproofing system shall be installed prior to the laying of marble slabs. The floors or the exposed wet areas shall be applied with two coats of approved waterproofing coating.
- 4.9.3. The reverse side of marble slabs in contact with the ground floor or exposed wet wall surface areas shall be applied with approved waterproof coating.

4.10. Vinyl

- 4.10.1. Vinyl sheet or vinyl tile flooring shall be high performance homogeneous-heterogeneous type and specified in accordance with the following type and performances:
 - 4.10.1.1. Vinyl Type 1: Heavy duty to withstand heavy traffic of trolleys.
 - 4.10.1.2. Vinyl Type 2: Anti-static to cater for aseptic and dust free environments.
 - 4.10.1.3. Vinyl Type 3: Anti-slip to cater for wet areas as well as slippery areas.

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4.10.1.4. Vinyl Type 4: Heavy duty, fully flexible and resilient for sports flooring and children play areas (Designed specially that combines tough wear layer with a resilient backing for comforts and under floor sound deadening properties and attractive good looks).

4.10.1.5. Vinyl Type 5: High Resistant to Chemical.

- 4.10.2. All joints to be hot welded and matching coloured. The skirting to the vinyl floor must be of the same vinyl to 150mm high with approved cove former and finished with matching coloured UPVC capping strips with approved recommended acrylic adhesive strictly to manufacturer's method of installation.
- 4.10.3. Vinyl sheets shall have Polyurethane Reinforced (PUR) surface treatment for easy maintenance.
- 4.10.4. Approved metal dividing clips shall be installed when vinyl flooring meets with other floor finishes.
- 4.10.5. Prior to the application of vinyl floor covering, the Contractor shall ensure that the floor substrate has a perfectly even surface, dry and free from dust and sand. Vinyl sheets shall be installed onto floor flatness tolerance of not more than ± 3 mm for every 3m length floor area ready to receive vinyl flooring. Self-levelling compound of approved quality to be installed before finishing with vinyl flooring. The flatness tolerance shall strictly adhere to the manufacturer's method of installation.
- 4.10.6. Types of adhesive with low VOC shall be used strictly in accordance with the recommendation of the manufacturer.
- 4.10.7. Laying of all type's vinyl flooring shall only be carried out by specialists from the approved supplier of the material.
- 4.10.8. The Contractor shall incorporate damp proof treatment before laying the vinyl flooring to ensure that the floor slab/ or base screed is free from rising damp.
- 4.10.9. For waiting areas, corridors and other specific areas, the vinyl floors shall be completed with designed motifs, graphics and interplay of colours to the S.O.'s concurrence.
- 4.10.10. Stainless steel floor trap and gratings provided in vinyl flooring area shall be of special approved type that is suitable for vinyl flooring and shall be installed to manufacturer's specification and instructions.
- 4.10.11. Approved anti-slip nosing strips shall be used wherever vinyl is being laid on steps or staircases. Special approved type of metal grating suitable for vinyl flooring shall be used.

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4.11. Indoor Sport Floors - Cushion PVC Sport Flooring

4.11.1. Unless otherwise specified in the Drawings, multi-purpose game court surfaces shall be finished with Cushion PVC Sport Flooring sheets endorsed and recommended surfacing systems with excellent shock absorption, elasticity, flexibility, strong protective membrane, waterproof, resilience and slip resistance to ensure great sports performance.

4.11.2. Cushion PVC Sport Flooring sheets shall be minimum overall thickness of 7.5mm comprising surface layer with protecsol treated, calendered and grained 100% PVC sheet.

4.11.3. It is reinforced by a double layer of non-woven fiberglass grid and double density closed cell foam. Shall undergone Sanosol treatment for fungistatic and bacteriostatic, surface treated with Protecsol cross-linked dirt protection treatment.

Weight: 4.7kg/m²,
Shock Absorption (EN 14808): P1
Impact Protection Index (IPI) (AC-P90-205) =76%,
Vertical Deformation (EN 14809): < 2mm,
Energy Return (pr EN WI 217): 0.4 m/s,
Abrasion Resistance (EN ISO 5470-1): <350mg,
Sliding Coefficient (EN 13036-4): 80-100,
Indentation Resistance (EN1516) : < 0.5mm,
Abrasion resistance EN ISO 5470-1) < 350mg.
Ball bounce (EN12235) >90%
Fire (EN13501-1): Cfl-S1
Complied to GREEN Label/ Certificate
Low VOC

4.11.4. Cushion PVC flooring sheets shall comply with approved or accredited by major sport federations, namely Badminton Wall Federation (BWF), International Basketball Federation (FIBA), International Table Tennis Federation (ITTF), Asean Football Confederation (AFC), Fédération Internationale de Volleyball (FIVB), International Floorball Federation (IFF).

4.11.5. The final appearance and performance of the floor covering will be determined and affected, in part, by the condition of the subfloor. The general requirement for the subfloor must be absolutely hard, smooth finished level, dry, structurally sound, free from cracks and other irregularities, free from contamination with paint, plaster, oil, grease or any substances that could affect the adhesion. A damp proof membrane must be laid under the concrete to act as a barrier against underlying hydrostatic pressure and moisture (for ground floor only). Cracks or hollowness must be repaired and filled with an appropriate material. The subfloor must be level with a tolerance of 3mm over 2m straight edge.

4.11.6. The floor covering should be underlayment 5mm self-levelling compound (e.g. CL 11 or NC146) with primer and applied in accordance with the manufacturer's instructions. The tensile bending strength after 28 days is 6N/mm² and compressive strength after 28 days is 30N/mm². Self-levelling compound shall comply with green label certification.

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- 4.11.7. The top of the covering is finished with damp proof membrane (for ground floor only) (e.g. HydroEpoxy 300 or PE146), a 2-component water based epoxy polyamide membrane/barrier coating. The cured membrane shall withstand 250kPa hydrostatic pressure which is equivalent to a 25m head of water. Application is in accordance with manufacturer's instruction.
- 4.11.8. Cushion PVC Sport Flooring sheets installation shall only use low VOC adhesives.

5. Carpet

5.1. Carpet Tiles

- 5.1.1. Unless otherwise specified in the Drawings, all carpets shall be of high quality, durable, loop pile type of 100% Nylon type 6 fibre (ASTM D 629-72/ANSI), 1/12 gauge, minimum 7mm overall thickness of pile height and cushion backing, 16 oz per sq. yard pile weight (normal traffic area), 24 oz per sq. yard pile weight (heavy traffic area).
- 5.1.2. Carpets shall be coated with protective coating (e.g. 3M Scotchgard™ or equivalent) for stain resistant and easier cleaning.
- 5.1.3. All ground floor areas, which are specified using carpet tiles, shall have approved damp proof membrane on the ground floor slabs.
- 5.1.4. Unless otherwise specified in the Drawings, wall edges shall be with approved minimum 100mm height timber skirting.
- 5.1.5. The Contractor shall be required to submit samples of the various colours/patterns and SIRIM Eco-Label certification.
- 5.1.6. Aluminium dividing strips or other suitable rust proof metal gripper strips shall be laid at junctions of different floor finishes and finishing flushed with flooring.
- 5.1.7. Carpet tiles can be laid over any smooth, hard floor like parquet, laminated flooring and stone. Ensure the surface is clean, level and dry before installation.
- 5.1.8. All floor areas, which are specified using carpets, must be dry, level, and free from dirt, grease, oil, paint, sealer, old adhesives, and other residues.
- 5.1.9. Carpet tiles installation shall only use low formaldehyde water-based adhesive.
- 5.1.10. Carpet tiles used shall be laid with close butt joints, stretched and balanced so that all seams are parallel with minimum bows with suitable rustproof metal gripper strips securely installed.
- 5.1.11. The carpets shall be installed in largest practical pieces and salvage shall be trimmed as required to assure colour uniformity and pattern match at seams. All carpet shall have its edges trimmed and neatly fitted around all perimeters, openings and obstructions.

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5.1.12. Warranty minimum 2 years on manufacturing defects. Supply and install by approved installer by manufacturer.

5.2. Broadloom Carpet (Roll Carpet / wall to wall carpet)

5.2.1. Machine Tufted Carpet

- 5.2.1.1. Unless otherwise specified in the Drawings, the machine tufted carpet shall be of high quality, durable, loop pile type or cut pile type or combination of both of 100% Nylon type 6 fibre (ASTM D 629-72/ANSI), 1/12 gauges, minimum 7mm overall thickness of pile height and PVC backing underlay, minimum 18oz per sq. yard pile weight (normal traffic area), minimum 24oz per sq. yard pile weight (heavy traffic area).
- 5.2.1.2. Broadloom carpets shall be coated with protective coating (e.g. 3M Scotchgard™ or equivalent) for stain resistant and easier cleaning.
- 5.2.1.3. All ground floor areas, which are specified using carpets, shall have approved damp proof membrane applied on the floor slabs. Unless otherwise specified in the Drawings, all carpets shall be laid with 6mm thick rubber-crumb underlay.
- 5.2.1.4. Unless otherwise specified in the Drawings, wall edges shall be minimum 100mm height timber skirting.
- 5.2.1.5. All floor areas, which are specified using carpets, must be dry, level, and free from dirt, grease, oil, paint, sealer, old adhesives, and other residues.
- 5.2.1.6. The Contractor shall be required to submit samples of the various colours/patterns and SIRIM Eco-Label certification.
- 5.2.1.7. Aluminium dividing strips or other suitable rust proof metal gripper strips shall be laid at junctions of different floor finishes and finishing flushed with flooring.
- 5.2.1.8. Broadloom carpets used shall be laid with close butt joints with underlay, stretched and balanced so that all seams are parallel with minimum bows with suitable rustproof metal/ wood gripper/ gripper strips securely installed.
- 5.2.1.9. The carpets shall be installed in largest practical pieces and salvage shall be trimmed as required to assure colour uniformity and pattern match at seams. All carpet shall have its edges trimmed and neatly fitted around all perimeters, openings and obstructions.
- 5.2.1.10. Warranty minimum 2 years on manufacturing defects. Supply and install by approved installer by manufacturer.

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5.2.2. Axminster Carpet

- 5.2.2.1. Unless otherwise specified in the Drawings, the axminster carpet shall be of high quality, durable, cut pile type of 80% Wool 20% Nylon type 6 fibre (ASTM D 629-72/ANSI), 1/12 gauges 7/7 rows and pitch, minimum 7mm overall thickness of pile height and jute backing, minimum 32oz per sq. yard pile weight (normal traffic area), minimum 42oz per sq. yard pile weight (heavy traffic area).
- 5.2.2.2. Broadloom carpets shall be coated with protective coating (e.g. 3M Scotchgard™ or equivalent) for stain resistant and easier cleaning.
- 5.2.2.3. All ground floor areas, which are specified using carpets, shall have approved damp proof membrane applied on the floor slabs. Unless otherwise specified in the Drawings, all carpets shall be laid with 6mm thick rubber-crumble underlay.
- 5.2.2.4. Unless otherwise specified in the Drawings, wall edges shall be minimum 100mm height timber skirting.
- 5.2.2.5. All floor areas, which are specified using carpets, must be dry, level, and free from dirt, grease, oil, paint, sealer, old adhesives, and other residues.
- 5.2.2.6. The Contractor shall be required to submit samples of the various colours/patterns and SIRIM Eco-Label certification.
- 5.2.2.7. Aluminium dividing strips or other suitable rust proof metal gripper strips shall be laid at junctions of different floor finishes and finishing flushed with flooring.
- 5.2.2.8. Broadloom carpets used shall be laid with close butt joints with underlay, stretched and balanced so that all seams are parallel with minimum bows with suitable rustproof metal/ wood gripper/ gripper strips securely installed.
- 5.2.2.9. The carpets shall be installed in largest practical pieces and salvage shall be trimmed as required to assure colour uniformity and pattern match at seams. All carpet shall have its edges trimmed and neatly fitted around all perimeters, openings and obstructions.
- 5.2.2.10. Warranty minimum 5 years on manufacturing defects. Supply and install by approved installer by manufacturer.

5.2.3. Stone Plastic Composite (SPC) Flooring

- 5.2.3.1. Overall thickness: 5mm to 7mm for commercial application, 4mm to 5mm for residential application.
- 5.2.3.2. Wear layer thickness: 0.3mm to 0.5mm for residential application, 0.5mm to 0.7mm for commercial application.
- 5.2.3.3. Adhesive thickness: 2mm to 3mm for residential application.

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5.2.3.4. Length: 60-inch/ 152.4cm planks.

5.2.3.5. Width: 9-inch/ 22.66cm planks.

5.2.3.6. Thickness: 5.7mm thickness.

5.2.3.7. Core material: Waterproof Core – Rigid Vinyl – SPC.

5.2.3.8. Surface texture: Natural texture.

5.2.3.9. Warranty: Lifetime residential warranty and 10 years commercial warranty.

6. Seamless Flooring System

- 6.1. All concrete floor slabs shall be applied with waterproofing and floor hardener. High-performance, self-levelling epoxy or polyurethane (PU) resin shall be used in areas that are subject to heavy-duty machinery and high traffic.
- 6.2. Chemical resistant epoxy resin shall be used in laboratories and/or stores unless otherwise specified.
- 6.3. Polyurethane resin shall be used in areas that need hygienic clean floors and subject to thermal shocks, such as food preparation areas, cold storage, or freezer in kitchens.
- 6.4. Polished concrete, wherever specified, shall be a super flat concrete floor slab treated with an approved coat of nano lithium concrete densifier. It shall be grinded to either 800, 1500, or 3000 grit level (depending on the function) before executing works. Polished concrete shall be low maintenance, waterproof, chemical resistant, and with the following specification:
 - i. Compressive strength: 8 N/mm² (ASTM C942-99)
 - ii. Abrasion Resistance: 70.3mg weight loss & wear index at 1000 cycles (ASTM D4060)
 - iii. Skid Resistance: Wet: 62, Dry: 82 (ASTM E303)
 - iv. Water absorption: 4.89% (BS 1881: Part 122)
 - v. Pull out adhesion test: 967 Psi (ASTM D45410)
- 6.5. Heavy duty coloured stamped or stencilled concrete or any other approved alternatives shall be used at driveways and car porches unless otherwise specified.
- 6.6. Coloured concrete floor hardener shall be provided in areas of heavy machinery works. It shall be laid with a self-levelling epoxy floor complete with floor hardener and crystallisation or cementitious waterproofing. A proprietary floor hardener system shall be used and applied following the manufacturer's recommendation. Floor hardener materials shall be of high quality, heavy-duty 5mm thick above 150mm thick concrete floor slab.

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1. General

- 1.1. Unless otherwise specified or shown on the Drawings, all ceilings for internal use shall be a range of gypsum plasterboards or as approved by the S.O. with class 'O' fire rating and all ceiling installations shall comply with the classification of fire spread as stipulated in the 8th Schedule Uniform Building By-Law 1984.
- 1.2. All concealed ceilings shall be provided with dedicated service access to the ceiling void for maintenance of services above the ceiling space in accordance with the Drawings and approval of the S.O..
- 1.3. All sprinkler heads (drops) shall have a 12.5mm diameter oversize ring, sleeve or adaptor through the ceiling tile to allow for free movement of the sprinkler pipes. It shall also comply with the local fire regulations and to the S.O.'s approval.
- 1.4. The ceiling installation shall not commence works until the building is effectively weather-tight and the work area of wet trades has been completed and dried.

2. Acoustic Requirements

- 2.1. Acoustic requirements specified or shown on the Drawings, such as sound absorption, sound insulation (against air-borne and impact noise) shall be tested in accordance with BS EN 13964, BS EN ISO 10140, BS EN ISO 354[WTH1] or other acceptable standards.
- 2.2. A full test report shall be submitted to the S.O. as proof of compliance. It shall relate to the entire specified system. Any variations shall be endorsed by the test laboratory or field testing. Test reports, comments and the testing authority shall be stated in the manufacturer's trade literature or be made available upon request or both.
- 2.3. All acoustic ceilings shall be of proprietary system using mineral fibre boards or spray applied cellulose on ceiling and/or soffit of slab as approved by the S.O. and conforms to class 'O' fire rating classification comply with BS 476 Part 6 & Part 7.

3. Materials and Ceiling Components

3.1. Zinc-Coated and Aluminium/Zinc Coated Steel

Zinc-coated and aluminium/zinc-coated steel used for the construction of suspended ceiling components shall comply with MS 1196 or other equivalent Standards. The Contractor shall provide proof of compliance to the approval of the S.O.. Where sections have been cut from zinc-coated or aluminium/zinc-coated sheets, the cut edges shall be treated with protective anti-rust paint to prevent corrosion. All pre-painted finish for ceilings shall be as specified under SECTION G: ROOFING.

3.2. Linear Strip Ceiling

Unless otherwise specified or shown on the Drawings, linear strip ceiling shall be aluminium pre-painted anodized, consisting of 150mm width x 12.5mm deep x 0.6mm thick panel fixed in accordance with manufacturer's recommendation and to S.O.'s approval.

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3.3. Plasterboard

3.3.1. All plasterboards dimensions, its tolerances and flexural breaking load shall comply with BS EN 520. The board shall carry class 'O' approval from JBPM.

3.3.2. Unless otherwise specified in the Drawings the size for plasterboard ceiling shall be 600mm x 600mm x 9mm thick min. and shall be suspended from the soffit with adjustable hanger rods in accordance with the manufacturer's recommendation and S.O.'s approval.

3.4. Plasterboard with improved core adhesion at high temperature (Type F)

The type of board and test requirements shall be in accordance with BS EN 520, and to the approval of the S.O.. The board shall carry Class 'O' approval from JBPM.

3.5. Plasterboard with reduced water absorption (Type H)

The types of moisture resistance board to receive paint finish shall be in accordance with BS EN 520 and to the approval of the S.O.. The board shall carry Class 'O' approval from JBPM.

3.6. Mineral Fibre Boards

3.6.1. Unless otherwise specified, the board size shall be 600mm x 1200mm x 15mm thick sq. edges. The board shall carry Class 'O' approval from the JBPM and the requirement of sag resistance shall be minimum of RH95 and above.

3.6.2. Mineral Fibre Board shall have a requirement of Noise Reduction Coefficient (NRC) rating minimum of 0.70.

3.6.3. Surface coating of the board shall be applied with vinyl latex paint in white colour at the factory and the surface design/texture of the board shall be to S.O.'s approval.

3.7. Fibre Cement Ceiling Panel

Fibre cement ceiling panel shall be asbestos free and shall be an autoclaved cellulose fibre cement flat board. Thickness must be minimum 3.2mm, 4.5mm and 6mm (internal) and 6mm, 9mm for (external). The basic composition of the panel should consist of cement, refined sand and cellulose fibre. The material shall be classified as Class O in accordance with BS476 Part 4, or Part 6 and Part 7 requirements (fire-listed) under SIRIM QAS fire listing scheme.

3.8. Acoustic Glass Wool Ceiling Panel

Acoustic glass wool ceiling panel shall be lightweight fibre glass wool material with high acoustical sound absorption of NRC: 0.90-1.00 (ASTMC 423). Unless otherwise specified the size of the panel shall be 600mm x 1200mm x 20mm thick, sq. edge fixed to aluminium tee exposed grid systems, suspended from the soffit with adjustable hanger rods in accordance with manufacturer's recommendation and S.O.'s approval.

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3.9. Glass Fibre Reinforced Gypsum (GRG)

3.9.1. GRG Boards are manufactured by glass fibre reinforced gypsum and consist of non-combustible high-grade gypsum casting plaster with glass fibre membranes. Unless otherwise specified minimum sizes shall be 1200mm X 900mm x 9mm thick. The board shall conform to the following:

Fire performance : GRG Boards are rated non-combustible as defined in BS 476: Part 4.

Dry Density : Approx. 1660kg/m²

3.9.2. GRG boards shall be installed in accordance with the manufacturer's recommendation and to S.O.'s approval.

3.10. Cornice

3.10.1. Unless otherwise specified, cornice shall be provided of the same ceiling material for all plaster ceiling materials.

3.10.2. Cornice shall be fixed to the walls and ceiling using proprietary adhesive or as recommended by the manufacturer and approved by the S.O..

3.10.3. Large cornices shall be fixed using screws together with cornice adhesive as recommended by the cornice manufacturer and to S.O.'s approval.

3.10.4. Cornice should be carried and handled carefully to avoid cracking the core or wrinkling the paper liner. Where possible, the Contractor shall use full lengths of cornice and mitre all joints.

3.10.5. The Contractor shall ensure accurate and level placement by marking ceilings and walls with a line at the cornice edge.

3.10.6. Cornice with shorter length shall be installed first followed by the longer lengths by bowing out to spring mitres fit into place.

3.11. Reinforcing/Joining Tape

The tape shall not be less than 50mm width paper tape in accordance with ASTM C475 from an approved manufacturer and to S.O.'s approval.

3.12. Jointing Compound

Jointing compound shall be of setting type or pre-mixed multi-purpose gypsum based air drying type compound, in accordance with BS EN 13963 and to the approval of the S.O..

3.13. Sealants

The application of fire sealant for plasterboard with improved core adhesion at high temperature (Type F) and wet area sealant for plasterboard with reduced water absorption (Type H) shall be in accordance with BS 8212 and to the approval of the S.O.. The appropriate type of sealant shall be used for the required type of plasterboard. Elastomeric sealants can be used at the perimeter of the dry lining or partitioning to provide an airtight construction and to the approval of the S.O..

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3.14. Control Joint

Unless otherwise specified, control joints shall be provided in a long continuous run of ceiling, spaced at not more than 12m centres maximum and recommended by the manufacturer and to the approval of the S.O..

3.15. Anchors and Fasteners

- 3.15.1. The Contractor shall submit the details of the proposed proprietary anchor to the S.O. for approval.
- 3.15.2. Notwithstanding the above, the alternative anchor proposed shall be made of carbon steel galvanised to minimum thickness of 5 µm or stainless steel in accordance with European Technical Approval Guideline ETAG 001 Metal Anchors for Use in Concrete.
- 3.15.3. The size of the anchor fixing shall not be less than 6mm diameter (M6) with effective anchorage depth of not less than 30mm measured from the soffit of the floor slab. The hole for the anchor shall be drilled using a drill bit of corresponding size to the proprietary anchor. The design resistance in all load directions shall not be less than 1.10kN.
- 3.15.4. Shot-fired (hybrid-pin) alternative anchors shall not be used to install the suspended ceiling hangers to the concrete soffit. Screws with nylon wing plugs shall not be used as ceiling anchors to install the suspended ceilings.
- 3.15.5. Fasteners shall have a corrosion-resistant finish and be appropriate for intended use, in accordance with BS EN 14566. The heads of fasteners shall be shaped so that they can be driven slightly below the surface of the plasterboard without punching through the paper liner.

3.16. Acoustical Cellulose Insulation

- 3.16.1. Spray Applied Acoustical Cellulose Insulation on ceiling and/or soffit of slab shall be:
 - 3.16.1.1 Thickness – minimum 30mm
 - 3.16.1.2 Thermal conductivity (k-value) = 0.0029 W/mK tested to ASTM C-177.
 - 3.16.1.3 Fire retardant Class “O” complying with BS476 Part 6 & 7 and endorsed by JBPM.
 - 3.16.1.4 Average moisture absorption of not more than 15% as per ASTM C739.
 - 3.16.1.5 Tested Noise Reduction Coefficient of minimum NRC 0.75 at 30mm thickness.
 - 3.16.1.6 Tested to be non-toxic and asbestos free, contain no carcinogenic materials and shall not cause any skin irritation to humans

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- 3.16.2. Where required, appropriate surface preparation and treatment should be done on the surface of the substrate according to manufacturer's recommendation.
- 3.16.3. The application of cellulose insulation shall be applied strictly to manufacturer's method statement and to S.O.'s approval.

4. Ceiling Suspension System

4.1. General

- 4.1.1. Batten systems (furring channels) as vertical ceiling hangers shall not be allowed for the installation of proprietary ceiling systems.
- 4.1.2. Where grid ceiling suspension systems are installed exposed to wind condition (outside building), all lay-in ceiling panels/boards shall be secured to the suspension system with minimum two proprietary 'hold-down clip' for each tile as recommended by the manufacturer and approved by the S.O..
- 4.1.3. Only proprietary adjustable butterfly type locking clips (rod joiner) shall be used with a minimum thickness of 0.48mm and galvanised coating mass of minimum 80g/sq. m. The locking clips shall be of min. steel grade SK-5 or approved equivalent with a minimum pull off strength of 110kgs.

4.2. Fixed Ceiling System

- 4.2.1. Timber framing or metal framing system shall be designed and installed to support the fixed ceiling panels/boards on the external or outside space of the building as shown on the Drawings. All external ceilings shall use fixed ceiling system.
- 4.2.2. All timber materials used shall be treated and as specified under SECTION I: TIMBER, JOINERY AND IRONMONGERY. Unless otherwise specified, ceiling boards fixed to the timber frames shall be with butt 'V' joint using nails or screws as recommended by the ceiling manufacturer and to S.O.'s approval.
- 4.2.3. Where conceal ceilings are used, all ceiling panels/boards fixed to the metal frames shall be screwed permanently to the metal framing system as recommended by the ceiling manufacturer and to S.O.'s approval.
- 4.2.4. All screw fixings of the ceiling panel/boards to the framing system shall be completely sealed to match with the ceiling surface. All external ceilings shall be painted with weather resistant paint as specified under SECTION N: PAINTING.

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4.3. Grid Ceiling Suspension System

4.3.1. Vertical Suspension Members

- 4.3.1.1. Ceiling hangers shall be galvanised mild steel machine straightened hanger rods of minimum 4mm diameter consisting of two pieces length with a galvanization thickness of minimum 80g/sq. m. and tensile strength of minimum 350MPa. held together by a galvanised rod joiner (adjustable type galvanised locking clips). Only proprietary adjustable locking clips (butterfly type) shall be used as a rod joiner.
- 4.3.1.2. Proprietary anchor fixing shall not be less than 6mm diameter (M6) with effective anchorage depth of not less than 30mm measured from the soffit of the floor slab. The hole for the anchor shall be drilled using a drill bit of corresponding size to the anchor. The proprietary anchor is fixed to the structural soffit at a distance 200mm away from the wall and then spaced equal to or not more than 1200mm centre to centre (c/c) to form the grid of the ceiling hanger.
- 4.3.1.3. One end of the hanger shall be attached to a pre-drilled G300 steel grade with AZ150 zinc aluminium alloy L-shaped soffit cleat 60mm x 20mm x 25mm (width) and minimum base metal thickness of 1.15mm with a galvanization thickness of minimum 80g/sq. m. for suspending the pre-straightened hanger rod. The other end of the hanger shall be secured using proprietary locking clips to the primary T-section. The T-sections shall be fixed accordingly to the required ceiling level by adjusting the length of the ceiling hanger through the rod joiner. Alternatively, zinc coated M6 x 60mm fisheye anchor may be considered at soffit.
- 4.3.1.4. One end of the pre-straightened hanger rod shall be hooked to the pre-drilled soffit cleat and the other end of the hanger shall be secured to the primary T-section using proprietary locking clips. The T-sections shall be fixed accordingly to the required ceiling level by adjusting the length of the ceiling hanger through the rod joiner.
- 4.3.1.5. The proprietary adjustable locking clips (butterfly type rod joiner) shall be 0.5mm minimum thickness with galvanised coating mass of minimum 80g/sq. m. The locking clips shall be of minimum steel grade SK-5 and with a minimum pull off strength of 110kgs.

4.3.2. Horizontal Suspension Members

- 4.3.2.1. The T-grid system shall be manufactured to a minimum 24mm width x 30mm height T-section rigidized (rotary stitching) on all T-sections and with a load carrying capacity of minimum 20kgs/m² per ASTM C635. All T-sections shall be in pre-painted white or powder coated colour white. Installation shall refer to the manufacturer's method statement.

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- 4.3.2.2. Perimeter wall angles shall be securely fixed to the adjacent perimeter walls using appropriate fixings forming part of the grid ceiling system as recommended by the manufacturer and approved by the S.O..

4.4. Concealed Ceiling Suspension System (Soffit-ceiling distance < 1800mm)

Unless otherwise shown on the Drawings and when the distance between the concrete soffit and the suspended ceiling board is less than 1800mm in vertical height, the concealed ceiling suspension system shall be as follows:

4.4.1. Vertical Suspension Members

- 4.4.1.1. Ceiling hangers shall be rigidized galvanised mild steel 25mm x 25mm angle section with 0.5mm base metal thickness or galvanised mild steel machine straightened hanger rods of minimum 4mm diameter with a galvanization thickness of minimum 80g/sq. m. and tensile strength of minimum 350MPa. The rod shall be in 2 pieces and should be used in conjunction with the adjustable suspension (butterfly type) clip/rod joiner. Levelling of the ceiling shall be executed in accordance with the manufacturer's method statement.
- 4.4.1.2. Proprietary anchor fixing shall not be less than 6mm diameter (M6 or ¼") with effective anchorage depth of not less than 30mm measured from the soffit of the floor slab. The hole for the anchor shall be drilled using a drill bit of corresponding size to the anchor. The proprietary anchor shall be fixed to the structural soffit at a distance 200mm away from the wall and then spaced equal to or not more than 1000mm c/c to form the grid of the ceiling hanger.
- 4.4.1.3. Where hanger rods are used, one end of the hanger rod shall be attached to a pre-drilled G300 steel grade with AZ150 zinc aluminium alloy L-shaped soffit cleat 60mm x 20mm x 25mm (width) and minimum base metal thickness of 1.15mm. Alternatively, zinc coated M6 x 60mm fisheye anchors may be considered at soffit. The other end of the hanger shall be secured using proprietary locking clips to the primary channel (main runners).
- 4.4.1.4. Where mild steel angle sections are used as ceiling hangers, one end of the ceiling hanger shall be connected to the pre-drilled proprietary anchor fastener to the soffit slab. The other end of the hanger shall be secured using proprietary locking clips or suspension brackets to the primary channel (main runners).

4.4.2. Horizontal Members

- 4.4.2.1. Primary rigidized galvanised steel channel (main runners) shall be 34mm x 12mm x 0.4mm minimum BMT at a distance of 100mm away from the wall and spaced equal to or not more than 1000mm c/c (the minimum thickness may vary according to the profile with larger cross section values with appropriate justification from manufacturer). Installation shall refer to the manufacturer's method statement.

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- 4.4.2.2. Secondary rigidized galvanised steel channel 34mm x 12mm x 0.4mm minimum BMT shall be secured using proprietary locking clips or suspension brackets to the primary channel.
- 4.4.2.3. The primary and secondary channels shall be connected using galvanised proprietary locking clips or suspension brackets with minimum thickness of 0.5mm (the minimum thickness may vary according to the profile with larger cross section values with appropriate justification from manufacturer) and screwed as recommended by the manufacturer. And no tilting movements are allowed on the primary channel once secured with locking clips.
- 4.4.2.4. Unless otherwise specified, a single layer 9mm thick gypsum board ceiling shall be screwed using approved drywall screw minimum (3.5mm Ø) x 25mm length fixed at maximum distance of 200mm c/c to the secondary channel as recommended by the manufacturer.

4.5. Concealed Ceiling Suspension System (Floor-ceiling distance > 1800mm)

Unless otherwise shown on the drawings or when the distance between the concrete soffit and the suspended ceiling board exceeds 1800mm in vertical height, the concealed ceiling suspension system shall be as follows:

4.5.1. Vertical suspension members

- 4.5.1.1. Ceiling hanger system shall be galvanised mild steel threaded rods of not less than 6mm diameter.
- 4.5.1.2. Fixing of vertical suspension hangers to soffit slab shall be by using threaded rod and proprietary anchor (drop in anchor or equivalent). Identify the actual location of the suspended point on Site, mark the position for drilling, the position should be no more than 100mm away from the perimeter wall, drilling at least 28mm depth. Insert corresponding diameter drop-in anchor or equivalent, for best result hammer the "pin" slightly inside the drop-in-anchor. Cut threaded rod to require suspension length and screw fix the threaded rod into the corresponding diameter drop-in-anchor or equivalent. Slightly pull the threaded rod to check the fixing.
- 4.5.1.3. One end of the threaded ceiling hanger rod shall be connected to the pre-drilled anchor fastener (drop-in anchors or equivalent) and the other end of the threaded rod shall be secured to the proprietary locking clips or suspension brackets with two M6 nuts and locked to the primary channel (main runners).

4.5.2. Horizontal Members

- 4.5.2.1. Primary channel shall be galvanised steel 38mm x 12mm x 1mm thick minimum placed at a distance of 100mm away from the wall and spaced equal to or not more than 1000mm c/c. The primary channel shall have the characteristic strength of at least 250N/mm². Installation shall refer to manufacturer's method statement.

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- 4.5.2.2. The dimension of the secondary channel shall be at not less than 50mm x 20mm x 0.5mm thick minimum place at 450mm c/c minimum for 9mm thickness board and 600mm c/c minimum for 12mm thickness board. The secondary channel shall have the characteristic strength of at least 250N/mm².
- 4.5.2.3. The primary and secondary channel shall be connected using galvanize proprietary locking clip with minimum thickness of 0.5mm (the thickness may vary according to the profile with larger cross section values with appropriate justification from manufacturer) and screw as recommended by the manufacturer.
- 4.5.2.4. Unless otherwise specified, a single layer 9mm thick minimum plasterboard ceiling shall be screwed using approved drywall screw minimum (3.5mm Ø) x 25mm length fixed at maximum 200mm c/c to the secondary channel as recommended by the manufacturer.

4.6. Performance and Installation Requirements

- 4.6.1. Suspended ceiling systems are not designed for bearing additional weight and shall not be regarded as structural elements. Electrical wiring systems, including cable trays, conduits, junction boxes, lighting fixtures, air-conditioning ducts, air diffusers and other appurtenances shall not be placed directly on the ceiling and shall be independently supported and independently braced from the structure.
- 4.6.2. Suspended ceilings shall be designed to ensure that detrimental levels of water and condensation are not formed within or on the surfaces of the ceiling and related components and the ceilings shall be designed according to Class C conditions of BS EN 13964.
- 4.6.3. Other steel components of the substructure such as supporting member, perimeter trim, etc. shall have a characteristic strength of at least 250N/mm² and their tolerances shall comply with BS EN 13964. No bends or notches or drilling or other alterations from its original state are allowed on steel components unless allowed by the manufacturer.
- 4.6.4. Where not specified, tolerances for the ceiling shall comply with BS EN 13964. The maximum deflection between two suspension points shall not exceed L/500 where L is the suspension distance between the two points.
- 4.6.5. The top fixing of all suspension components shall be made to the primary structural framing element, unless specifically designed otherwise. The Contractor shall ensure the fixings are of a corrosion-resistant material suitable for the intended application, and fixings shall be compatible with the material of the structure to which they are to be fitted.

4.7. Structural Steel Fixing

- 4.7.1. Self-drilling screws are not allowed for structural steel, unless specifically designed otherwise. These screws shall not be placed in tension unless specifically designed for that purpose.
- 4.7.2. Penetrations made into the structural steel by drilling shall be duly approved by the S.O..

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4.7.3. Clips shall be installed strictly in accordance with the manufacturer's recommendations.

4.8. Cold Formed Truss/Timber Truss Fixing

4.8.1. Suspended ceiling system fixings to cold formed trusses shall only be allowed by using steel plate straps. For the case of proprietary truss systems, the Contractor shall obtain written approval from the Truss System Provider and the S.O..

4.8.2. Fixings to timber joists shall be made into the side of the timber, with five times the diameter of the fastener clear edge distances.

4.9. Glued Laminated Timber Fixing

Top fixing to glued laminated timber members shall only be allowed with the approval of a P.E. The glued laminated timber shall be fabricated as specified under SECTION I: TIMBER, JOINERY AND IRONMONGERY.

4.10. Concrete Fixing

4.10.1. Shot-fired fasteners are not allowed to be installed directly to a concrete flat roof slab. Separate structural framing elements for ceiling fixing shall be specifically designed if required and it shall be approved by the S.O..

4.10.2. Fixing to aerated/lightweight concrete shall only be made in accordance with the manufacturer's recommendations.

4.11. Purlin fixing

4.11.1. Fixings shall be made of steel plate straps. No connections requiring drillings to the web/lip of the purlins are allowed, unless specifically designed otherwise.

4.11.2. Where flange connections are necessary, they should be made as close as possible to the web of the purlin, and design calculations shall be provided to ensure the structural capacity of the purlin is not compromised.

4.11.3. Fixings shall be selected and installed in accordance with the manufacturer's specification and approved by the S.O..

4.12. All concrete expansion bolts shall be installed in accordance with the manufacturer's recommendations taking due care to maintain minimum edge distances, spacing and embedment depth.

4.13. Ceiling hangers shall be installed in accordance with the ceiling system manufacturer's recommendation. Bends as means of levelling the ceiling or to avoid plenum services, shall not be made in the ceiling hangers. Where ceiling hangers cannot be secured at the specified spacing, secondary members shall be installed to manufacturer's recommendation.

4.14. In areas where the suspended ceiling is adjacent to rooms or areas with 24 hours air-conditioning and the concrete soffits are applied with PU foam, the ceiling suspension hanger shall be secured to the concrete soffit using M6 x 30mm A4 stainless steel (DIN17440) anchor bolts as specified or shown on the Drawings.

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4.15. Unless otherwise shown on the Drawings, plasterboard partitions shall be fixed to the primary framing members of the ceiling suspension system in accordance with BS 8212.

4.16. Suspended Ceiling Exposed to Wind (Outside Building).

4.16.1. Wind Load

4.16.1.1. The minimum basic wind speed shall be 35 m/s. However, the minimum basic wind speed shall be increased to 41 m/s for lightweight covering.

4.16.1.2. The requirement of wind load shall be as stated in the MS 1553 – Code of Practice on Wind Loading for Building Structures. The minimum basic wind speed shall be as specified above or as per the value stated in MS 1553 whichever higher.

4.16.1.3. Load combinations shall be clearly identified (as per MS EN 1993 Part 1 to Part 3 or other equivalent standards recognised internationally) and itemised to enable design checking to be carried out upon the most adverse conditions or the effect (e.g. effect of uplift) under consideration.

4.16.1.4. Where the grid ceilings system is installed to areas exposed to wind condition (outside buildings), all lay-in ceiling panels/boards shall be secured to the suspension system with min. two proprietary 'hold-down clip' for each tile as recommended by the manufacturer and approved by the S.O.. Installation shall refer to the manufacturer's method statement.

4.17. Testing and Inspection

4.17.1. The Contractor shall carry out in-situ Pull-Out Test for the complete ceiling suspension (hanger) system inclusive of the rod joiner and the anchors. The sampling rate shall be five (5) samples for every 200 number of hangers installed and the points of testing shall be carried out subject to S.O.'s approval.

4.17.2. The minimum load for the pull-out test shall be 0.5 kN applied to each complete ceiling suspension sample inclusive of rod joiner where applicable. The test sample shall be left for the duration of minimum 8 hours and the observation shall be recorded and submitted to the S.O. for approval.

4.17.3. The Contractor shall inform the S.O. in writing to request for inspection and approval prior to closing up of the ceiling suspension system with ceiling panels.

4.18. 24 Hours Air Conditioning Rooms

All ceiling for 24 hours air conditioning rooms shall made from soffit and apply with spray a layer Polyurethane Spray Foam Insulation System with K-value ≤ 0.0272 W/(m²K), zero Formaldehyde and VOC's content ≤ 17.67 g/L. to wall and under the soffit of the floor slab. Minimum 50mm thick and extended at least 1.5m all around. Top most floor which allocates AHU room shall have soffit ceiling with skim coat.

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4.19. Warranty

4.19.1. When a proprietary ceiling system is used, the Contractor shall submit to the S.O. a warranty from the manufacturer with the following provisions:

- 4.19.1.1 The products used are genuine and free from manufacturing defects;
- 4.19.1.2 The complete ceiling suspension (hanger) system are installed in accordance with the manufacturer's method statement, recommendation, guidance and specifications that will deliver the specified level of performance;
- 4.19.1.3 The warranty certificate shall cover a period of 10 years from the date of Certificate of Practical Completion against any defect or failure due to the installation and workmanship by the manufacturer's registered panel installer.

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1. General

Generally, all glass shall conform to MS 1135 and shall be free from bubbles, specks and other defects. Samples shall be submitted for the approval of the S.O..

2. Sealants

- 2.1. Unless otherwise specified in the Drawings, sealants shall be silicone, rubber or other approved type applied in accordance with the manufacturer's instructions.
- 2.2. Joint sealant for aluminium profile shall be of silicone, polyurethane, polysulphide or other equivalent suitable for its intended use.
- 2.3. Joint sealant for uPVC profile shall be of silicone, polyurethane, polysulphide, ethylene propylene diene monomer (EPDM) rubber, thermoplastic elastomers (TPE) or other equivalent suitable for its intended use.
- 2.4. Joint sealant for non-structural use in building shall be an approved type and shall comply with BS EN 15651-2.
- 2.5. Joint sealant for structural use in building shall be an approved type and shall comply with BS EN 13022.

3. Glass Thickness

Unless otherwise specified or shown on the Drawings, the type and minimum thickness of glass shall be as stated in the Schedule of Glass in **APPENDIX M1**.

4. Glazing

- 4.1. All doors and windows etc. except louver windows shall be glazed as shown on the Drawings or the Schedule of Doors and Windows.
- 4.2. All glass shall be cut to size with 2mm clearance all around the rebates. All exposed edges of glass panes shall be rounded off.
- 4.3. All glazing works shall be carried out strictly in accordance with the manufacturer's instruction.
- 4.4. Figured or textured glass surface for windows shall be installed facing the interior.

5. Clear Glass

Clear float glass shall be to BS 952, Type I, Class 1, Quality Q3, and 6mm thick unless otherwise indicated on Drawings.

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6. Safety Glass

6.1. Safety glass shall be manufactured in accordance with BS 6206.

6.1.1. Tempered Glass

A single piece of specially heat-treated or chemically treated glass, with a stress pattern such that the piece when fractured reduces to numerous fragments, with no large jagged edges. Fully tempered glass shall be glazing quality, manufactured in accordance with BS 6206 and unless otherwise specified shall be 6.0mm thick Type I.

6.1.2. Laminated Safety Glass

Laminated safety shall consist of two (2) or more layers of glass with one (1) or more layers of transparent/ pigmented and specially treated Polyvinyl Butyral (PVB) sandwiched between the glass layers. The glass shall have comprehensive strength 1000N/mm² and unless otherwise specified.

6.1.3. Bullet Resistant Laminated Glass

Bullet resistant laminated glass shall comply with BS EN 356 or BS EN 1063. Framing to glass shall be supplied by the glass manufacturer, including polyurethane gaskets. The glass composite should combine properties which have abrasion resistance elements.

6.1.4. Wire Glass

Wire glass shall be manufactured in accordance with SIRIM standard and JBPM approval. Wire glass which is installed at any Fire Rated Wall or Fire Rated Door should have JBPM approval.

7. Decorative Glass

7.1. Glass Blocks

Glass blocks may be solid or hollow blocks with clear, coloured or obscured appearance and shall be manufactured in square or rectangular units on the product. Installation shall be in accordance with manufacturer's instructions.

7.2. Spandrel Panel (pacified)

Spandrel is a portion of the exterior wall of a multi-storey building that covers the area below the sill of the vision glass installation. Spandrel panel (pacified) shall be heat strengthened or tempered float glass with ceramic frit or silicone polyester enamel pacifier coating applied to surface.

7.3. Reflective Glass

A metallic coating shall be applied to one side of the glass to increase the amount of reflection by the glass in both the visible and infra-red (light and heat) range of the electromagnetic spectrum. This metallic coating shall be applied to clear or body tinted glass. U value for this glass shall be in between 5.1 to 5.7 W/m².K for 6mm thickness.

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8. Low Emission Glass

- 8.1. Low-E glass units shall be permanently marked with the appropriate certification label of the SIRIM Ecolabel.
- 8.2. Low-E glass falls into two broad categories: soft coat and hard coat. Both applications involve depositing a thin, transparent coating of silver or tin oxide on the glass surface to allow short-wavelength sunlight to pass through while blocking long-wavelength heat radiation. The difference between the two (2) coatings lies in their application, which affects the glazing performance and durability.
- 8.3. Soft (or sputtered) coat is the most common type of low-E glass. In this application, the layer of silver is deposited onto the glass through a sputtering process after the glass has been manufactured. This type of coating is fairly delicate and must be protected within an insulated glass unit (IGU) to prevent scratching.
- 8.4. Hard coat (or pyrolytic) is the most common type of low-e. The process is applying a thin layer of tin oxide onto the surface of the molten hot glass. Applying the tin at this stage welds it to the glass, resulting in a durable coating.
- 8.5. The minimum U-Value for tropical design for double glazed Low-E glass shall be ranges from 3.8 to 3.6 W/sq.m.K for 6mm thick (with 6mm air space/layer) and 3.5 to 1.0 W/m².K for 6mm thick (with 12.9mm air space/ layer). The U-Value for single glazed Low-E glass with 6mm thickness shall range from 5.6 to 3.8 W/m².K. This glass shall be used as safety fire rated glass for doors and windows.
- 8.6. Solar Heat Gain Coefficient (SHGC) or Shading Coefficient is a measure of how much solar heat is transmitted through the glass. The SHGC ranges from 0 to 1.

9. Glazing Work to Timber Frames

- 9.1. The grooves and rebates to be glazed shall first be cleaned, primed with wood primer, painted with one (1) coat of oil paint and allowed to dry, followed by the application of a thin bed of putty or synthetic sealant.
- 9.2. The glass panes shall then be properly placed and secured in the grooves or rebates with timber beadings as detailed in the Drawings.
- 9.3. Where the glass panes are to be secured with putty or synthetic sealants, the glass shall be placed and held in the grooves or rebates with approved sprigs driven at intervals of not exceeding 300mm centres. The glass shall then be finally secured with back-putty or sealants finished true to profile or as detailed in the Drawings.
- 9.4. Installation of timber frames for doors and windows shall refer to SECTION I: TIMBER, JOINERY AND IRONMONGERY.

10. Glazing Work to Metal Frames

- 10.1. The grooves and rebates to be glazed shall first be cleaned of rust and primed with an approved metal primer and allowed to dry, followed by the application of a thin bed of glazing putty or sealant. The glass panes shall then be placed and secured in the grooves and rebates with metal, aluminium beadings or neoprene rubber in accordance with the manufacturer's instructions or as detailed in the Drawings.

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- 10.2. Where the glass panes are to be secured with putty, the panes shall be placed and held in the grooves or rebates with spring clips sets in holes in the frame. The glass shall then be finally secured with back-putty or synthetic sealants finished true to profile or as detailed in the drawings.
- 10.3. Installation of metal frames for doors and windows shall refer to SECTION J: STRUCTURAL STEEL AND METALWORKS.

11. Glazing Works to Louvred Window

- 11.1. The glass blades for fixed louvred window shall be properly housed in the grooves of the timber frames and secured in position with timber beadings as shown on the Drawings.
- 11.2. In the case of adjustable louvred windows, the louvred frames shall be fixed on to the vertical members of the window frame and secured with 20mm long dome headed galvanised screws fixed at 200mm centres. The louvre blades shall then be inserted and secured in the flanged clips, all in accordance with the manufacturer's instructions.
- 11.3. The position of handles shall be as shown on the Drawings.

12. Glazing to UPVC Frame

- 12.1. Generally, all glazing work to uPVC frames shall conform to BS EN 12608. All glazing works shall be carried out strictly in accordance with the manufacturer's instructions.
- 12.2. Unless otherwise specified in the Drawings, the frame shall be fitted at least 10mm inwards from the outside edge of the face of the brickwork. It is essential that the windows are installed true and square by measuring the window's diagonals after the installation.
- 12.3. The gap between the window frame sill and brickwork shall be sealed with silicone sealant as approved by the S.O..

13. Frameless Glazing

- 13.1. Where shown, approved frameless glazing must conform to BS 5234, BS 6180 and BS 6399.
- 13.2. Unless otherwise shown on the Drawings, the jointing method for frameless glazing shall be strictly in accordance with the manufacturers' instructions.
- 13.3. The Contractor shall submit method statements for the fixing and installation of the frameless glazing system for the S.O.'s approval.

14. Glazing Works to Patented Windows, Doors, Panels and Sky Lights.

Unless otherwise shown on the Drawings, the installation and glazing of patented windows, doors, roof-lights, etc. shall be strictly in accordance with the manufacturer's instructions.

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15. Fixing of Glass Blocks

- 15.1. Unless otherwise specified the size of the glass blocks shall be 190mm x 190mm x 80mm and approved by the S.O.. The glass blocks shall be laid butt-jointed in cement and sand mortar (1:4) by volume.
- 15.2. Before the first course is laid, the base to receive the glass blocks shall be coated with an approved bitumen emulsion or similar material.
- 15.3. Each panel of the glass blocks shall have a clearance of 13mm at sides and top with surrounding structure. The clearance shall or as approved by the S.O. be filled with non-hardening compound and finished with detail in the Drawings.
- 15.4. Approved expanded metal reinforcement shall be provided at every fourth course. Unless otherwise specified in the Drawings, all joints between the blocks shall be pointed with white cement and the exposed areas of the non-hardening compound shall be painted to match the surrounding structure.

16. Product Delivery, Storage and Handling

- 16.1. Glass units shall be delivered, handled and stored in accordance with manufacturer's instructions.
- 16.2. The units shall be protected prior to installation, to prevent damage to glass and glazing materials from temperature changes, moisture and direct exposure to sun.

17. Storage

All glass shall be stored on Site in a dry, sheltered location in racks in near vertical position with the edges of the glass protected from damage. A protective sheeting shall be provided to prevent spillage of materials onto the surface of the glass. Water collection between sheets shall be controlled by the use of spacers.

18. Protection

- 18.1. All installed products shall be protected until completion of the project.
- 18.2. All damaged or broken panels shall be repaired or replaced before substantial completion.
- 18.3. Glass shall be protected from damage. Glass units with damage or imperfections of type that impairs performance or appearance shall be removed and disposed of and replaced with new units of specified materials.

19. Installation

Glass shall be installed in accordance with the manufacturer's instructions.

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20. Cleaning Upon Completion

- 20.1. After installation, the fabricator shall remove any excess sealants, caulking, putty and other misplaced materials from all surfaces including adjacent work. The window frame and glass shall be cleaned thoroughly as recommended by the manufacturers. Cracked or defective panes shall be replaced to the approval of the S.O..
- 20.2. Any excess glazing materials shall be removed from finish surfaces.
- 20.3. Manufacturer's labels/logos shall be removed after glass installation is complete.

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APPENDIX M1

SCHEDULE OF GLASS

No.	Type of Glass	Minimum Glass Thickness (mm)	Application
1.	Clear Float Glass	6	● External use windows and doors ● Interior framed glass screens, partitions ● Display windows, showcases, display shelves ● Furniture: Table-tops/ cabinet
		10	● Interior frameless glass screens, partitions
		19	● External wall curtain
2.	Tinted Float Glass	6	● External use on windows and doors ● Interior framed glass screens, partitions ● Display windows, showcases, display shelves ● Furniture: Table-tops
		10	● Interior frameless glass screens, partitions
		19	● External wall curtain
3.	Clear Figured (obscured) Glass	6	● Windows ● Furniture, display bases, house fittings, partitions etc. ● Decoration e.g. Front doors, display etc.
4.	Grey/Tinted Figured Glass	5	● Windows ● Furniture, display bases, house fittings, partitions etc. ● Decoration e.g.. Front doors, display etc.
5.	Toughened/Tempered Glass	6	● Furniture, interior decorations, table tops, showcases, partitions etc. ● Railing, Shower screen, sliding door ● Solar panel application
		10	● Escalator side plates, sport complexes partition, spandrel for wall & decorative paneling. ● Door panel (one or two leaf)
		15	● Curtain wall of high-rise building, airport.
6.	Laminated Glass	6	● Skylights, glass roofs and the like ● High security places e.g. Burglar resistant showcases and the like. ● Places where safety necessary e.g. Verandah side panels and the like.
		12	● Animal observatory windows & aquariums ● Safety window (bullet/earthquake & fire) ● Acoustic glazing ● Armored vehicle
7.	Wired Glass i. Clear & Polished ii. Figured and Translucent	6	● Where nominal fire protection is required – window, door & partition

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8.	Lead Glass - Laminated crystal clear glass with minimum 2mm thick lead sheeting sandwiched in between.	9mm total thickness	• X-Ray rooms
9.	Heat Strengthened glass	8	• Vision panel
10.	Reflective Glass	4	• Internal partition • Entrance, privacy window/door, decorative wall, spandrel glazing
11	Double glaze Glass	10	• Vertical/sloped glazing, building facade
12	Sand Blasted Glass	4	• Laboratories window/door. • Server room, external window, cool storage, train window.
		8	• Sound proof window/ acoustic window
		8	• Door & Window
		12	• Interior Wall
		19	• External Wall

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1. General

- 1.1. All paints to be used shall be those supplied by approved manufacturers. The quality of paints shall comply with MS 125 in respect of oil/enamel paints and MS 134 in respect of emulsion paint/acrylic paint.
- 1.2. Prior to commencing painting work, the Contractor shall submit the following to the S.O.:
 - 1.2.1. Name of the paint manufacturer and the manufacturer's certification that the paint conforms to the relevant standard as specified in sub-section 1.1 hereof together with the proof that such certification have been verified by tests carried out by SIRIM or ISO in the last 3 years.
 - 1.2.2. The performance warranty by the manufacturer to the Government on the performance of the paint against any peeling, cracking, fungus/ algae growth and discoloration which may arise during a period of 5 years or more from the date of practical completion due to insufficiency in material or workmanship. The terms of the performance warranty shall be as stipulated in **APPENDIX N1** and as approved by the S.O..
 - 1.2.3. Name of the painting applicator as approved by the paint manufacturer including written evidence of the current approval.
 - 1.2.4. A copy of the method statement including procedure for the painting works in accordance with these specifications and manufacturer's instructions.
 - 1.2.5. All paints shall be delivered to the Site in the manufacturer's original sealed containers unopened and shall be used strictly in accordance with the manufacturer's instructions.
- 1.3. Paints shall not be adulterated and any paint that has deteriorated shall not be used and shall be removed from the Site forthwith.
- 1.4. Unless otherwise specified in the Drawings, the types of paint to be used for the work on exposed surfaces shall be as stated in the 'Schedule of Paint Finish' attached hereinafter.
- 1.5. No painting shall be done under conditions which may jeopardize the quality of finish paintwork.
- 1.6. During painting, care shall be taken to prevent stain or damage to other works.
- 1.7. Surfaces to be painted shall be dry, free from dirt, oil, grease, old loose paint and other deleterious matter. All cracks shall be raked out and stopped and all holes and dents shall be filled.
- 1.8. Unless otherwise specified in the manufacturer's instructions, each coat of paint applied on timber or metal surfaces shall be allowed to dry and subsequently rubbed down lightly with sandpaper before the next coat is applied. Any dirt or dust shall be removed from preceding coats immediately before proceeding with application of the next coat.
- 1.9. All priming to shop fabricated components shall be done at shop.

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- 1.10. All prime surfaces shall be inspected and approved by the S.O. before commencement of painting works.
- 1.11. Finish surfaces shall be uniform in finish and colour and be free from brush marks or other defects.
- 1.12. Sample areas showing all tints of paints to be used shall be prepared by the Contractor as and when required by the S.O..

2. Painting to Timber Work

2.1. Painting to New Timber Work

- 2.1.1. Unless otherwise as shown on the Drawings, all exposed wrot surfaces of timber shall be painted as specified hereinafter.
- 2.1.2. Before painting to new timber work, all knots shall be covered with knotting and all nail holes, cracks, etc. shall be stopped with white lead and putty (1:3) and shall be primed with aluminium wood primer well brushed in.
- 2.1.3. Unless otherwise specified, the prepared surface shall be painted with one (1) undercoat (alkyd undercoat) and shall be finished with two (2) coats of premium semi-gloss fungus resisting alkyd paint or three (3) coats UV protection, low odour alkyd wood finish.
- 2.1.4. Timber decks shall be applied with three (3) coats of scratch resistant, UV protection, fast drying urethane alkyd wood finish. Each preceding coat shall be allowed to dry thoroughly and rubbed down lightly with fine sandpaper and thoroughly cleaned before applying the next coat.
- 2.1.5. All timber surfaces abutting concrete or brickwork shall be primed before fixing or assembling.
- 2.1.6. All ironmongeries except hinges shall be removed before painting begins and shall be carefully re-fixed.

2.2. Repainting Existing Timber Work

Where repainting to existing timber work is specified, the following procedure shall be adhered to. If the surface is intact, it shall be rubbed down with fine sandpaper to the approval of the S.O.. Then one (1) coat of undercoat shall be applied followed by two (2) coats of gloss enamel paint unless otherwise specified. Where cracking and flaking have occurred, the entire existing paint shall be removed by burning off or by use of paint remover as approved by the S.O.. The surfaces shall then be thoroughly cleaned and shall be applied with minimum one (1) coat aluminium wood primer followed by one (1) undercoat and unless otherwise specified in the Drawings, shall be finished with two (2) coats of gloss enamel paint.

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3. Painting to Metal Work

3.1. Painting New Steel and Ironwork

The areas to be painted shall be cleaned down and be free from rust, scale, oil, grease, dirt and dust. One (1) coat of approved metallic primer shall be applied followed by one (1) coat of premium alkyd undercoat unless specified and shall be finished with two (2) finishing coats of gloss/semi-gloss fungus resisting alkyd paint.

Soil and vent pipes shall be primed as above and given two (2) coats of approved bituminous paint.

3.2. Repainting Existing Steel and Ironwork

3.2.1. Where repainting to existing steel or ironwork is stated in the Drawings, the following procedure shall be adhered to. Where a firm surface exists, it shall be scuffed with fine sandpaper to the approval of the S.O. and spot primed if necessary, before the application of by one (1) coat of premium alkyd undercoat unless specified and shall be finished with two (2) finishing coats of gloss/semi-gloss fungus resisting alkyd or gloss enamel paint.

3.2.2. If the old paint is in a bad, deteriorated condition the whole paint shall be removed by the use of approved paint remover or by scraping as approved by the S.O.. The surface shall be thoroughly cleaned and shall be applied with one (1) coat approved metallic primer, by one (1) coat of premium alkyd undercoat unless specified and shall be finished with two (2) finishing coats of gloss/semi-gloss fungus resisting alkyd or gloss enamel paint.

3.3. Painting New Galvanised Ironwork

Where painting to new galvanised ironwork is specified, the surfaces shall be applied with one (1) coat of approved self-etching quick drying metallic primer unless otherwise specified and shall be finished with two (2) finishing coats of gloss/semi-gloss fungus resisting alkyd paint or gloss enamel paint.

3.4. Repainting Existing Galvanised Ironwork

3.4.1. Where repainting to existing galvanised ironwork is specified, the following procedure shall be adhered to. If the surface is not corroded, it shall be lightly sanded and all dirt's, oil, and grease removed by washing with an approved solvent and applied with one (1) coat of approved metallic primer unless otherwise specified, shall be finished with two (2) finishing coats of gloss/semi-gloss fungus resisting alkyd paint or gloss enamel paint. If the surface has corroded, the whole paint shall be removed by the use of approved paint remover or by scraping as approved by S.O..

3.4.2. When the surface is completely clean, it shall be applied with one (1) coat approved metallic primer, unless otherwise specified, shall be finished with two (2) finishing coats of gloss/semi-gloss fungus resisting alkyd paint or gloss enamel paint.

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4. Painting to Masonry Work

4.1. Painting New Plastered/Masonry Surfaces

- 4.1.1. The new plastered or masonry surfaces shall be allowed to dry completely and shall be cleaned down to remove dust, dirt, plaster splashes, and the like. In case of old unpainted walls, all fungus, mosses, lichens and vegetative growth shall also be removed.
- 4.1.2. The cleaned surfaces of the external walls shall be applied with one (1) coat of approved alkaline resisting primer and unless otherwise specified in the Drawings, followed with two (2) coats of ultra-violet (UV) weather resistant emulsion paint.
- 4.1.3. The external wall surfaces shall be applied with one (1) coat of approved alkaline resisting primer, unless otherwise stated in the Drawings, followed with two (2) coats of 100% acrylic with heat reflective and UV protected, and temperature reduction weather resistant acrylic emulsion paint for Green Ratings Certification as approved by the S.O..
- 4.1.4. The internal wall surfaces shall be applied with one (1) coat of approved modified acrylic sealer, and unless otherwise as shown on the Drawings, followed with two (2) coats of low VOC acrylic paint.

4.2. Repainting Existing Plastered or Masonry Surfaces

- 4.2.1. Where repainting to existing plastered or the masonry surface is specified, the following procedure shall be adhered to. All existing paint shall be removed by scraping and the surface shall be washed with high pressure water jet (for Non-Conservation Projects). All cracks and other imperfections shall be made good and the surface should be allowed to dry completely.
- 4.2.2. The surface shall then be applied with two (2) coats of any other type of water-based emulsion paint as described hereinbefore for Painting New Plastered/Masonry Surfaces and as approved by the S.O..
- 4.2.3. However, for buildings which fall under heritage status, repainting works shall refer to *Garis Panduan Pemuliharaan Bangunan Warisan 2016* (or latest edition).

4.3. Textured Wall

- 4.3.1. Natural Spray Granite textured wall shall be applied with one (1) coat of approved alkaline resisting acrylic primer, unless otherwise stated in the Drawings, followed with two (2) layers natural fine stone and ceramic chips texture with high build acrylic resin and two (2) clear finish coats.
- 4.3.2. Spray Tile textured wall shall be applied with one (1) coat of approved alkaline resisting acrylic primer, unless otherwise specified in the Drawings, followed with one (1) coat of spray tiles texture and two (2) coats of pure acrylic based premium weather paint.

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5. Treatment to Fair Face Surfaces

Surfaces that are to be left bare such as fair-face brickwork, fair-face concrete or stones and the like shall be thoroughly clean, dry and free from grease, dust and loose or flaking materials. The surfaces shall then be treated with an approved colourless silicon-based water repellent liquid applied in accordance with the manufacturer's instructions. The solution shall be applied in two (2) coats over the entire area and crevices by brushing.

6. Epoxy Coatings

Epoxy coatings shall be applied with one (1) coat of approved penetrative epoxy sealer, followed with two (2) coats epoxy topcoat.

7. Silicone Paint

Silicone paint for external walls and ceiling shall be applied with one (1) coat of pigmented water base penetration water repellent and two (2) finishing coats of breathable silicone paint of approved colour applied strictly in accordance with manufacturer's instruction.

8. Painting on Floor Surfaces

- 8.1. Painting on concrete driveway shall be applied with one (1) coat of floor primer at 100 µm DFT, followed by one (1) coat of floor glass flake at 300 µm DFT or floor non-slip aggregate (fine/medium) and followed with two (2) coats of floor polyurethane (PU) topcoat at 50 µm DFT per coat.
- 8.2. Painting on car park parking bay floors shall be applied with one (1) coat of floor primer at 100 µm DFT, then followed with two (2) coats of floor polyurethane (PU) topcoat at 50 µm DFT per coat.
- 8.3. Painting on TNB substation internal floors shall be applied with one (1) coat of approved two-pack epoxy sealer, followed with two (2) coats of two pack epoxy floor coating at 50 µm DFT per coat, unless otherwise stated in the Drawings.

9. Painting to Timber-based Products

9.1. Chipboard Surfaces

- 9.1.1. Before painting, all nail holes, crevices and the like shall be stopped with white lead and putty (1:3). The surface shall then be smoothened by rubbing down with fine sandpaper and finally cleaned to remove dust. Where the board is to be finished with enamel paint, one (1) undercoat and two (2) finishing coats of gloss enamel paint shall be applied. If the board is to be finished with emulsion paint, one (1) undercoat and two (2) coats of emulsion paint shall be applied.
- 9.1.2. Where repainting to existing enamel paint finished chipboard is required, the following procedure shall be adhered to. If the paintwork is still intact, it shall be rubbed down with fine sandpaper to the approval of the S.O.. Then one (1) coat of undercoat shall be applied followed by one (1) coat of gloss enamel paint.

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9.1.3. Where cracking and flaking has occurred, the entire existing paint shall be removed by burning off, as approved by the S.O.. The surfaces shall then thoroughly clean and shall be applied with one (1) undercoat and finished with two (2) coats of gloss enamel paint.

9.1.4. Where repainting to existing emulsion paint finished chipboard is required, the surface shall then be thoroughly cleaned and applied with two (2) coats of emulsion paint.

9.2. Hardboard Surfaces

Before painting to hardboard, all nail holes, crevices and the like shall be filled with approved putty. The surface shall then be applied with one (1) undercoat and two (2) coats of emulsion paint unless otherwise specified.

9.3. Wood Cement Board Surfaces

Before painting to wood cement board, all nail holes, crevices and the like shall be filled with approved filling compound of alkali resistant type. The surface shall then be lightly sanded, and any dust should be removed from the surface with a piece of clean, coarse cloth. The surface shall then be applied with one (1) undercoat and two (2) coats of emulsion paint unless otherwise specified.

10. Painting to Gypsum Board and The Like

Before painting the surfaces shall be clean and free from dirt. The surfaces shall then be applied with one (1) undercoat and two (2) coats of emulsion paint. Similar procedure shall be followed where repainting to existing painted surfaces is required.

11. Painting to Laboratory Bench Tops

11.1. Timber tops of benches in laboratories that are required to be painted shall be prepared as described hereinbefore for timber work. The surfaces shall then be applied with one (1) coat aluminium wood primer followed by one (1) coat approved chemical resistant primer and finished with two (2) coats of approved chemical resistant gloss enamel paint in accordance with manufacturer's instructions.

11.2. Where repainting to existing timber tops laboratory benches is required, the surfaces shall be rubbed down lightly with fine sandpaper. The surfaces shall then be thoroughly cleaned and shall be applied with one (1) coat of approved chemical resistant primer followed by one (1) coat of approved chemical resistant gloss enamel paint.

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12. Varnishing

12.1. Varnishing to New Timberwork

- 12.1.1. The surfaces to be varnished shall be smoothed with fine sandpaper and all crevices, holes and the like, if any, shall be filled with approved whiting. It shall be clean, dry, free from dust, dirt and wax before the application of varnish. Unless otherwise specified, approved by the S.O., the surfaces shall be applied with three (3) coats of approved UV protection, low odour alkyd wood finish or varnishing mixture used strictly in accordance with the manufacturer's instructions.
- 12.1.2. Where non-patented products are allowed to be used, the varnishing mixture shall consist of methylated spirit, shellac and approved stain forming the first coat followed by one (1) coat of an approved mixture consisting of thinner and lacquer. The mixtures shall be of uniform consistency throughout. Unless otherwise specified in the Drawings, the finish shall be glossed and as approved by the S.O..
- 12.1.3. Timber deck surfaces shall be applied with three (3) coats of approved scratch resistant, UV protection, fast drying low odour urethane alkyd wood finish.

12.2. Re-varnishing To Existing Timberwork

Where re-varnishing to timberwork is specified in the Drawings, the surface shall first be thoroughly scuffed to remove the existing varnish. The surface shall then be smoothed with fine sandpaper, cleaned, dried and free from dust, dirt and wax. It shall then be varnished as described hereinbefore for new timberwork.

13. Painting Works for Buildings in Coastal Areas.

- 13.1. External walls shall be applied with one (1) coat of approved pliolite based alkaline resisting primer sealer, unless otherwise specified in the Drawings, followed with two (2) coats of elastomeric weather resistant paint of approved colour applied strictly in accordance with manufacturer's instruction.
- 13.2. Unless otherwise specified in the Drawings, the internal walls shall be applied with one (1) coat of approved water based alkaline resistant acrylic wall sealer, followed with two (2) coats of low volatile organic compounds (VOCs), alkylphenol ethoxylate (APEO) free, formaldehyde free acrylic premium emulsion paint of approved colour applied strictly in accordance with manufacturer's instruction.
- 13.3. Mild steel shall be applied with one (1) coat of zinc rich epoxy, one (1) coat of surface tolerant epoxy mastic and followed with two (2) coats of polyurethane topcoat.
- 13.4. Galvanised steel shall be applied with one (1) coat of surface tolerant epoxy mastic and followed with two (2) coats of polyurethane topcoat.
- 13.5. Roofing sheet coatings for marine environments shall refer to SECTION G: ROOFING.
- 13.6. Coatings of fasteners used shall comply with AS 3566 Class 4 and be certified as such by the supplier of fasteners and as approved by the S.O..

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14. Painting Works to Clinical Areas (Hygienic Areas)

- 14.1. All external walls shall be applied with one (1) coat of approved siloxane primer sealer, unless otherwise stated in the Drawings, followed with two (2) coats of silicone emulsion water repellent paint applied strictly in accordance with manufacturer's instruction.
- 14.2. Internal walls shall be applied with one (1) coat of approved ultra-low VOCs alkaline resisting primer sealer, followed with two (2) coats of anti-bacteria, anti-fungus, low VOCs, 100% APEO free, formaldehyde free acrylic premium emulsion paint.
- 14.3. Internal walls (clinical areas) shall be applied with one (1) coat of approved ultra-low VOCs epoxy primer sealer, followed with two (2) coats of anti-bacteria, anti-fungus, low VOCs, 100% APEO free, formaldehyde free epoxy paint.
- 14.4. Internal walls (clinical areas with 24 Hours Air-Conditioning) shall be applied with one (1) coat of approved ultra-low VOCs acrylic water-based primer sealer, followed with two (2) coats of anti-bacteria, anti-fungus, low VOCs, 100% APEO free, formaldehyde free Polyurethane paint.

15. Completion of Painting Works

On completion of paintwork, all paint marks inadvertently left on glass, floors, tiles and other surfaces shall be removed. Any stain or marking on finished paintwork shall be removed and touched up to the approval of the S.O..

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APPENDIX N1

PAINT PERFORMANCE WARRANTY (SPECIMEN)

1. Coverage of Performance Warranty

We the paint Manufacturer hereby warrants that for a period of **5 years** from the date of Practical Completion, the paint system shall not be affected by the following defects:

- (i) **Peeling**
This condition is manifested when the paint film peels away or detaches from the substrate.
- (ii) **Cracking**
This condition is manifested by any visible cracking on the paint film other than that caused by plastering cracks and structural defects.
- (iii) **Fungus/Algae Growth**
This condition is established when there is a growth of microorganisms on the surface of the paint films which would result in the marring of the appearance of the paint film through discoloration.
- (iv) **Discoloration**
This condition occurs when the coating loses its original colour in patches and excessive discoloration appears.

2. Procedure for Claims

- (i) Any defect claims shall be made in writing and delivered by post or by hand to the Manufacturer.
- (ii) A technical team from the Manufacturer will be dispatched to evaluate the nature of the claim. Should our findings conclude the defects as within the scope of warranty, then the Manufacturer shall make good such defects.
- (iii) Should the Manufacturer's technical team conclude that the defects fall outside the scope of the warranty, the Manufacturer shall not be held responsible for the claim.
- (iv) Should the Government disagree with the conclusion of the technical team pertaining to the defects in particular, then an independent third party competent in such technical evaluation shall be appointed to investigate the disputed defects.
- (v) The appointment of independent third party competent in such technical evaluation shall only be appointed upon the mutual agreement between the Government and the Manufacturer.
- (vi) The findings of the third party shall be conclusive and mutually accepted by the Government and the Manufacturer.
- (vii) If the findings of the independent third party are within the coverage of this performance warranty, all cost shall be borne by the Manufacturer or otherwise such cost shall be borne by the Contractor.

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(viii) All claims for the defects must be received by the Manufacturer not later than fourteen (14) days from the expiry of the warranty period.

MANUFACTURER

Company Stamp

.....
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Signature

Name:

Date:

WITNESS

Company Stamp

.....
.....
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.....

Signature

Name:

Date:

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1. Scope of Work

- 1.1. The work to be performed under this contract shall comprise, but not limited to the supply, delivery, installation, testing, adjusting, balancing, commissioning and maintenance of the following principal services and the associated works and items:
- 1.2. Internal Cold Water Plumbing System
 - 1.2.1. Internal piping system complete with all bends, tees, sockets, valves, plugs, reducers, brackets, supports and other necessary accessories to complete the installation.
 - 1.2.2. Water Tank (Suction and Storage Tank)
- 1.3. Internal Sanitary Plumbing System
 - 1.3.1. Internal piping complete with all necessary bends, tees, sockets, branches, offsets, and other necessary accessories to complete the installation.
 - 1.3.2. Internal inspection chamber, gully trap and grease trap.
- 1.4. The Contractor shall at his own cost be responsible to appoint Suruhanjaya Perkhidmatan Air Negara (SPAN) certified personnel for the submission, supervision, construction, testing and certification of the completed works.
- 1.5. The Contractor shall prepare and submit working Drawings to the S.O. for approval within thirty (30) days from the date of acceptance of tender. In preparing these working Drawings, the Contractor shall coordinate with the building layout and constructional details of the architectural, structural and electrical Drawings.
- 1.6. The Drawings shall be fully dimensioned and show all the precise locations, arrangement and loading of the equipment. The Drawings shall also indicate location and details of all foundation, supports, chases, core holes, opening in partition walls, floors and roof and any other information required for works or services to be provided by others.
- 1.7. The Drawings submitted shall be modified as necessary and, if requested by S.O., re-submitted for final approval. Six (6) sets of Drawings shall then be submitted for distribution to all parties concerned.
- 1.8. The Contractor shall submit method statement (upon S.O. request), samples of materials or execute samples of workmanship (mock-up) for S.O.'s approval, and for further samples as required until the samples submitted or executed are, in accordance with this specification.
- 1.9. Samples, after approval, shall indicate the standard of materials and workmanship to be maintained in the execution of the Works.
- 1.10. After connection work is done, the Contractor shall ensure that all system to be operational as required.
- 1.11. The Contractor shall service and maintain the above-mentioned cold water and sanitary plumbing system during Defect Liability Period (DLP) from the date of Certificate of Practical Completion (CPC) in good operating condition until Certificate of Making Good Defect (CMGD).



**SECTION O: INTERNAL COLD
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- 1.12. The Contractor shall submit the As-built Drawings, Operation and Maintenance Manual (OMM) complete with Schedule of Maintenance before handing over subject to S.O.'s approval.

Exclusion:

The boundary of scope of work between mechanical works and civil works can be referred from FIGURE O1 to FIGURE O4 in the Appendix.

2. Internal Cold Water Plumbing System

2.1. General

All water supply plumbing and installation shall be executed in accordance with the latest edition of the following:

- 2.1.1 Act 655 - Water Services Industry Act 2006
- 2.1.2. Water Services Industry (Water Reticulation and Plumbing) Rules 2014
- 2.1.3. BS 8558:2011 – Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806.

The Contractor shall submit method statement of installation if required by the S.O..

2.2 Pipework (Material Pipes Standards)

2.2.1 General

Pipework for water supply plumbing shall be to the dimensions shown in the Drawings or as specified hereinafter and shall be complete with all bends, tees, sockets, plugs, reducers, brackets, supports and other accessories to complete the installation.

2.2.2 Standards

- 2.2.2.1. All pipes, fittings and equipment used for water supply plumbing and installation shall be of the type and make approved by SPAN and as mentioned in the Drawings.
- 2.2.2.2. The standards stated in this Specification shall comply with their latest edition issued or relevant standards approved by SPAN.

The details of the internal piping shall be referred to **TABLE O1**.

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TABLE O1: LIST OF INTERNAL PIPING

Type of pipe	Minimum wall thickness & pressure rating	Standard	Fitting
High Density Polyethylene (HDPE)	PN 12.5 at 20°C (equivalent to 10 bar derated working pressure at 30°C)	MS 1058 or BS EN 12201 and marked with SIRIM certification numbers	Moulded integrally dezincified brass with BSP threads of BS EN 12420:2014 or BS EN 12165:2016. Nickel and Chromium plated to BS 1224 service condition NO. 2.
Acrylonitrile Butadiene Styrene (ABS)	PN 12 to MS 1419: Part 1: 2007	MS 1419: Part 1: 2007	MS 1419: Part 2: 2007 - Fitting MS 1419: Part 3: 2007 - Solvent cement. All ABS pipes, fittings and solvent cement shall be supplied by the same manufacturers.
Polybutylene (PB)	PN 15 at 20°C (equivalent to 15 bar derated working pressure at 30°C)	MS ISO 15876 or AS/NZS 2642	Moulded integrally dezincified brass with BSP threads of BS EN 12420:2014 or BS EN 12165:2016. Nickel and Chromium plated to BS 1224 service condition NO. 2.
Polypropylene random co-polymer (PP-R)	PN 14 at 70°C	MS 2286 or BS EN ISO 15874	Moulded integrally dezincified brass with BSP threads of BS EN 12420:2014 or BS EN 12165:2016. Nickel and Chromium plated to BS 1224 service condition NO. 2.
Stainless Steel (SS)	BS EN 10312: <Ø 12mm → Series 1 ≥Ø 12mm → Series 1 or Series 2 or ASTM A312/A312M: Ø ½" – Ø 2" → Schedule 40S (Threaded) Ø 2½" – Ø 8" → Schedule 10S (Welded)	MS 1841: 2010, BS EN 10312 ASTM A312/A312M or JIS G 3448	Stainless steel compression fittings to BS 4368 or SAS 322: 2003 Ø ½" – Ø 2" → (Schedule 40S) Threaded & screw fittings according to ISO 4144:2003 Ø 2½" – Ø 8" → (Schedule 10S) Butt weld fittings according to ASTM A 403 / A 403M
Copper Tubing	Type K	BS EN 1057 BS 2871	Brazing according to BS EN 1254: Part 1 or Compression joint according to BS EN 1254: Part 2 or Accelerated 'push fit' according to BS EN 1254: Part 2
Crosslinked Polyethylene (PE-X)	PN 12 at 70°C	MS 1736: Part 2	MS 1736: Part 3 - Fitting Moulded integrally dezincified brass with BSP threads of BS EN 12420:2014 or BS EN 12165:2016. Nickel and Chromium plated to BS 1224 service condition NO. 2.

2.3 Pipe Installation

- 2.3.1. Pipes and fittings shall be cleaned and free from manufacturing burrs and site debris.
- 2.3.2. The pipes shall be adequately protected against damage during transit. Each delivery of pipes shall be accompanied by the manufacturer's testing certificate.
- 2.3.3. Internal Piping
 - 2.3.3.1. All installation shall be done according to the approved Drawings and pipe manufacturer's recommendation. Plumber shall be competent in various types of installation. Special care shall be taken in the arrangement of piping to ensure a neat finishing and alignment.
 - 2.3.3.2. Services pipes and distribution pipes except those buried under ground level shall be concealed in wall, ceilings, boxed up or laid within the common trench, services shaft, etc. provided where possible. All work shall be executed in such a manner to avoid cutting into finished work in walls, aprons, beam, etc. where practicable as the work proceeds. Pipe work to be buried or concealed shall not be covered or plastered before they are examined, tested and approved by the S.O..
 - 2.3.3.3. Installation of valves and fittings shall be grouped where this will not affect their operation, to reduce the number of joints to a minimum.
 - 2.3.3.4. All necessary isolating valves, check valves and other fittings as required are as shown in the approved Drawings. Every section of major branch supply piping shall be installed a gate valve at the point of connection to the supply.
 - 2.3.3.5. Minimum diameter for internal cold water plumbing system shall be 20mm (3/4") except for flush valve system where minimum diameter shall be 25mm (1"). Final branches to fittings shall be 20mm diameters and the sizes of feeders from which these branches are taken shall be as in **TABLE O2**:

TABLE O2: DIAMETER OF FEEDERS TO NUMBER OF FITTING SERVED

No of Fittings Served	Diameter of Feeders
1	20mm
2	20mm
3, 4	25mm
5, 6, 7	32mm
8, 9, 10, 11, 12	40mm
13, 14, 15, 16, 17, 18	50mm

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2.3.4. Threaded Joints

2.3.4.1. Threaded end connections for plastic (ABS/PE/PB) pipes shall have tapered thread forms complying with **AS ISO 7.1-2008 and AS ISO 7.2-2008** or equivalent approved standard in accordance with manufacturer's instruction.

2.3.4.2. Where threaded joint is to be made between plastic (ABS/PE/PB) pipes and metal, the plastic (ABS/PE/PB) pipes should be the male component of the joint.

2.3.4.3. All screwed joints shall be made by using Teflon tape or approved jointing compound.

2.3.5. Flanged Joints

Flanged joints or other suitable methods can be used for pipe more than 50mm and working pressure more than 10 bar (PN10).

2.3.6. Bends

Bends of all piping shall have a radius of not less than 5 times the diameter and shall be of standard type.

2.4. Pipe Supports

2.4.1. Pipe supports, hangers, anchors, guides etc. shall be supplied and installed for proper support.

2.4.2. Vertical riser shall be supported at each floor with galvanized iron (G.I) riser clamps or other material subject to S.O.'s approval.

2.4.3. Horizontal pipe runs shall be supported on hangers of split ring adjustable type or clevis type. Where pipelines run along walls, columns or ceilings, brackets or clamps may be used.

2.4.4. Piping at all equipment, valve positions and at main junctions, shall be adequately supported to prevent any distortion or transmission of strain to connect equipment or valves.

2.4.5. Where pipe lines run in a common group, they shall be supported from a common hanger bar as indicated in the approved Drawings.

2.4.6. Pipe supports and hangers shall be spaced at intervals as shown in **TABLE O3** and **TABLE O4**:

**TABLE O3. RECOMMENDED MAXIMUM SPACING OF SUPPORT FOR HORIZONTAL
COLD WATER PIPE**

Pipe Size (mm)	Recommended Maximum Spacing of Support (m)	
	Non-metal	Metal
20	0.8	1.5
25	0.85	1.8
32	1.0	2.4
40	1.1	2.4
50	1.25	2.4
80	1.65	3.0
100	1.9	3.0

Source: British Standards Institute. (2010). BS EN 806-4: Specifications for installations inside buildings conveying water for human consumption. Installation

**TABLE O4: RECOMMENDED MAXIMUM SPACING OF SUPPORT FOR VERTICAL
COLD WATER PIPE**

Pipe Size (mm)	Recommended Maximum Spacing of Support (m)	
	Non-metal	Metal
20	1.0	2.4
25	1.1	2.4
32	1.3	3.0
40	1.3	3.0
50	1.6	3.6
80	2.1	3.6
100	2.5	3.6

Source: British Standards Institute. (2010). BS EN 806-4: Specifications for installations inside buildings conveying water for human consumption. Installation

- 2.4.7. Vertical pipes shall be supported at least at the top and bottom of each riser, at each floor level, and at each isolating valve. In addition, a further support shall be provided between floor levels for pipes smaller than 32mm.

2.5. Pipe Sleeve and Cover Plate

- 2.5.1. Where pipes are required to be laid through structural beams or slabs, G.I./uPVC pipe sleeves shall be provided. All pipes shall be properly secured in place with brackets.
- 2.5.2. All exposed piping within occupied rooms shall be boxed up to S.O.'s approval.
- 2.5.3. Where pipe past through fire break walls or other partitions, clearance between pipes and sleeves shall be tightly pegged with suitable fire rated material to form a sound and fire barrier.

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2.6. Valves and Fitting

- 2.6.1. All valves shall be of SPAN approved, manufactured and generally constructed in accordance with relevant standard. All valves shall be suitable for system operating pressure.
- 2.6.2. All valves and fittings necessary for the correct control, operation and maintenance of all services shall be provided and installed to the satisfaction of the S.O.. Samples shall be submitted for S.O.'s approval before installation. Valves shall be installed where they are easily accessible for maintenance and operating purposes.
- 2.6.3. Each valve shall be of the same nominal size as the pipeline in which it is installed, except for control, pressure reducing and similar valves which shall be correctly sized as per specific duty and functionality. Connection between each valve and adjacent piping or equipment shall be made either flange or threaded joints may be applicable.
- 2.6.4. Before installation, every valve shall be blown out with air to remove any foreign matter lodged in the valve.
- 2.6.5. Stop Valves / Gate Valves
 - 2.6.5.1. Stop valves / gate valves are generally used as isolation valves.
 - 2.6.5.2. Full bore copper alloy screw-down stop valves / gate valves of the same diameter as the pipe shall be provided and fixed for control in the following positions:
 - 2.6.5.3. On the service pipe before it enters the building.
 - (i) On each branch of the service pipe.
 - (ii) On the inlet to each storage or feed cistern.
 - (iii) On the inlet to each flushing cistern.
 - (iv) On the outlet of each storage tank or feeder cistern.
 - (v) In other position on the pipe as shown or indicated, other than on overflow/warning pipe.
 - (vi) For system with pressure reducing valve (PRV), location of the gate valves shall be as indicated in the approved drawings.
 - 2.6.5.4. Stop valve of 50mm and below shall be complied with MS 1022 and stop valve of 50mm and above shall be complied with BS EN 1213.
 - 2.6.5.5. Gate valve of various sizes shall be complied with BS EN 12288 (copper alloy valves) and BS EN 1171 (cast iron valves) (PN12 above).
 - 2.6.5.6. Gate valve sized from 65mm to 100mm shall be either screwed or flanged end complied with above mentioned standards.



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2.6.5.7. Valves with reduced flow areas shall not be used for water closet flush valves and flushing cistern.

2.6.5.8. All valves shall have hand-wheel with externally screwed bronze or stainless steel spindle.

2.6.6. Pressure Gauges

2.6.6.1. Dial type with 3-way gauge cock shall be supplied and installed where indicated in the approved Drawings.

2.6.6.2. A pressure gauge shall be installed at every suction pipe, every delivery pipe and at the common header pipe.

2.6.6.3. Pressure gauges shall be minimum 100mm diameter dial face type and having ranges suitable for the service pressure encountered. The measuring range of the gauge should be 125% of the maximum pressure.

2.6.6.4. The gauges shall be industrial type shock proof, liquid filled, stainless steel casing and IP 65 Ingress Protection Rating.

2.6.6.5. The construction of pressure gauges shall comply with BS EN 837-1.

2.6.7. Pressure Reducing Valve (PRV)

Air vent and pressure reducing valve shall be installed at 30m intervals along downpipes to restrict the pressure sustained by the fittings to prevent water hammer and other effect.

2.6.8. Check Valves

2.6.8.1. Where shown on the Drawings, non-slam-type check valves shall be supplied and fitted.

2.6.8.2. Valves shall be selected in relation to the velocity of the water in the pipe. In all cases, the valve is required to operate silently on reversal of water flow and if necessary, valves of the double or articulated clack type or the spring assisted type shall be fitted.

2.6.9. Water Metre

Suitable water metre approved by SPAN shall be supplied and installed as required.

2.7. Water Tank

2.7.1. Water Tank Material

All water tanks for water supply shall be of the type and capacity shown or stated on the Drawings. The water tanks shall be watertight and properly supported.

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2.7.2. Fibreglass Reinforced Plastic (FRP) Water Tank

- 2.7.2.1. The tanks shall be scrubbed down and flushed out with clean water and sterilized with chemical containing chlorine before being put into use.
- 2.7.2.2. Water tank design shall comply with the following standards:
- (i) MS 1241 - FRP Water Tank
 - (ii) MS 1390 - FRP Sectional Water Tank
 - (iii) Any other standards approved by SPAN
- 2.7.2.3. Materials for the construction of panels shall conform to MS 1241. The surface of FRP panels shall be manufactured with built-in stabilizer against embrittlement due to ultra-violet radiation.
- 2.7.2.4. The panel shall be of hot press moulded and fabricated from fibreglass reinforced plastic (FRP) of dimension 1 metre x 1 metre square with maximum tolerance of 1.5mm. Each FRP panel will be manufactured with flanges at a right angle of 90° to all sides of each panel. The thickness of the flange for the side wall and base plates will not be less than 10mm and the landed width of each flange will not be less than 70mm for base and side panels.
- 2.7.2.5. Water storage tank of 10,000 litres or more shall have internal compartments to facilitate maintenance of the water tank. Alternatively, multiple tanks may be employed. An equalizing pipe shall be provided between each compartment or between each separate storage tank supplying water to the same distribution pipe.
- 2.7.2.6. Physical Properties of the FRP Panel is as shown in **TABLE O5**:

TABLE O5: PHYSICAL PROPERTIES OF FRP PANEL

Parametre	Results
Tensile strength	>70 MN/m ²
Bending strength	>100 MN/m ²
Elastic modulus in bend	>6,000 MN/m ²
Hardness	30% or 90% of the resin manufacturer specification whichever is higher
Glass content	>25%
Water absorption	1.0%

Source: *Malaysian Standard. (2010). MS 1390: Glass-Fibre Reinforced Polyester Panels and Panel Water Tanks – Specification (First Revision)*

2.7.2.7. Jointing Material

- (i) The jointing material shall be synthetic rubber as sealant with stainless steel washer, nuts and bolts.
- (ii) The holes for the bolts will be 12mm $\pm$ 1.5 to 2.0mm in diameter, suitable for M12 bolts and nuts.

2.7.2.8. Connections

- (i) All holes and pipe connection made in wall, top and bottom of tanks shall be factory fabricated before delivery of tank to Site. The positions and type pipe connections shall be carried out strictly in accordance with the manufacturer's recommendations.

2.7.2.9. Painting

- (i) The internal face of the water tank shall be given two (2) coats of non-toxic, non-corrosive paint and external one (1) coat primer and two (2) coats of non-corrosive paint to S.O. approval.

2.7.3. High Density Polyethylene (HDPE) Tank

- 2.7.3.1. The HDPE tanks shall be constructed of physiologically safe, non-toxic, inert, visor-elastic, UV-resistant high-density polyethylene of one-piece moulded seamless construction to BS 4213 or MS 1225 and SIRIM certified without welding or joint. The tanks shall be manufactured from 100% virgin food grade resins without the additional recycled or reworked material. The resin used must be certified by the resin manufacturer to be food grade compliance and suited for the potable water.
- 2.7.3.2. The tanks and all piping connections shall be installed strictly in accordance with manufacturer's instructions and specification and the installation shall be supervised and verified by the manufacturer.
- 2.7.3.3. The tanks shall come with a minimum 10 years warranty against defect in materials, manufacture and workmanship by the tank manufacturer. The warranty certificate shall be submitted to S.O. before handing over.

2.7.4. Stainless Steel Tank

- 2.7.4.1. Stainless steel tank design shall comply with the following standards shown in **TABLE O6**:

TABLE O6: STANDARD FOR THE RESPECTIVE STEEL TANK

Type of water tank	Standard
Stainless steel storage tank	JKR 20200-0041-99
Pressed steel sectional rectangular tank panel	BS 1564

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2.7.5. Stainless Steel Storage Tank

- 2.7.5.1. Material used in the fabrication of this tank shall be of Grade 304 stainless steel ASTM Designation: A240/A240M-94a or equivalent standards and supported by the respective mill certificates.
- 2.7.5.2. The finished surface of the materials used shall be of bright annealed (BA) and/or non-shining (2B) finished.
- 2.7.5.3. The tank shall be manufactured inclusive of the following components:
 - (i) Top cap
 - (ii) Top cover
 - (iii) Tank body
 - (iv) Bottom cover
 - (v) Stand (for round bottom & spherical types only)
- 2.7.5.4. The stands (except for flat bottom type), fittings and accessories such as internal and external ladder, tank cover, screw nut, etc. of the tank shall be made of similar stainless steel materials of the above grade.
- 2.7.5.5. Each tank shall be marked / labelled on the external upper part of the tank body according to the following information:
 - (i) Manufacturer's name and/or trademark
 - (ii) Date of manufacture
 - (iii) Serial number and model
 - (iv) Capacity

2.7.6. Pressed Steel Sectional Rectangular Tank Panel Water Tank

- 2.7.6.1. Material for the pressed steel sectional water tank shall be manufactured from 0.8mm thickness Grade 304 stainless steel plate inner surface composite with minimum of 5mm external surface of mild steel plate.
- 2.7.6.2. The reinforcement for pressed steel sectional water tank shall be reinforced using suitable support. Detail calculation for internal / external reinforcement design shall be submitted to S.O. for record.
- 2.7.6.3. All bolts, nuts and washers in contact with water shall be of stainless steel Grade 304. All external bolts, nuts and washers in contact with water shall be of hot dipped galvanized mild steel.
- 2.7.6.4. The cover for pressed steel sectional water tank shall be constructed 1.2m x 1.2m / 1m x 1m from 1.2mm thickness Grade 316 stainless steel plate.



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2.7.6.5. Non-toxic PVC foam shall be used for jointing between flanges.

2.7.7. Tank Components and Accessories

2.7.7.1. The installation of storage / domestic tanks shall include but not limited to the following accessories and fitting to the tanks:

- (i) Overflow / warning pipe, outlet tapping and scour pipes shall discharge outside the building or to a point shown or stated on the approved Drawings.
- (ii) Access manholes with cover, the number, locations and details of which shall be approved by S.O..
- (iii) Mosquito-proof air vents to the tank cover at the positions and as per details approved by S.O..
- (iv) Water tanks of 2 metres depth or more shall be provided with internal and external ladders. The internal ladder and external ladder shall be made of stainless steel grade 304 unless otherwise specified. The ladder width shall not be less than 300mm and the length shall be suitable for the tank specified. The maximum height from floor finish level to the first ladder step shall be 300mm.
- (v) Water level indicators and scales graduated in metres to suit the depth of the tank as shown on the approved Drawings.
- (vi) Float Operated / Ball Valves
 - a) Float operated valve shall comply with BS 1212. The combination of body pattern, seat number and size of float to suit the required pressure zone shall be as per standard.
 - b) All ball valves shall be supplied and fitted complete with back nuts, ball float, arm, etc.. Ball floats may be of soldered copper or brass or alternatively polyethylene and PVC.
- (vii) Pilot Operated Valve
 - a) Pilot-operated valve shall comply with AWWA C530-07. The configuration and material of main valve, vertical float rod and float shall be as per standard and specification.
- (viii) Drain Cocks
 - a) Gunmetal drain cocks shall be provided as necessary to ensure that all sections of the pipework and plant can be effectively drained. The sizes of drain cocks shall be as follows: -
 - i. Tanks, plant and pipes above 6" diameter
- $\geq 1"$ diameter

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- ii. Pipes 3" to 5" diameter
- 0.75" diameter
- iii. Pipes up to 2.5" diameter
- 0.5" diameter

2.7.8. Water Tank Foundation

2.7.8.1. Panel Tank

- (i) Unless otherwise shown on the approved Drawings, the foundations shall be constructed to provide continuous support to all base panel joints in one direction at 1000mm nominal centres according to panel sizes. The concrete foundation shall have a width of at least 300mm and height of at least 600mm. All foundations shall be constructed according to JKR standard specifications.
- (ii) If concrete slab is used, dwarf walls or steel beams shall be placed between the tank and the base level to allow a minimum clearance of 500mm to enable ease of tank installation and subsequent bolts tighten and adjustments after installation.
- (iii) Whenever recommended by the tank manufacturer, the steel skid base shall be designed and constructed in accordance with manufacturer's instructions, and details. In such cases, the continuous support can be spaced at greater than 1000mm nominal centres as recommended by the manufacturer.

2.7.8.2. Round Tank

- (i) The concrete plinth shall have minimum of 100mm height complete with 5mm mild steel base plate as per tank size.

2.7.9. Flange Joint (Nozzle)

Flange joint used for the inlet, outlet and scour of storage tanks shall be made of stainless steel Grade 304 externally and internally. Joint gaskets shall be of 5mm thick, medium rubber reinforced with two-ply flexible fabric and complying with BS 6956, or approved silica sealant used in the FRP tanks. All bolts, nuts and washer used for flange nozzles shall be made of stainless steel Grade 304.

2.8. Cleaning, Painting and Identification

2.8.1. Cleaning of Pipework

- 2.8.1.1. All pipes, fittings, etc., shall be kept closed against moisture and foreign matters when stored on Site.
- 2.8.1.2. All pipes, fittings, valves and accessories shall be thoroughly cleaned internally and externally before their installation and again where necessary before closing up.
- 2.8.1.3. After installation and before putting into service, all pipework including fittings, valves shall be thoroughly cleaned internally.



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2.8.2. Painting and Identification

- 2.8.2.1. All pumping equipment shall be factory painted according to the manufacturer's recommendations.
- 2.8.2.2. All thermoplastic pipes, fittings, valves, etc., exposed directly to sunlight shall be painted with water-based exterior-grade latex paint.
- 2.8.2.3. All surfaces to be painted shall be first thoroughly cleaned to remove dirt, scales, grease spots etc.. Surface shall be completely dry before painting.
- 2.8.2.4. All surfaces shall have minimum one (1) coat primer and two (2) coats finish subject to S.O.'s approval.

2.8.3. Pipework Identification

- 2.8.3.1. All pipes installed shall be identified in accordance with their relevant standards.
- 2.8.3.2. Directional arrows shall be painted on the pipework in the plant rooms, tank room and vertical risers. Lettering and the direction of flow must be indicated by painting a black / white arrow on to the pipelines at appropriate intervals. These arrows shall be 3" long on pipes up to 50mm (2") diameter, 150mm (6") long for pipes over 50mm (2") diameter.

2.8.4. Labels for Valves and Controls

All control valves, relays, switches and instrumentation shall be identified by black or white engraved laminated plastic labels, securely attached to the item by means of non-corrodible screws or rivet or any other method approved by the S.O., or when such item is installed on or within panels or cubicle, the labels shall be located immediately below the item.

3. Sanitary Plumbing System

3.1. Rules and Regulation by Law

- 3.1.1. All the workmanship and material for the supply, installation, testing, adjusting, balancing & commissioning of all system and accessories shall comply with the following rules and regulation requirements:
 - 3.1.1.1. Drainage, Sanitation and Sanitary Plumbing By-Laws of the Street, Drainage and Building Act. 1974;
 - 3.1.1.2. Gravity Drainage Systems Inside Buildings - Sanitary Pipework, Layout and Calculation, BS EN 12056 Part 1, Part 2 & Part 5;
 - 3.1.1.3. Code of Practice for Sanitary System in Buildings, MS 1402:2006;
 - 3.1.1.4. Local Authority By-Laws in force at time of installation; and
 - 3.1.1.5. Other relevant rules and regulations.

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3.2. Material Standard

- 3.2.1. Pipework for sanitary plumbing shall be to the dimensions shown on the Drawings or as specified hereinafter and shall be complete with all fittings, brackets, supports and other accessories to complete the installation.
- 3.2.2. All pipes, fittings and equipment used for sanitary plumbing and installation shall be of the type and make approved by SPAN and as mentioned in the Drawings.
- 3.2.3. The standards stated in this Specification shall comply with their latest edition issued or relevant standards approved by SIRIM.
- 3.2.4. The following standards in their latest edition as shown in **TABLE 07** shall apply:

TABLE 07. STANDARD FOR DIFFERENT TYPES OF SANITARY PIPE

Item	Standard
Unplasticized polyvinyl chloride (uPVC)	MS 1063, BS EN 1329-1, BS 4514, MS 628, BS EN ISO 1452-2:2009
Unplasticized polyvinyl chloride (uPVC) (Underground)	MS 979: Part 1 (Ø100mm & Ø155mm) MS 979: Part 2 (Ø200mm and above) or BS EN 1401-1, MS 1085
Poly propylene (PP)	MS ISO 7671:2012
Cast Iron Pipes	BS 416 for heavy grade pipes BS 437 for spigot / socket drain
Galvanized Iron	BS EN 10255 "Heavy"

3.3. Definition of Sanitary Pipe

3.3.1. Soil (Black Water) Pipe

Pipes attached to a building and designed to convey sewage or waste matter from any water closet (W.C) or urinal.

3.3.2. Waste (Grey Water) Pipe

3.3.2.1. A separate waste pipe shall be provided for the following:

- (i) Dirty water from baths, basins, wash troughs, ablution, floor trap and other waste containing a small proportion of soap and /or dirt; and
- (ii) Greasy water from kitchen sinks and equipment where grease traps or interceptors are required.



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3.4. Sanitary Discharge System

All main stacks shall be minimum 100mm diameter or subject to S.O.'s approval.

3.4.1. The discharge system can be classified as follows:

3.4.1.1. Single Stack System

- (i) In this system, all appliances discharge separately into a single discharge stack. All traps are unventilated and those on pipes 50mm and below must have 75mm water seals (trap). The stack is directly connected to the manhole.

3.4.1.2. Fully Ventilated System

- (i) All appliances are directly discharged to a common stack and essential features of this system are the provision of 75mm deep seal traps on baths, basins and sinks as well as the provision of a ventilating pipe to which every appliance connected.

3.4.1.3. The Modified Single Stack System

- (i) The modified single stack system basically similar to the single stack system, with the exception that the W.C.'s only are ventilated direct to the main ventilating pipe.
- (ii) The depth of the water seal to all appliances, except W.C.'s shall 75mm.
- (iii) The depth of the water seal to W.C.'s shall be 50mm to the main discharge stack.

3.4.1.4. Ventilated System

- (i) The discharge from W.C.'s, urinal and other soil appliances are conveyed via a main discharge soil (soil pipe) and finally to the sewer line.
- (ii) A separate waste pipe conveys the discharge from waste basins, baths, sinks to the waste water drain through a trapped gully.

3.5. Pipework Material

3.5.1. UPVC Soil, Waste and Vent Pipes

- 3.5.1.1. All pipes shall run in accordance with layout sizes shown on the approved Drawings. The pipes shall be provided, fixed and connected to fittings and sanitary installation complete with all necessary bends, tees, sockets, branches, offsets, inspection pieces, etc.. Pipes shall be joined with approved solvent in accordance with the manufacturer's instructions.

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- 3.5.1.2. Pipes, fittings and the system of unplasticised polyvinyl chloride (uPVC) in the field of soil, ventilation and waste discharge (low and high temperature) inside buildings, for soil and waste discharge systems buried in ground within the building structure and for soil, ventilation and waste discharge for both inside buildings and buried in building structure shall comply to MS 1063 or BS EN 1329 Part 1 or BS 4514 (size Ø82mm only).
- 3.5.1.3. Pipes, fittings and the system of unplasticised polyvinyl chloride (uPVC) piping systems shall comply to MS 1063; or BS EN 1329: Part 1; or BS 4514 (size Ø82mm only)
- (i) For soil, ventilation and waste discharge (low and high temperature) inside buildings (marked with “B”).
 - (ii) For soil and waste discharge systems buried in ground within the building structure (marked with “D”).
 - (iii) For soil, ventilation and waste discharge for both inside buildings and buried in building structure (marked with “BD”).
- 3.5.1.4. The pipes and the fittings shall be coloured through the wall. The colour of pipes and fittings shall be as follows:
- (i) “B” code – white
 - (ii) “D” code – brown
 - (iii) “BD” code - white
- 3.5.1.5. All underground sewerage pipe and fittings of Ø4” (100mm) diameter and Ø6” (150mm) diameter shall be of uPVC Brown complied to MS 979: Part 1; and for size Ø200mm and above complied to MS 979: Part 2 or BS EN 1401 Part 1 or BS 4660 (fitting of nominal size 110mm and 160mm only).
- 3.5.1.6. Main soil, waste and vent pipes shall be carried up to the roof level and protected by vent cowl and weather apron as per approved Drawings.
- 3.5.1.7. All pipes shall be fixed in straight runs and all horizontal runs shall be laid to gradients in accordance with BS EN 12056 Part 2 and in any event not less than 18mm/m unless otherwise instructed.
- 3.5.1.8. UPVC Waste, Vent and Soil System (Inside building, buried in building structure and buried in ground within building structure)
- (i) The uPVC pipes, fittings and system shall comply in all respects with the requirements of MS 1063 or other relevant standard certified by SIRIM / SPAN.
 - (ii) Pipes shall be supplied in plain-ended lengths and the minimum acceptable with thickness of pipe and fittings as shown in **TABLE O8**:

**TABLE O8: MINIMUM ACCEPTABLE THICKNESS OF uPVC
WASTE PIPE AND FITTINGS**

Nominal Sizes (mm)	Wall Thickness (mm)		
	Pipes (mm)	Fittings (mm)	Sockets (mm)
32	3.0	3.0	2.0
40	3.0	3.0	2.0
50	3.0	3.0	2.0
63	3.0	3.0	2.0
75	3.0	3.0	2.0
80	3.0	3.0	2.3
82	3.0	3.0	2.3
90	3.0	3.0	2.3
100	3.0	3.0	2.3
110	3.2	3.2	2.4
125	3.2	3.2	2.4
140	3.2	3.2 / 3.5*	2.4 / 2.6*
160	3.2	3.2 / 4.0*	2.4 / 3.0*
180	3.6 / 4.4*	3.6 / 4.4*	2.7 / 3.3*
200	3.9 / 4.9*	3.9 / 4.9*	2.9 / 3.7*
250	4.9 / 6.2*	4.9 / 6.2*	3.7 / 4.7*
315	6.2 / 7.7*	6.2 / 7.7*	4.7 / 5.8*

Note * For soil and waste discharge systems buried in ground within the building structure and for soil, ventilation and waste discharge for both inside buildings and buried in building structure.

- (iii) The method of jointing to be employed shall be that solvent welding using the manufacturer's approved cement. Seal ring fittings shall be used where necessary to accommodate thermal movement or the sockets of standard fittings shall be converted to seal ring adaptor.
- (iv) Access shall be provided where necessary either by means of an integrally moulded door in an access fitting with an externally fitted rubber seal and secured with two-piece clamp type door fitted into the pipe run.

3.5.1.9. Underground uPVC Sewerage Pipes and Fittings

- (i) The underground uPVC sewerage pipes and fittings shall comply in all respects with the requirement of MS 979: Part 1 (Ø100mm and Ø155mm) and MS 979: Part 2 (Ø200mm and above) or other relevant standard certified by SIRIM / SPAN.
- (ii) Pipes shall be supplied in plain-ended lengths.
- (iii) The minimum acceptable wall thickness of pipes and fittings shall be as shown in **TABLE O9**:

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**TABLE O9: MINIMUM ACCEPTABLE THICKNESS OF
UNDERGROUND UPVC PIPE AND FITTINGS**

Nominal Sizes (mm)	Wall Thickness (mm)		
	Pipes	Fittings	Junctions
100	3.2	3.4	3.4
155	4.1	4.1	4.1
200	4.9	4.9	4.9
250	6.1	6.1	6.1

- (iv) The method of jointing to be employed shall be strictly to manufacturer's recommendation.

3.5.1.10. Expansion Joints (Expansion Coupling for uPVC Pipes)

- (i) Where pipework is constructed using solvent welded joints, expansion joints for uPVC pipes shall be carried out in accordance with the manufacturer's recommendations.
- (ii) Expansion joints shall be provided at a maximum of 4 metre centre for soil, 2 metre centre for waste and between fixed points over 1 metre centre.

3.5.1.11. Cast Iron/Galvanized Iron Pipe

- (i) Where shown or stated on the Drawing, 100mm diameter cast iron soil and vent pipes internally coated with anti-corrosive bituminous coating shall be provided, fixed and connected to the fittings and sanitary system.
- (ii) All main and branch soil pipe and fittings shall be cast iron to BS 416 Heavy grade coated with an approved tar-based composition.
- (iii) Main and branch vent pipe and fittings shall be cast iron to BS 416 Heavy grade factory coated with an approved certificate tar-based composition.
- (iv) Branch vent pipe of 2" (50mm) diameter and below shall be galvanized to BS 10255: Heavy grade.
- (v) Cast iron pipes shall be jointed with an approved certificate resin with molten lead and well-sealed. All necessary bends, tees, sockets, branches, offsets, inspection pieces, shall be provided where necessary.

3.5.1.12. Other Material

- (i) All material not specifically mentioned above shall conform to the latest edition of their respective British Standard and/or Malaysian Standard or equivalent specification and shall be to the approval of SIRIM / SPAN.

3.6. Workmanship & Pipe Support

- 3.6.1. The installation, method of jointing and fixing shall comply in all respects to the manufacturer's recommendation and comply with latest relevant standards.
- 3.6.2. All soil, waste and vent pipes, pipe hooks clamps and clips shall be placed tight up against the head or underside of the collar. Extension clips shall be used where it is necessary to run the pipe clear of the wall.
- 3.6.3. Use only fixings that are compatible with the materials and system of pipework. Do not exceed the maximum spacing between fixings for sanitary pipes given below.
- 3.6.4. Maximum intervals between pipe supports shall be:

3.6.4.1. Horizontal Position

**TABLE O10: RECOMMENDED MAXIMUM SPACING OF
SUPPORT FOR HORIZONTAL SANITARY
PIPE**

Pipe Size (mm)	Recommended Maximum Spacing of Support (m)	
	Non-metal	Metal
32	0.5	2.1
40	0.5	2.4
50	0.6	2.7
80	1.0	3.0
100	1.0	3.0
150	1.2	NA

Source: British Standards Institute. (2000). BS EN 12056-2: Gravity drainage systems inside buildings. Sanitary pipework, layout and calculation

3.6.4.2. Vertical Position

3.7. Ventilating Pipe

- 3.7.1. Main ventilating stack pipe shall be discharged to the open air or connected to the discharge stack above the spillover level of the highest appliance on the stack. (Soil pipe or single stack system shall in all cases be vented by upward extension of the soil or combined pipe).
- 3.7.2. The upward vent pipe shall be straight and free from any bends or angles except where unavoidable. It shall be extended through the roof to the required height with the open end protected by means of copper wire globe or approved cowl. The distance of outlet is not less than 900mm above the head of any window or other opening into a building and within a horizontal distance of 3m.
- 3.7.3. All vent and branch vent pipes shall be graded 18mm/m (minimum 1°) to drip back to the soil or waste pipe by gravity. A branch vent must rise vertically or at an angle of not more than 45° from the vertical to a point 150mm above the fixture it is venting before running horizontally.

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3.7.4. Main ventilating pipe shall not be less than 50mm dia. or 2/3 of the diameter of the main soil/waste pipe whichever the larger diameter is.

3.8. Anti-Syphonage

3.8.1. An anti-syphonage pipe shall be carried up from each fixture to the branch or main vent pipe above the level of the fixture to prevent the loss of the water seal in traps.

3.8.2. No fixture shall be connected to the soil, waste or combined pipe at any point between the trap and the anti-syphonage pipe, which it serves.

3.8.3. In special cases, anti-syphonage vent pipe could be connected to the waste, combined pipe or soil pipe on the opposite side of the water seal to the fixture at a point, which should be between 75mm to 300mm from the crown of the trap. In the case of bath and closet pan, the vent pipe shall not exceed 1.2m from the crown of the trap.

3.8.4. Before connecting to the main vent pipe all anti-syphonage pipework shall rise above the floor level of the sanitary appliances.

3.8.5. Anti-syphonage pipework shall not be less than 32mm diameter.

3.9. Traps

Each sanitary appliance shall be fitted with a trap either as an integral part of the appliance or attached to and immediately beneath its outlet. All traps shall be accessible and provided with adequate facility for cleaning. The internal surface of the trap shall be smooth throughout. Generally, the trap shall be of the same material as the soil/waste pipe.

3.10. Floor Traps

Floor trap in all areas, unless otherwise specified, shall be 100mm diameter similar materials to the pipe traps complete with grating and self-tapping screw.

3.11. Testing Tees

Testing tees shall be located on the vertical stacks between floors to enable each floor to be tested independently as specified hereafter. Upon completion of testing, the tees shall be sealed up with lead joint or solvent joint where uPVC pipe is specified.

3.12. Grease Interceptors/Waste Drain Trap (Where Specified)

3.12.1. The body of the interceptor and baffles shall be made of stainless steel Grade 316. The baffles shall be of removable type.

3.12.2. Grease interceptors shall be certified by relevant authority. It shall be of floor mounted or fully recessed manual type complete with extension collar or extension piece to suit the structural requirement where required.

3.13. Reducing Fitting

Wherever reduction in pipe sizes takes place, reducing fitting shall be used.



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3.14. Cleaning Eyes and Inspection Opening

3.14.1. To provide access for the proper inspection, cleaning and testing of the entire length of pipe, inspection openings and cleaning eyes shall be provided on all soil, waste and combined pipes at:

3.14.1.1. Each change of direction of piping; and

3.14.1.2. Based on each soil, waste or vent stack.

3.15. Temporary Closing of Pipework (Ingress of Contaminants)

As soon as pipes have been installed, all openings shall be capped or plugged to prevent the entrance of materials that would obstruct or choke the pipes. It is the responsibility of the Contractor to ensure that caps and plugs are left in place until removal is necessary for completion of installation.

3.16. Inspection Chamber / Gully Trap

The works shall include the construction of all inspection chambers / gully trap generally as shown on the civil/tender/working Drawings and specification. Inspection chamber and gully trap shall not be located in clinical areas, clean areas or any other areas that will affect the cleanliness, functionality and operability of the spaces.

3.17. Underground/Buried Pipe (For Sanitary)

3.17.1. All underground/buried pipes shall be carefully laid on beddings free from rocks, stones and other broken materials. Unless otherwise stated, all direct buried pipework shall be installed in open trench.

3.17.2. Excavation and Trenching for Piping

3.17.2.1. The Contractor shall perform all excavation to the depths indicated in the Drawings or as specified in conformance with local authority requirements.

3.17.2.2. All excess excavation materials shall be removed from the Site. The Contractor shall prevent surface water from flowing into trenches or the excavations by using sheeting and shoring method thus ensuring the safety of personnel. Any water accumulating therein shall be removed.

3.17.3. Trench Excavation

Trenches shall be of necessary width for the proper laying of the pipe, and the banks shall be as nearly vertical as practicable. The bottoms of the trenches shall be accurately graded to provide uniform bearing and supports for each section of the pipe on undisturbed soil at every point along its entire length, or may be over excavated 100mm below depth indicated and filled with well tamped salt free coarse sand or other approved materials. Layers of brick, concrete base and angle blocks shall be used support for the laying of piping.

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**TABLE O12: TRENCHES WIDTH FOR DIFFERENT PIPE
DIAMETER**

Pipe Diameter Inches	Trenches Width Inches
3 and under	15 - 24
4 - 6	18 - 28
8	20- 30

3.17.4. Depth of Trench's Cover

The minimum depth of trenches covered with concrete slab shall be 450mm from top of pipe to finished ground level and trenches without concrete slab shall be 750mm.

3.17.5. Protection of Existing Utilities

3.17.5.1. Existing utility lines or other completed utility lines if damaged by the Contractor shall be repaired at his own expense.

3.17.5.2. When connecting to existing utility lines, no section of the existing piping shall be abandoned unless it is specifically indicated in the Drawings.

3.17.6. Backfilling of Trenches

Trenches shall not be backfilled until all required pressure and other tests have been performed. Backfill and compaction shall comply to Civil & Structural Engineer's requirements.

4. Testing, Adjusting, Balancing and Commissioning (TABC)

4.1. General

All work to be performed shall be in accordance with this specification and the commercial practice.

4.1. Internal Cold Water Plumbing System

4.1.1. The Contractor shall allow for the cost of all tests to the plumbing system to the satisfaction of the S.O.. The completed plumbing system shall be tested for hydraulic performance.

4.1.2. The cost for providing all testing, adjusting, balancing and commissioning as well as calibrated measuring equipment, all materials and consumables such as fuel, electricity, water etc. shall be borne by the Contractor.

4.1.3. All pipework which is to be encased or concealed shall be tested, approved and recorded before it is finally enclosed.

4.1.4. The Contractor shall give the S.O. a minimum of full seven (7) days notice of his readiness to carry out acceptance tests, completed testing sheet and schedule for S.O.'s approval.

4.1.5. Before the commencement of acceptance tests, the Contractor shall have completed all preliminary testing and adjusted the equipment to its proper running order.



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- 4.1.6. During the testing period, no modification, adjustment or other work on the installation shall be carried out without the permission of the S.O.. Should there be any contravention of this requirement, the results of all tests completed may be rejected and a retest shall be carried out.
- 4.1.7. No acceptance test shall be carried out except in the presence of the S.O., the State Water Authority's representative (if required) and the Contractor or their respective representative appointed for the purpose.
- 4.1.8. If the installation fails to perform during testing in accordance with the requirements of the Specification or acceptance criteria, the S.O. may reject the whole or any part of it. The Contractor shall bear all costs and expenses for all retests and remedial works.
- 4.1.9. Testing of Internal Pipework

4.1.9.1. Pressure Test

- (i) Internal reticulation and main distribution pipes shall be slowly and carefully charged with water in order that all air is expelled from the system. The system shall be allowed to stand full for 24 hours. An air relief valve should be provided at the highest point in the system to bleed off any air that is present.
- (ii) A test pressure of 1.5 times the maximum working pressure shall be applied for 24 hours.
- (iii) No pipework shall be covered or concealed until it has been tested to the satisfaction of the S.O. or his representatives. Where arrangement of work makes necessary, the piping system shall be tested by sections to prove joints between sections.
- (iv) The completed system shall be inspected for leaks during the test. Should any signs of leakage occur in the tanks or pipework, their positions shall be marked and the Contractor shall carry out remedial measures. The pressure tests procedure shall be repeated until the whole water system passes. The pipe installation is considered to have passed the pressure test if no visible leak and no drop in the pressure reading are observed during the test.
- (v) All equipment not designed to withstand test pressure shall be disconnected during test, but shall be reconnected and tested under actual working pressure.
- (vi) The permanently installed pumps shall not be used for pressure testing of the water system.

4.1.9.2. Flow Test

- (i) During the flow test, all pumps shall be run with all valves fully open and the following data shall be recorded:
 - a) Flow at pump outlet into storage tank

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- b) Head at pump discharge outlet
- c) Current consumed
- d) Voltage

4.1.9.3. Flushing of Cold Water System

- (i) After completion of the pressure tests to the satisfaction of the S.O., the whole piping and water storage system shall be thoroughly flushed with potable water before they are put into use.
- (ii) The Contractor shall ensure the system is fit for purpose and the water in the pipeline is safe for consumption after flushing.
- (iii) The Contractor, at his own expense, shall use water supply for cleaning and flushing out of all the plumbing system that he had installed as per Contract.
- (iv) Control valves and all equipment liable to damage, shall be disconnected before cleaning out. All strainers shall be thoroughly cleaned out during and at the completion of the clean out operation.

4.1.9.4. Balancing

- (i) Prior to balancing, all isolation/gate valves shall be checked to be in the fully open position for the pumping system.

4.1.9.5. Records

- (i) All pressure, flow and balancing tests shall be recorded by Contractor and certified by S.O. or S.O.'s representatives.
- (ii) The S.O. reserves the rights to order a re-test if the Contractor fail to produce authentic test record.

4.1.10. Testing of Storage Water Tank

4.1.10.1. After flushing, the tank shall be filled with water to maximum operating capacity level and the level of water surface shall be carefully recorded. The tank shall be accepted as satisfactory if after a period of 48 hours there is:

- (i) No measured reduction in water level, due allowance being made for evaporation from the surface of water;
- (ii) No visible sign of leakage from any part of tank;
- (iii) No deformation of any part of the surface.

4.1.10.2. If the test results do not satisfy the above conditions of test, the Contractor shall locate and rectify all defects and leakages and the test shall be repeated. The Contractor shall bear all costs and expenses for all tests and remedial works.



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4.1.11. Testing of Pump (If Applicable)

All pumps and motors shall be checked for flow rates, pressures and RPM. The input signal device sensors and controllers shall be checked to ensure the pumps cut-in and cut-out at predetermined water levels.

4.1.12. Post Occupancy Testing, Adjusting, Balancing and Commissioning

4.1.12.1. Further adjustments to the system controls such as re-balancing, re-tuning, re-checking and re-adjustment etc. shall be made whilst the building is occupied and the installation is in use during the Defects Liability Period. The cost of the adjustment shall be included in the tender.

4.2. Sanitary Plumbing System

4.2.1. The S.O. reserves the right to request for water, air or smoke tests as well as for hydraulic performance to be performed by the Contractor at his expense including the furnishing of the necessary equipment. The testing procedure shall be in accordance with MS 1402: Part 3.

4.2.2. Water Test

4.2.2.1. There is no justification for a water flood test to be applied to the whole of the plumbing system. The part of the system mainly at risk is that below the lowest sanitary appliances and this may be tested by inserting a test plug in the lower end of the pipe and filling the pipe with water up to the flood level of the lowest sanitary appliances, provided that the static head does not exceed 6m. This is a visual inspection.

4.2.3. Air Test

4.2.3.1. Air test may be performed by inserting expanding rubber testing plugs in the lower and upper ends of the main soil pipe and main ventilating pipes and sealing the plugs with water necessary. The water seals of all sanitary appliances shall be fully charged.

4.2.3.2. The testing plug at the upper end of the ventilation pipe should be fitted with a tee-piece with cock on each branch. A flexible tube manometre should be fixed to one branch while air pressure is being introduced into the system through the other branch until the desired pressure is indicated on the manometre scale.

4.2.3.3. The air test applied shall be 3.8 mbar (38mm water gauge) in period not less than 3 minutes without loss.

4.2.4. Smoke Test

4.2.4.1. Smoke can be introduced into the system by a small machine under the source pressure as for the air test. The whole system shall be filled with smoke before the openings are sealed with plugs.

4.2.4.2. The pressure on the smoke shall be maintained for 3 minutes after the last opening has been sealed.

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4.2.4.3. Smoke test is not recommended if uPVC pipe material is adopted. Rubber jointing components can also be adversely affected.

4.2.4.4. Smoke testing shall normally only be used instead of air test when an undetectable leak in the system occurs.

4.2.5. Hydraulic Performance

Hydraulic performance discharge tests shall be made from all appliances singly and correctively. Obstruction in any of the pipelines shall be traced and the whole system examined for proper hydraulic performance including the retention of an adequate water seal in each trap.

5. Comprehensive Service and Maintenance for Internal Cold Water and Sanitary Plumbing System

5.1. General

All work to be performed shall be in accordance with this Specification and the commercial practice.

5.2. Workmanship and Materials

5.2.1. The work described in this Specification shall be performed by skilful workmen in the service, maintenance and repair of the internal cold water and sanitary plumbing system and shall be executed in accordance with the good engineering practice.

5.2.2. All materials to be supplied in connection with work under this Specification shall be new, unused, genuine, and shall generally be the best quality in manufacturing and performance.

5.3. Supervision

5.3.1. The Contractor shall have a competent Plumber in charge of the service, maintenance and repair work to be carried out under this Specification and shall be in the direct employ of the Contractor, and acceptable to the S.O..

5.3.2. The Contractor shall have in his direct employ workmen who are skilled in the service, maintenance and repair of internal cold water and sanitary plumbing system.

5.4. Scope of Work

5.4.1. The work covered under this Specification is to service and maintain all equipment comprising the complete internal cold water and sanitary plumbing system strictly accordance with the servicing and maintenance schedule as set out in sub-section 5.6..

5.4.2. The Contractor shall rectify any defects in any parts of the complete internal cold water and sanitary plumbing system observed during routine inspection and service and shall repair such defects if required to do so by the S.O..

5.4.3. The Contractor shall also provide emergency repair service at any time if required to do so by the S.O..



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5.5. Consumable Materials

- 5.5.1. The Contractor shall include in his service and maintenance contract for the supply of the following consumable materials as and when required.
- 5.5.1.1. All oils and greases required for the lubrication of motor bearing, packing, pivots and other moving parts.
- 5.5.1.2. All cotton waste, soap detergent and other cleaning materials required for cleaning purpose.
- 5.5.1.3. All consumable filter elements.
- 5.5.1.4. All tap washers.
- 5.5.1.5. All electric contact points required to replace worn electric contact points in switchgears, electric control gears and electric relays.
- 5.5.1.6. All electric fuses required to replace blown or defective fuses.
- 5.5.1.7. All indicator lamps required to replace blown lamps.
- 5.5.2. The cost of these consumable materials shall not be charged for separately but shall be included in the schedule quoted by the Contractor for the service and maintenance of the complete internal cold water and sanitary plumbing system.

5.6. Servicing and Maintenance Schedule

- 5.6.1. The Contractor shall inspect and service all equipment comprising the complete internal cold water and sanitary plumbing system periodically as scheduled in the approved check list except where otherwise directed by the S.O..
- 5.6.2. The Contractor shall report in writing to the S.O. any defect/s observed in any part or parts of the complete internal cold water and sanitary plumbing system. The technical report shall state the causes of the defects observed and shall include the estimate of repairs required for non-consumable material or any part or equipment damaged by catastrophic event or vandalism.

5.7. Check List (Monthly Report)

- 5.7.1. Pumps (If Applicable)
- 5.7.1.1. Check all seals, glands and pipeline for leakage.
- 5.7.1.2. Check all pump bearing and lubricate with oil or grease.
- 5.7.1.3. Check the alignment and condition of coupling.
- 5.7.1.4. Check all bolt and nut for tightness.
- 5.7.1.5. Clean pumps casing and shaft.
- 5.7.1.6. Check and record pump running pressure.

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- 5.7.2. Electric Motor Pumps (If Applicable)
 - 5.7.2.1. Check motor bearing and rewinding.
 - 5.7.2.2. Check carbon brush and slip rings and clean as necessary.
 - 5.7.2.3. Check and record motor running amperes, voltages and resistance of cable.
- 5.7.3. All Electrical Starters, Electrical Control Gears, and Ancillary Electrical Apparatus (If Applicable)
 - 5.7.3.1. Clean and adjust all bearings, pivots and other moving parts as necessary.
 - 5.7.3.2. Clean or renew electric contactors as necessary.
 - 5.7.3.3. Renew electric fuse as necessary.
 - 5.7.3.4. Check the performance of the complete pumping and associated equipment as necessary.
- 5.7.4. Cold Water Piping
 - 5.7.4.1. Check water leakages in piping and rectify accordingly.
 - 5.7.4.2. Check water leakages in valve and rectify accordingly.
 - 5.7.4.3. Check excessive vibration of piping during pumping.
 - 5.7.4.4. Clean strainer baskets.
 - 5.7.4.5. Check all water taps for leakages and replace rubber washer as necessary.
 - 5.7.4.6. Check ball float valves and adjust as necessary.
 - 5.7.4.7. Check water level control indicator.
 - 5.7.4.8. Check water leakage at any part of jointing of panel water tank.
- 5.7.5. Internal Sanitary Plumbing System
 - 5.7.5.1. Check access covers, caps and cleaning eyes.
 - 5.7.5.2. Check any water leakage at any part of jointing of internal sanitary pipe system.
 - 5.7.5.3. Check discharge pipe systems:
 - (i) It shall be kept in a clean and sound condition.
 - (ii) Any blockages shall be removed by using hand operated rods and capable passing through the system without damaging the internal surfaces of pipes and fittings.



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5.8. Inspection and Records

- 5.8.1. Inspect and check all other equipment under this Contract, whether or not these are specifically mentioned in the check list.
- 5.8.2. The Contractor is responsible for the operation of the plant and equipment on correct methods of operating the plant and equipment and on the maintenance points to be watched.
- 5.8.3. Report in writing to the S.O. any defects observed in any part or parts of the complete internal cold water and sanitary plumbing system. The report shall state the cause/s of the defect/s observed and shall include an estimate of the cost of repairs required.
- 5.8.4. Service and maintenance records shall be properly updated and kept by the Contractor or as instructed by the S.O..

5.9. Sampling of Storage Water

- 5.9.1. The Contractor shall have deemed to have included the sampling and testing of water in storage tanks.
- 5.9.2. The Contractor shall be responsible for ensuring that water quality testing is regularly done on the cold or domestic water supply network to monitor the water quality provided to the end user against the most current revision of the State Water Authority guidelines for domestic and drinking water.
- 5.9.3. Samples for testing to be performed every six (6) months shall include:
 - 5.9.3.1. Chemical Analysis
 - 5.9.3.2. Bacteriological Analysis
- 5.9.4. In the event the cold or domestic water quality does not meet the most recent revision of the State Water Authority guidelines for domestic and drinking water (the most current revision at the time of sampling), the Contractor shall immediately notify the S.O. and recommend appropriate action for approval.
- 5.9.5. The above-mentioned tests shall be performed again until the approval of the S.O. is obtained.

5.10. Repairs

- 5.10.1. The Contractor shall repair any defects in the complete internal cold water and sanitary plumbing system on the instruction of the S.O..