Type of Doors, Windows etc.	Ironmongery for each type of doors, windows etc.
	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	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 DGFR. 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.
5.3. Standard size of 2400mm x 2100mm	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 DGFR. 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 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.
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 number 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 number 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.

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Type of Doors, Windows etc.	Ironmongery for each type of doors, windows etc.
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 falls 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 H/2

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 .....m^3

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

1.1. Unless otherwise specified or shown on the Drawings, all ceilings shall be of gypsum plasterboards or as approved by the S.O. with class 'O' fire rating and all ceiling installation shall comply with the classification of fire spread as stipulated in the 8th Schedule Uniform Building By-Law 1984.

1.2. All conceal ceilings shall be provided with service access to the ceiling void for maintenance of services above the ceiling space in accordance to the Drawings and approval of the S.O..

1.3. All sprinkler heads (drops) shall have 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 Contractor shall not commence the ceiling installation works until the building is effectively weather-tight and the work area of wet trades has been completed and dried.

2. Submittals

2.1. Unless otherwise specified, the Contractor shall submit manufacturer's shop drawings and design calculations for the complete proprietary ceiling system showing compliance to all specifications including the method of installation of the ceiling board/panels, hangers, fittings and all accessories duly certified by an Architect registered with the Board of Architects or a P.E. with practising certificate registered with the Board of Engineers Malaysia.

2.2. The contractor shall submit method statement from the proprietary ceiling system supplier/manufacturer of the installation works to the S.O. for approval prior to the commencement of the works at site. No installation of ceiling works shall commence until approval is given in writing by the S.O..

3. Setting Out

3.1. The ceiling layout shall be planned prior to installation to determine the grid configuration, direction et cetera to ensure that all fixings points are compatible with the structural members or other services, or both.

3.2. Mechanical and electrical services shall be completed before installation of the suspension systems. Mechanical services and electrical wiring systems, including cable trays, conduits, junction boxes, down-lights and other appurtenances shall be independently supported and independently braced from the ceiling support system. Suspension hangers may be installed before or during installation of services with the approval of the S.O..

3.3. The shop drawings used for the ceiling installation shall contain sufficient information to allow the installer to set out the ceiling grid. The finished height of the ceiling shall be shown clearly on the drawings.

3.4. Sufficient information should be clearly indicated on the drawings to enable the ceiling module and setting out points in each ceiling area applicable to all relevant trades to be established early. All trades shall work to the same setting out points and data.

3.5. The ceiling height in each area shall be marked in relation to the elevation benchmarks and then transferred by means of a water level, rotating laser or other

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approved devices. Setting out lines should be in both directions and squared accurately at the outset.

4. Acoustic Requirements

4.1. Acoustic requirements specified or shown on the Drawings, such as sound absorption, sound insulation and impact sound insulation shall be tested in accordance with BS EN 13964, BS EN ISO 140 or other acceptable standards.

4.2. 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.

4.3. 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.

5. Materials and Ceiling Components

5.1. Zinc-Coated and Aluminium/Zinc Coated Steel

Zinc-coated and aluminum/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.

5.2. Linear Strip Ceiling

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

5.3. Plasterboard

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

5.3.2. Unless otherwise specified in the Drawings the size for plasterboard ceiling shall be 600mm x 1200mm x 9mm thick minimum and shall be suspended from the soffit with adjustable hanger rods in accordance to manufacturer's recommendation and S.O.'s approval.

5.4. 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 DGFR.

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5.5. 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 DGFR.

5.6. Mineral Fibre Boards

5.6.1. Unless otherwise specified, the board size shall be 600mm x 1200mm x 15mm thick square edges. The board shall carry Class 'O' approval from the DGFR and the minimum sag resistance shall be of RH 99.

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

5.7. Fibre Cement Ceiling Panel

Fibre cement ceiling panel shall be asbestos free and shall be an autoclaved cellulose fibre cement flat board. The basic composition consists of cement, refined sand and cellulose fibre. The material shall be classified as Class 'O' and shall be 'Fire- Listed' under SIRIM QAS Fire Listing Scheme.

5.8. 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, square edge fixed to aluminium tee exposed grid systems, suspended from the soffit with adjustable hanger rods in accordance to manufacturer's recommendation and S.O.'s approval.

5.9. Glass Fibre Reinforced Gypsum (GRG)

5.9.1. GRG Boards are manufactured by glass fibre reinforced gypsum and comprise of non-combustible high-grade gypsum casting plaster with glass fibre membranes. Unless otherwise specified shall be in sizes of 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

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

5.10. Cornice

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

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

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

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5.10.4. 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.

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

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

5.11. Reinforcing/Jointing tape

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

5.12. Jointing compound

Jointing compound shall 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..

5.13. 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..

5.14. Control joint

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

5.15. Anchors and Fasteners

5.15.1. The Contractor shall submit the details of the proposed proprietary anchor to the S.O. for approval.

5.15.2. Notwithstanding the above, the alternative anchor proposed shall be made of carbon steel galvanized to minimum thickness of 5 µm or stainless steel in accordance to European Technical Approval Guideline ETAG 001 Metal Anchors for Use in Concrete.

5.15.3. 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 drill bit of corresponding size to the proprietary anchor. The design resistance in all load directions shall not be less than 1.10kN.

5.15.4. Shot-fired alternative anchors shall not be allowed. 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.

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5.15.5. 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.

5.16. Acoustical Cellulose Insulation

5.16.1. Spray Applied Acoustical Cellulose Insulation on ceiling and/or soffit of slab shall be:

5.16.1.1. Thickness – minimum 30mm

5.16.1.2. Thermal conductivity (k-value) = 0.0029 W/mK tested to ASTM C-177.

5.16.1.3. Fire retardant Class “O” complying with BS476 Part 6 & 7 and endorsed by Jabatan Bomba Dan Penyelamat Malaysia.

5.16.1.4. Average moisture absorption of not more than 15% as per ASTM C739.

5.16.1.5. Tested Noise Reduction Coefficient of NRC 0.75 at 30mm thickness.

5.16.1.6. Tested to be non-toxic and asbestos free, contain no carcinogenic materials and shall not cause any skin irritation to humans

5.16.2. Where required, appropriate surface preparation and treatment should be done on the surface of the substrate according to manufacturer’s recommendation.

5.16.3. The application of cellulose insulation shall be applied strictly to manufacturer’s method statement and to S.O.’s approval

6. Ceiling Suspension System

6.1. General

6.1.1. Batten system (furring channels) as vertical ceiling hangers shall not be allowed for the installation of proprietary ceiling system.

6.1.2. Where grid ceiling suspension system 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..

6.1.3. Only proprietary adjustable butterfly type locking clips (rod joiner) shall be used with a minimum thickness of 0.48mm and galvanize coating mass of minimum 80g/sq.m. The locking clips shall be of minimum steel grade SK-5 or approved equivalent with a minimum pull off strength of 110kgs.

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6.2. Fixed Ceiling System

6.2.1. 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.

6.2.2. All timber materials used shall be treated and as specified under SECTION H: 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.

6.2.3. Where conceal ceiling 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.

6.2.4. All screw fixings of the ceiling panel/boards to the framing system shall be completely sealed to match with the ceiling surface. All external ceiling shall be painted with weather resistant paint as specified under SECTION O: PAINTING.

6.3. Grid Ceiling Suspension System

6.3.1. Vertical suspension members

6.3.1.1. Ceiling hangers shall be galvanized mild steel machine straightened hanger rods of minimum 4mm diameter consisting of 2 pieces length with a galvanization thickness of minimum 80g/sq.m and tensile strength of minimum 350MPa., held together by a galvanized rod joiner (adjustable type galvanized locking clips). Only proprietary adjustable locking clips (butterfly type) shall be used as a rod joiner.

6.3.1.2. 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 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

6.3.1.3. One end of the hanger shall be attached to a pre-drilled galvanized mild steel L-shaped soffit cleat 25mm x 25mm x 50mm (width) and minimum base metal thickness of 2mm with a galvanization thickness of mimimum 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.

6.3.1.4. 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

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6.3.1.5. The proprietary adjustable locking clips (butterfly type rod joiner) shall be 0.5mm minimum thickness with galvanize 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.

6.3.2. Horizontal suspension members

6.3.2.1. 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 powder coated colour white. Installation shall refer to manufacturer's method statement.

6.3.2.2. 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..

6.4. 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:

6.4.1. Vertical suspension members

6.4.1.1. Ceiling hangers shall be rigidized galvanize mild steel 25mm x 25mm angle section with 0.5mm base metal thickness OR galvanized 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 manufacturer's method statement.

6.4.1.2. 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 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 centre to centre (c/c) to form the grid of the ceiling hanger

6.4.1.3. Where hanger rods are used, one end of the hanger rod shall be attached to a pre-drilled galvanized mild steel L-shaped soffit cleat 25mm x 25mm x 50mm (width) with minimum base metal thickness of 2mm. The other end of the hanger shall be secured using proprietary locking clips to the primary channel (main runners).

6.4.1.4. 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

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clips or suspension brackets to the primary channel (main runners).

6.4.2. Horizontal members

6.4.2.1. 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 varies according to the profile with larger cross section values with appropriate justification from manufacturer). Installation shall refer to manufacturer's method statement.

6.4.2.2. Secondary rigidized galvanize steel channel 34mm x 12mm x 0.4mm minimum BMT shall be secured using proprietary locking clips or suspension brackets to the primary channel.

6.4.2.3. The primary and secondary channels shall be connected using galvanized proprietary locking clips or suspension brackets with minimum thickness of 0.5mm (the minimum thickness may varies according to the profile with larger cross section values with appropriate justification from manufacturer) and screwed as recommended by the manufacturer. And no tilting movement are allowed on Primary channel once secured with locking clips.

6.4.2.4. Unless otherwise specified, a single layer 9mm thick gypsum plasterboard ceiling shall be screwed using galvanized wafer head dry wall screw Ø 4mm x 25mm length fixed at maximum distance of 200mm c/c to the secondary channel as recommended by the manufacturer.

6.5. 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:

6.5.1. Vertical suspension members

6.5.1.1. Ceiling hanger system shall be galvanized mild steel threaded rods of not less than 6mm diameter.

6.5.1.2. 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 suspended point on site, mark the position for drilling, the position should 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.

6.5.1.3. 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

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brackets with two M6 nuts and locked to the primary channel (main runners).

6.5.2. Horizontal members

6.5.2.1. 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

6.5.2.2. 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.

6.5.2.3. 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.

6.5.2.4. Unless otherwise specified, a single layer 9mm thick minimum plasterboard ceiling shall be screwed using galvanized dry wall screw Ø4mm x 25mm length at maximum 200mm c/c to the secondary channel as recommended by the manufacturer.

6.6. Performance and Installation Requirements

6.6.1. Suspended ceiling systems are not designed for 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.

6.6.2. 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.

6.6.3. Other steel components of the substructure such as supporting member, perimeter trim, et cetera 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.

6.6.4. 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.

6.6.5. 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-

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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.

6.7. Structural steel fixing

6.7.1. 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.

6.7.2. Penetrations made into the structural steel by drilling shall be duly approved by the S.O..

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

6.8. Cold formed truss/timber truss fixing

6.8.1. 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..

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

6.9. 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 H: TIMBER, JOINERY AND IRONMONGERY.

6.10. Concrete fixing

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

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

6.11. Purlin fixing

6.11.1. 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.

6.11.2. 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.

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

6.12. 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.

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6.13. Ceiling hangers shall be installed in accordance to 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.

6.14. In areas where the suspended ceiling is adjacent to rooms or areas with twenty four (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.

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

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

6.16.1. Wind Load

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

6.16.1.2. 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.

6.16.1.3. 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.

6.16.1.4. Where 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 minimum two proprietary `hold-down clip' for each tile as recommended by the manufacturer and approved by the S.O.. Installation shall refer to manufacturer's method statement.

6.17. Testing and Inspection

6.17.1. 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 5 samples for every 200 number of hangers installed and the points of testing shall be carried out subject to S.O.'s approval.

6.17.2. 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 8 hours and the observation shall be recorded and submitted to the S.O. for approval.

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6.17.3. 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.

6.18. Warranty

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

6.18.1.1. The products used are genuine and free from manufacturing defects;

6.18.1.2. 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;

6.18.1.3. 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 manufacturer's registered panel installer.

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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 related works. All materials shall conform to the relevant Malaysian or British or European Standards.

2. Hot Rolled Structural Steelworks

2.1. All hot rolled structural steelworks design, materials, drawings, workmanship, protective treatment, fire protection, Quality Assurance and Quality Control shall be in accordance with the *Specification for Structural Steelworks No. JKR 20601-0191-12.*

2.2. Quality Assurance and Quality Control (QA & QC)

The Contractor shall submit a Quality Assurance and Quality Control programme as specified in the Specification for Structural Steelworks as in sub-section 2.1..

2.3. Drawings and Design Calculations

2.3.1. The Drawings to be submitted by the Contractor based on construction drawings are as follows:

2.3.1.1. Fabrication drawings;
- Shop drawings;
- Erection drawings;

2.3.1.2. As-built drawings.

2.3.2. In the event that the Contractor is required to provide the design, he shall prepare Drawings with details in accordance with *MS EN 1993* or other relevant standards. The Drawings and design calculations shall be certified by a Professional Engineer. He shall also prepare Drawings and arrangements of temporary steelworks for the different stages of construction in compliance with the requirements specified in the *Specification for Structural Steelworks* as in sub-section 2.1..

2.4. Records

2.4.1. The Contractor shall submit to the S.O., document and records which shall include but not limited to:

2.4.1.1. Drawings as in sub-section 2.3. and documentation register;

2.4.1.2. Mill certificates for materials and certification for consumables;

2.4.1.3. Calibration of equipment;

2.4.1.4. Weld procedures, concessions et cetera;

2.4.1.5. Inspection and laboratory test reports;

2.4.1.6. Delivery schedules and method statements for fabrication and installation;

2.4.1.7. Surveys and final inspection results.

2.4.1.8. Completion of erection and hand over certification.

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2.5. Installation of Long Span Steel Trusses

The S.O. shall ensure that the installation of long span trusses more than 20m clear span is in accordance to the checklist of requirement and condition in **Appendix J/1.**

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 *Specification for Prefabricated Cold Formed Steel Roof Trusses (JKR 20601-0186-11).*

3.2. 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.

3.3. Duties of Professional Engineer

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

3.3.1.1. Preparation of roof truss analysis and design;

3.3.1.2. Preparation of drawings;

3.3.1.3. Design changes in every stage of work;

3.3.1.4. Certification for completion of roof truss installation;

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

3.4. Fabricator

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

3.5. Installer

All installation works shall be executed and supervised by qualified personnel with valid certificate issued by CIDB. The S.O. shall 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 roof trusses works, the following general limitation shall be applied:

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3.6.1.1. Maximum unsupported truss span 13 m with permitted deviation of ± 0.05m.

3.6.1.2. Maximum truss spacing of 1.2m with permitted deviation of ±0.025 m.

3.6.1.3. 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.

3.6.1.4. Minimum base steel thickness for main truss member shall be:

a) 1mm for unsymmetrical section or open cross section;

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;

c) 1mm for all bracings.

3.7. Analysis, Design Report and Drawings Submission

3.7.1. 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. Refer to **Appendix 3** of *JKR 20601-0186-11.*

3.7.2. All details in the construction drawings shall be sufficient to enable checking against the analysis and design report, including specifying and providing 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 types 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 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;

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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;

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.

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 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 O: 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 or described in the Bills of Quantities, 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.

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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.

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 on 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 15 μ (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 H: 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; Removable spreader bars, to ensure a perfect square during transportation and installation; and

4.4.1.4. 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.

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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.

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 and Et Cetera

The Contractor shall provide and fix approved collapsible steel gates, folding shutters, roller shutters and et cetera 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, et cetera and 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 et cetera 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 45^0 from the surface.

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APPENDIX J/1

CHECKLIST
FOR THE INSTALLATION OF LONG SPAN STEEL TRUSSES
(For Trusses exceeding 20m in Clear Span)

This checklist is to provide assistance to the S.O./Supervising Engineer prior to the commencement of any installation of long span steel roof trusses. Please tick and indicate whether all the items / conditions have been adhered fully.

No	ITEM	Compliance (√)
A	**DOCUMENTATIONS**	
A1	Approved Structural Drawings by the Designer	
A1.1	For JKR's in house design, the drawings must be approved and signed by the HODT.	
A1.2	For design by Consultants, all drawings must be approved and endorsed by the submitting Professional Engineer.	
A2	Shop drawings for erection purposes *issued* by the Steel Installer	
A2.1	The Professional Engineer (PE) appointed by the Steel Installer must ensure that, these shop drawings are in accordance to the design and any assumptions made for the design. Any additional joints/splicing and any other deviations required for the purpose of erections must be accompanied by the calculations and approved by this Professional Engineer.	
A2.2	Quality Assurance documentations for the fabrication of steel members must be approved by the PE appointed by the Steel Installer.	
A2.3	Competency certification from approved establishment for all erection supervisors and installers.	

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B.	**METHODOLOGY**	
B1	The Contractor shall prepare and submit the Method Statement to the S.O. for approval at least three (3) weeks prior to the erection commencement. A copy of the Method Statement must be submitted to the Designer's office for verification.	
B2	The Method Statement with the concurrence of the Designer shall be approved by the S.O.. (Item 12.4, Section A, *Standard Specification of Building Works, 2014*)	
B3	The Method Statement shall among others include the following:	
B3.1	Pre-erection survey and formal acceptance of site	
B3.2	Phased component delivery (if any)	
B3.3	Safety and environmental controls	
B3.4	Operative certification	
B3.5	Plant and equipment certification	
B3.6	Detailed Sequencing of Installation, and showing the movements of any plant/machinery required for the installation. **The installation sequencing must be divided into several major/critical stages for the purpose of verification.**	
B3.7	Quality Assurance documentations required for the installation	
B4	Erection must adhere fully to the Method Statement. Each stages of erection must be verified and approved by the Supervising Engineer or the S.O..	

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C.	**SAFETY**	
C1	All internal or external temporary bracings required for the installation must be designed and approved by the P.E. appointed by the Steel Installer.	
C2	All temporary bracings must be shown in the Shop Drawings.	
C3	The Contractor shall prepare plan showing width and level of access, level of prepared working area for site traffic and plant movements, and areas available for temporary storage.	
C4	Unless required and approved by the S.O. otherwise, all welding works shall to be done at ground level.	
D	**CERTIFICATION OF COMPLETION**	
D1	The Contractor shall certify that he/she has made all the necessary inspections to ensure all steelworks and the corresponding connections has been erected and constructed in accordance with the work's drawings, specification and contract requirements.	

Saya telah menyemak dan bersetuju

……

(Cop & Tandatangan oleh S.O./Wakil S.O.)

Tarikh ……

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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 D: 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 plasticizer 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 D: 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 forty five (45) minutes after mixing.

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

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

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 twenty-four (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..

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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 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 15m^2. On the surface where the concrete is still green, each bay shall not exceed 30m^2. 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 et cetera of tiles, bricks and others so as to produce neat and fit joints.

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 or described in the B.Q., 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..

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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.

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, plasticizer or plasterlime shall be added to the mix in accordance with the manufacturer's instruction.

2.1.2. The plaster shall be applied in two coats generally to a total thickness of 20mm to brickwall and 12mm to soffits, beams, columns, brick-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.

2.2. 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 reach 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 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.

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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 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..

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 ten (10) minutes after mixing and is complete in about forty-five (45) minutes; but not fully set for seventy two (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.

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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, creates 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.

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 F: SEWERAGE.

3. Paving Work

3.1. Cement Paving

3.1.1. Unless otherwise shown on the Drawings or described in the B.Q., 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 apron shall finish to a slight fall towards surface drains.

3.1.2. Unless otherwise shown on the Drawings or described in the B.Q., skirtings shall be formed to a height of 150mm and thickness of 20mm, coved 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.

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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.

3.2.4. Unless otherwise shown on the Drawings or described in the B.Q., 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 of 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 in vertically on edge into the screed to form panels. Each panel shall not exceed $4m^2$ 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 to the manufacturer's recommendation onto the terrazzo surface to prevent future staining.

3.3.6. Unless otherwise shown on the Drawings or described in the B.Q., 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 of treads and risers to the approval of the S.O..

3.4. Waterproof Paving to Roof Slabs

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

3.5. Precast Concrete Paving

3.5.1. Unless otherwise shown on the Drawings or described in the B.Q., 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.

3.6. 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 good sub-grade.

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.

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 D: 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 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.

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3.8.2. The bricks shall be soaked as specified in SECTION E: 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 founded on properly compacted and blinded 100mm thick hardcore. The joints shall be filled with cement mortar (1:2) and finish flush.

4. Tiling Work

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 BIa] also referred to as heavy duty tiles shall comply with MS ISO 13006 and the size shall be tiles 300mm x 300mm.

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 BIa or, BIb] shall be vitreous hard wearing non-slip glazed complying with MS ISO 13006 and the tile size shall be 300mm x 300mm.

4.1.6. Unless otherwise specified in the Drawings or described in the B.Q., 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 standard manufacture from the same material to match flooring. 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.

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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 BIb or BIIa] 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 BIa or BIb] 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 BIa] 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.

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 thirty (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 BIIb and BIII require this saturation treatment; soaking of tiles of Group BIa, 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 installation 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

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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 centers horizontally and vertically; and

4.1.18.5. Where stresses are likely to be concentrated, for example at changes of alignment.

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/m^2, 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 500m^2 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/mm^2 for walls with cement: sand mortar bedding or 1.0N/mm^2 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..

4.2. 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 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 or described in the B.Q., all skirting shall be 100mm high to match floor tiling. The tiles at the bottom of the skirting shall be set at 45^0 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: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 13007-1. The selection and application of tile grouts for mosaic installations on walls and floors shall comply with MS ISO 13007-3.

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

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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 2 m 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 forty-eight (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-leveling 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.

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 eight (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

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the wall surfaces, the top of the covering is to be finished with PVC capping seal. This should be adhered to the wall surface approximately 100mm-150mm high prior to self-coving floor covering. The material is than 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 joint in conjuction with the surface of the wall finishes. It is recommended that the aluminium trim to be screwed on the wall surface.

4.5.10. Where area of excessive spillages of water, it is important that a watertight joint be achieved at 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 H: 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 suitable sanding machine. Any misaligned or defective timber strip shall be adjusted or replaced.

4.6.3. Unless otherwise shown on the Drawings or described in the B.Q., 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 (2) 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.

4.6.4. 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.

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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 H: 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 suitable sanding machine. Any misaligned or defective parquet shall be adjusted or replaced.

4.7.3. Unless otherwise shown on the Drawings or described in the B.Q., 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 (2) 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.

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 shall be bedded with cement: 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 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.

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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 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, 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 homogenous-heterogeneous type and specified in accordance to 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 environment.

4.10.1.3. Vinyl Type 3: Anti-slip to cater for wet areas as well as slippery areas.

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 sheet shall have Polyurethane Reinforced (PUR) surface treatment for easy maintenance.

4.10.4. Colours and patterns of vinyl flooring shall be to the PD's concurrence. 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. Vinyl sheets shall be installed onto floor flatness tolerance of not more than $\pm$ 3mm for every 3 m length floor area ready to receive vinyl flooring. Self-levelling compound of approved quality to be installed before

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finishing with vinyl flooring. The flatness tolerance shall strictly adhere to 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 of the proposed type of vinyl flooring.

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 P.D.'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.

4.11. Indoor Sport Floors - Cushion PVC Sport Flooring

4.11.1. Unless otherwise specified on the Drawings, multi purposed 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 of surface layer with protecsol treated, calendered and grained 100% PVC sheet.

4.11.3. Its reinforced by 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 Absoprtion (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

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4.11.4. Cushion PVC flooring sheets shall comply with approved or accredited by major sport federations, namely BWF, FIBA, ITTF, AFC, FIVB, 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 contaminated 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 underlting 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 2 meter straight edge.

4.11.6. The floor covering should be underlayment 5mm self levelling compound (eg. CL 11 or NC146) with Primer and applied in accordance with manufacturer's instruction. The tensile Bending strength after 28 days is 6N/mm2 and Compressive Strenght after 28 days is 30N/mm2. Self levelling compound shall complied with green label certification.

4.11.7. The top of the covering is finished with Damp Proof Membrane (For Ground floor only) (eg. 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 on 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 (eg. 3M Scotchgard™) 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 on 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.

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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. The carpets shall be installed in largest practical pieces and salvage shall be trimmed as required to assure color uniformity and pattern match at seams. All carpet shall have its edges trimmed and neatly fitted around all perimeters, openings and obstructions.

5.1.11. The carpets shall be installed in largest practical pieces and salvage shall be trimmed as required to assure color uniformity and pattern match at seams. All carpet shall have its edges trimmed and neatly fitted around all perimeters, openings and obstructions.

5.1.12. Warranty minimum 2 years on manufacturing defect. 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 on 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 18 oz per sq yard pile weight (normal traffic area), minimum 24 oz per sq yard pile weight (heavy traffic area).

5.2.1.2. Broadloom carpets shall be coated with protective coating (eg. 3M Scotchgard™) 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 on the Drawings, all carpets shall be laid with 6mm thick rubber-crumb underlay.

5.2.1.4. Unless otherwise specified on the Drawings, wall edges shall be with approved 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.

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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. The carpets shall be installed in largest practical pieces and salvage shall be trimmed as required to assure color uniformity and pattern match at seams. All carpet shall have its edges trimmed and neatly fitted around all perimeters, openings and obstructions.

5.2.1.9. 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 defect. Supply and install by approved installer by manufacturer.

5.2.2. Axminster Carpet

5.2.2.1. Unless otherwise specified on 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 32 oz per sq yard pile weight (normal traffic area), minimum 42 oz per sq yard pile weight (heavy traffic area).

5.2.2.2. Broadloom carpets shall be coated with protective coating (eg. 3M Scotchgard™) 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 on the Drawings, all carpets shall be laid with 6mm thick rubber-crumb underlay.

5.2.2.4. Unless otherwise specified on the Drawings, wall edges shall be with approved 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. The carpets shall be installed in largest practical pieces and salvage shall be trimmed as required to assure color 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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5.2.2.9. 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 defect. Supply and install by approved installer by manufacturer.

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1. General

The water reticulation and internal cold water plumbing works shall be executed by personnel with valid permits issued by SPAN as stipulated under Water Service Industry Act 2006. The Contractor shall be responsible for employing such personnel and all the work performed by them.

2. Products and Materials

2.1. All products and materials to be incorporated in the work shall be new and unused. Materials to be used within the scope of work shall be those approved by SPAN. When the quality of a material or process is not specifically set forth in the approved products and materials list, the Drawings, or the Specifications, the best available quality of the material or process shall be provided, subject to the approval of the S.O..

2.2. All products and materials shall be supplied by suppliers registered with SPAN. The Contractor shall provide proof to the S.O. in the form of a valid Confirmation Letter or Certificate of Registration issued by SPAN to the supplier. The products and materials shall also be subjected to other terms and conditions mentioned in these specifications.

2.3. All products and materials shall be of the makes and models tested and approved for use. It is the Contractor's responsibility to verify that products and materials received for the job conform to the current approved products and materials supplied by SPAN registered suppliers.

2.4. All products and materials furnished shall be subject to inspection for compliance with these specifications and all other appropriate specifications. The Contractor shall make application to the S.O. for inspection at least five (5) days in advance of starting any work.

3. Inspection

The S.O. shall at all times have access to the work wherever it is in preparation or progress and the Contractor shall provide proper facilities for such access and for inspection. The Contractor shall provide safe means to inspect the work. Failure or oversight of the S.O. or his representative to reject defective materials at the time of use, or to reject improper work at the time it is performed, shall not diminish the Contractor's obligations to comply with Drawings and Specifications. The Contractor shall remove and replace any faulty materials and work at no additional cost to the Government upon discovery of the defects or upon receipt of notice from the S.O. to do so.

4. Water Reticulation

4.1. Setting Out

All setting out for pipe laying works shall be performed by the Contractor's surveyor. Generally, stakes for alignment and grade shall be set at 10m intervals. The survey shall conform to the lines, grades, and dimensions shown on the Drawings. The Contractor shall preserve all monuments, benchmarks, survey markers and stakes. In case of their removal or destruction by the Contractor or his employees, agents or subcontractors, the Contractor shall be liable for the cost of their replacement.

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4.2. Excavation

4.2.1. General

All general excavation works shall be as specified in SECTION B: EXCAVATION AND EARTHWORKS.

4.2.2. Excavation for Pipe Trenches

4.2.2.1. Before commencing the excavation of pipe trenches, the routes of the pipelines shall be pegged out accurately. Strong sight rails shall be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary but not exceeding 100m apart. On these rails shall be marked the centre line and level to which the pipes are to be laid, and such rails shall be maintained in position and at the correct level from the time the excavation commences until backfilling is completed. The run of pipe trenches opened up ahead of pipe laying operations at any one time shall not be more than:

(i) 100m if the pipe laying operations are in an urban area,

(ii) 300m if the pipe laying operations are in the side tables of a trunk road, or

(iii) 600m if the pipe laying operations are in unoccupied land schemes or housing estates under development or are in the side tables of minor rural roads.

4.2.2.2. The S.O. may, at his absolute discretion, vary the distances stated above if he considers that traffic, road, weather or physical conditions warrant the variation.

4.2.2.3. Unless the S.O. permits otherwise, the trenches shall be excavated to the widths given in **TABLE L1**.

Table L1. Width of Pipe Trenches

External Pipe Diameter (D)	Width of Trench
Not exceeding 500mm	D+300mm
Exceeding 500mm	D+600mm

4.2.2.4. Where pipes are to be laid on a concrete bed, the width of the excavation at the bottom of the trench shall be the width of the underside of the concrete bed. At all joints the trench shall be so excavated as to give a working space of not less than 300mm all around the joint. Where bends are made by deflecting pipes at joints the trench shall be widen to permit this operation. The sides of the trench shall be cut vertical, and where necessary, shall be protected against caving in by timbering to the approval of the S.O..

4.2.2.5. The trench shall be excavated to the depths intended or shown in the Drawings and shall be finished and trimmed accurately to level and grade.

4.2.2.6. Should the ground be so wet or soft that, in the opinion of the S.O., it does not form a firm base for the pipe, or should rock be encountered at the bottom of the trench, the trench shall be

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excavated 250mm below the level intended or shown in the Drawings and then brought back to the correct level with good selected earth or sand well rammed into place. Such deepening of pipe trench and filling back shall be treated as a variation under the terms of the Contract. Should the bottom of the trench be inadvertently excavated below the specified level, it shall be brought back, at the Contractor's expense, to the correct level with good selected earth or sand carefully rammed into place.

4.2.3. Excavation of Road Crossings

4.2.3.1. No trench is to be excavated in the carriageway unless specific approval has been given by the relevant road authority. The whole operation of excavation and reinstatement of the trench shall be completed as quickly as possible. The Contractor shall ensure that minimum interference to traffic flow is maintained at all times.

4.2.3.2. A joint site inspection shall be arranged by the Contractor before commencement of work if so requested by the road authority. After pegging out, the Contractor shall inform the road authority and the police of the actual date of commencement at least one week in advance of and on the day of commencement.

4.2.3.3. If specific approval has been given to lay services across the road by open excavation, proper cutting of the metalled pavement shall be done and the Contractor shall ensure that the top edges of the excavation are neat and straight.

4.2.3.4. All materials from the excavation, if accepted for backfilling shall be neatly stacked outside the carriageway. Where there is no place to stack the excavated materials outside the carriageway, shall excavated materials shall be removed from the work site immediately after excavation.

4.2.3.5. Where specific approval has been given by the road authority for half width construction, the traffic lanes may be reduced to not less than 5.0m wide and where necessary, the shoulder should be strengthened to accommodate traffic load to the satisfaction of the S.O. by the Contractor and at the Contractor's cost.

4.2.3.6. Trenches shall be provided with adequate shuttering, walling and struts to prevent the adjoining road pavement from cracking and subsiding.

4.2.3.7. If a road diversion is required, the Contractor shall build it to the specifications of the road authority. It shall be maintained in good motorable condition until the reinstatement is completed.

4.2.3.8. Carriageway excavation across important and busy road and junctions shall be carried out during off-peak hours. The S.O. shall specify the appropriate times based on the merits of each case and such conditions shall be strictly adhered to by the Contractor.

4.2.4. Excavation of Rock in Trench

Rock shall mean those geological strata of hard material which necessitates the use of blasting or approved pneumatic tools for their

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removal. Solid boulders found in trench excavations and foundation pits shall be considered as rock if such boulders are of size each exceeding 0.08m³. Shale and clay boulders shall not be classified as rock. The S.O.'s decision as to whether or not the material of the excavation is to be classified as rock shall be final. The Contractor shall be entitled to extra payment for rock excavation only if reasonable notice is given to the S.O. to examine and measure such material prior to breaking up. The volume of rock excavated shall be taken as its volume in-situ before it is broken up.

4.2.5. Pipe Bedding

The pipe bedding and foundation shall be prepared according to the Drawings. No pipes shall be laid until the S.O. has inspected and approved the pipe bedding and foundation. Any work that has been carried out without the approval of the S.O. shall, on the instructions of the S.O., be uncovered or removed by the Contractor and reinstated to the S.O.'s approval at the Contractor's own expense

4.2.6. Crossing Water Courses

Where the pipeline crosses underneath streams, culverts and other water courses, the Contractor shall be deemed to have allowed for all additional measures necessary for the proper construction of the pipeline especially maintaining the flow of water.

4.2.7. Backfilling of Pipe Trenches

4.2.7.1. After the pipe laying has been approved by the S.O. and before the pipelines are tested, sufficient backfilling of the trenches will be permitted to prevent "snaking" and to maintain the pipes in position, but all joints shall be left exposed. In any other locality where the trench may be filled with water and cause flotation of the pipes, or elsewhere as may be decided by the S.O. the backfilling shall follow the pipe alignment as closely as possible.

4.2.7.2. In backfilling pipe trenches, only approved materials free from stones or rocks or other hard materials shall be carefully spread along the trench bottom between the pipes and the trench walls to a depth of about 150mm and shall be hand rammed. Further layers each of about 150mm thick of the same materials shall then be spread and rammed in the same manner up to the top of the pipes. The remainder of the backfilling may consist of coarse materials free from boulders and large earth clods. It shall be placed in layers each of 150mm thickness and hand or mechanically rammed until the backfill is 300mm above the top of the pipes. The rest of the trench backfill shall be in layers each of 300mm thickness and compacted by a mechanical vibrating tamper to finish off slightly proud of the surrounding ground. The degree of compaction of each layer shall not be less than 95 % of the dry density obtainable using the BS 1377 Compaction Test. The Contractor shall make good any settlement to avoid formation of drains or gullies within the refilled trenches.

4.2.7.3. Approved fill material to be used as backfill to the top of the pipes shall be uniform low plasticity granular material. The material shall be free from all organic or other materials subject to decay. Highly plastic or expansive soils or clay shall not be used. The filling material shall be readily compactable to its maximum density and must not form mud, or otherwise breakdown when wet.

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4.2.7.4. Should the material being placed as fill or backfill while acceptable at the time of selection, become unacceptable to the S.O. due to exposure to weather conditions or due to flooding or have become puddled, soft or segregated during the progress of the works, the Contractor shall, at his own expense, remove such damaged, softened or segregated material and replaced it with fresh approved material.

4.2.7.5. Where the pipeline crosses a road, approved sand shall be used as fill material up to the road formation level.

4.2.8. Backfilling of Excavations Other Than Pipe Trenches

4.2.8.1. Backfilling of all excavations shall not be carried out until the Works therein have been inspected and approved by the S.O.. In backfilling excavations other than pipe trench excavations, portions of the excavated materials may be used with the approval of the S.O.. Where required, approved materials shall be brought to the site for backfilling works. The materials shall be deposited and spread in layers of not more than 300mm deep, and each layer shall be thoroughly rammed by a mechanical vibrating tamper or smooth wheel roller and watered if required.

4.2.8.2. If so directed by the S.O., the backfilling shall be finished off slightly proud of the surrounding ground to allow for settlement, but the Contractor shall make good any settlement which may occur during the construction of the Works and during the Defects Liability Period of the Contract at his own expense.

4.2.9. Road Reinstatement

4.2.9.1. Road reinstatement works shall be carried out by the Contractor to a standard equivalent or superior to the road condition existing prior to excavation and to the requirements of the relevant road authority and approval of the S.O..

4.2.9.2. All backfilling shall be done by the Contractor with approved sand. No organic soil, broken pre-mix or stones are to be used. The sand shall be compacted in 225mm layers. The degree of compaction of each layer below the pavement course shall not be less than 95% of the dry density obtainable using the BS 1377 Compaction Test. The Contractor shall bear the cost of such tests and shall make good any works which are found to be unsatisfactory.

4.2.9.3. Sand material shall be deposited in layers on both sides of the pipe simultaneously and thoroughly compacted and around the pipe working alternately on either side of the pipe until the trench has been filled up to the base course formation level.

4.2.9.4. The Contractor shall reinstate the road pavement by replacing, in the proper sequence, any block or metalling removed, to the requirements of the relevant road authority and the approval of the S.O.. The road surface shall be reinstated with new materials of the type existing on site. Edges of the reinstated road pavement shall be straight and neatly finished to match the existing road to the satisfaction of the S.O..

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4.2.9.5. In the absence of any written requirement, all reinstatement works shall be carried out within 24 hours after backfilling.

4.2.9.6. If the Contractor fails to carry out the reinstatement to the requirements of the relevant road authority and the satisfaction of the S.O., the S.O. or the relevant authority may proceed with such repairs and the cost of such reinstatement shall be recouped by the S.O. from the Contractor.

4.3. Pipeworks

4.3.1. Handling and Laying Pipelines

All handling, laying and testing of pipelines shall comply to the latest technical specifications from SPAN or other relevant standards and also to the manufacturer's requirements:

4.3.1.1 The minimum cover for main pipelines shall be 1m. Under roads and hard standing the cover shall be 1.2m. Otherwise the pipes shall be encased with concrete grade 20P with minimum thickness of 150mm or as approved by the S.O..

4.3.1.2 The section of pipe line that runs across roads and culverts shall be made from Ductile Iron pipe (D.I) or mild steel pipe as approved by the local Water Authority.

4.3.2. Testing of Pipelines

4.3.2.1. The Contractor shall provide all water required for filling, testing and retesting the pipelines, and any pumps, pipework fittings and pressure gauges required for the purpose.

4.3.2.2. Whenever a section (which shall not exceed 1000m long in or adjacent to roads, or not exceeding 2000m long in open ground) of any pipeline has been laid, jointed and part backfilled as specified, it shall be prepared for testing by sealing the open ends temporarily with stop ends. The stop ends shall be of cast iron or steel. The stop end at the lower end of the section of the pipeline shall be fitted with a valved inlet pipe for use to fill the section of the pipeline with water and the stop end at the higher end of the section of the pipeline shall be fitted with a valved air release vent pipe. A pressure gauge shall be connected to the valved inlet pipe. The pressure gauge shall have a dial of not less than 150mm dia. and graduated to read up to 15 bars with 0.25 bar graduations. All pressure gauges shall be tested by the S.O. before use, and provisions shall be made for connecting the pressure gauge, if the S.O. so elects, to the valved inlet pipe.

4.3.2.3. The stop ends shall be braced to the satisfaction of the S.O. to withstand the end thrust which develops from water pressure. All weight, thrust and anchor blocks intended to prevent the vertical and lateral displacement of the pipes and specials shall have been properly completed and have attained an adequate strength before the tests are carried out. When gentle curves are effected by deflection pipes these pipes shall be securely packed with backfill to prevent movement.

4.3.2.4. The section of the pipeline to be tested shall be filled with water of fair quality, free from sediment and from a source approved by the

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S.O.. The water shall be introduced into the section of the pipeline through the valved inlet in the stop end at the lower end of the section. During filling, provision shall be made for the air to escape from all high spots in the section by properly installing all air valves and from the air released vent pipe in the stop end at the higher end of the section.The pressure/strength test shall be carried out first. Each section of the pipelines shall be tested to a pressure of 16.0 bars head of water.

4.3.2.5. After the section of the pipeline has been filled with water for a period of not less than seven (7) days, more water shall be pumped into the section to raise the pressure slowly in increments of 10m head of water with pause of one minute between each increment.

4.3.2.6. Should any appreciable drop in pressure be noted during one of these pauses the test shall be stopped until the cause of the pressure drop has been investigated and rectified. An engine driven pump may be used until 55m head pressure is attained, and thereafter only a hand operated pump shall be used.

4.3.2.7. The pressure/strength test shall be considered to have been passed when the pressure gauge shows no reduction in pressure during the specified one minute pause and also during the period of ten (10) minutes after full test pressure has been attained. If these conditions are not satisfied a thorough inspection of the section of the pipeline shall be made. All defects shall be repaired and the test shall be repeated.

4.3.2.8. The leakage test shall then follow. The pressure shall be reduced to 10.5 bars head of water and shall be maintained as constant as possible for a period of 24 hours. Make-up water shall be pumped into the section of the pipeline from time to time to maintain this pressure. The leakage test shall be considered to have been passed if the make-up water pumped into the section of the pipeline does not exceed the allowable leakage calculated as: 0.05l/mm of internal diameter per kilometer of pipe per 24 hours. If this specified rate of leakage is exceeded a thorough inspection of the section of the pipeline shall be made. All leaks discovered shall be repaired and the section shall be tested again.

4.3.2.9. Every section pipeline shall be tested as described above in the presence of the S.O.. Testing may be carried out between sluice valves but not against the gates of the sluice valves.

4.3.2.10. All permanent thrust block provided at bends shall be concreted and sufficiently cured prior to permission being given for testing. No temporary strutting or temporary bracing will be permitted in lieu of the permanent thrust blocks as the tests are also to subject these blocks to the transmitted pressures.

4.3.3. Flushing and Disinfecting Pipelines

When the final connections have been made and the pipeline has been tested to the satisfaction of the S.O. it shall be thoroughly cleaned, disinfected and flushed in sections by the Contractor. Water for this purpose shall be obtained from the Local Water Authority and the Contractor shall pay all the charges incurred in connection therewith.

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4.3.4. Non-Precast Valve chambers

4.3.4.1. Valve chambers shall be constructed to the size shown on the Drawings. Unless otherwise specified, all dimensions on plan shall be inside measurement. Manhole covers shall comply with BS EN 124.

4.3.4.2. Unless otherwise shown in the Drawings all manholes and chambers shall be brickwork in cement mortar 1:2. The brickwork shall be constructed on prescribed concrete mix Grade 20P foundation unless shown otherwise. The thicknesses and sizes shall be as shown on the Drawings. The inside of the chambers and manholes shall be lined with 12mm thick cement plaster (1:2). Externally, the exposed concrete or block brick surfaces shall be plastered with 12mm cement mortar (1:2) and terminated 150mm below the finished ground level. All internal angles shall be rounded off. Manholes and chambers shall provided with precast concrete cover unless otherwise specified on the Drawings. Approved typed wrought iron steps shall be built into the brick wall of all manholes and chambers of depth 2.0m or more and they shall be spaced not more than 300mm apart projecting 100mm over face of wall.

4.3.5. Precast Chambers

Precast valve chambers shall be as shown on the Drawings and in accordance with SECTION D: CONCRETING. Chamber covers shall comply with BS EN 124.

4.3.6. Washout (Scour Valves Location)

Washouts shall be constructed at locations specified in the Drawings or as may be directed by the S.O.. The washout branches shall be connected to the pipeline by special washout tees and sluice valves. From the washout sluice valves HDPE pipes shall be laid to the nearest drain or stream. The discharge point shall be downstream.

4.3.7. Indicator Post (Pipe and Valve Markers)

The Contractor shall provide and fix indicator posts close to the centre line of pipes, at valves, washout and other points as directed by the S.O.. The details of indicator posts are as shown on the Drawings.

4.3.8. Hot Tapping

4.3.8.1. The Contractor shall submit a method statement as how to conduct the hot tap that has been approved by the State Water Authorities to the S.O. prior to commencement of the works.

4.3.8.2. Hot tapping shall only be done in the presence of the State Water Authorities' representative. The tapping mechanism shall be of the self-purging type so that cutting chips are removed from the tapping machine and do not enter the pipeline.

4.3.8.3. All hot tap connections to existing pipelines, whether for mainline extension or service laterals, shall be performed by an authorised and qualified person.

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4.3.8.4. The tapping machine shall be cleaned and disinfected prior to attachment to the tapping valve and saddle.

4.3.9. Pipe Jacking

4.3.9.1. Placement of pipe by boring or jacking methods requires special S.O.'s approval for each instance. The methods and equipment used in boring and jacking operations shall be optional to the contractor, provided that the S.O. reviews them prior to any work.

4.3.9.2. The Contractor shall submit a method statement as how to conduct the pipe jacking operation to the S.O. for approval.

4.4. External Water Storage Tanks (Factory Fabricated Tanks)

4.4.1. The Contractor shall supply a new tank reservoir from a manufacturer specializing in the design, fabrication and erection of the approved water storage tanks.

4.4.2. The type of tanks that may be supplied and installed shall be only as shown in **Table L2**.

Table L2. Type of Water Storage Tank

No	Product Name	Specified conditions/ Requirements
1	Steel Tank with Lining or Coating (Non-Corrugated Type) (Glass Fused/Glass Coated/Epoxy Lining/HDPE) Lining	Maximum capacity allowed for elevated tanks is 2.3ML (500,000 gallons) and for ground storage tanks is 3.4ML (750,000 gallons). Maximum height allowed is 5m or 4 panels high whichever is lower. The minimum warranty period for the tank and sealant/lining shall be 10 years. The minimum thickness of PE/HDPE lining shall be 2.0mm.
2	Cylindrical Steel Tank - Double Fold System	Maximum capacity allowed is 4.5ML (1,000,000 gallons). Maximum height allowed is 5m. The minimum warranty period for the tank and sealant/lining shall be ten (10) years.
3	Polyethylene Storage Tanks (PE Storage Tanks)	Tanks shall have interlocking mechanisms. Tanks shall only be allowed up to 3,785.4L (1,000 gallons) capacity only. Multiple tanks on one tower structure shall be strictly not allowed.

4.4.3. The tank shown on the Drawings and specified herein shall be fabricated, supplied and installed by a manufacturer with a valid registration with SPAN.

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4.4.4. Installation of the tank shall be by the tank manufacturer or approved installer appointed by the manufacturer. The manufacturer shall be fully responsible for entire installation including tank erection, and the ultimate water tightness of the complete installation. Notwithstanding the above, the Contractor shall be fully responsible for the entire installation and completion of the final product.

4.4.5. Construction shall be governed by the Contract Drawings and specifications showing general dimensions

4.4.6. The water tank inclusive of all associated pipeworks shall be cleaned on completion, tested for watertightness and disinfected before it is commissioned.

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1. General

1.1. This section gives overview of Rainwater Harvesting System and describes its key components.

1.1 The rainwater harvesting system is an alternative to reduce the domestic water consumption in a building.

1.2 The Contractor shall comply with all relevant statutory requirement and regulations.

1.3 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 to 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 L: 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 rain water 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 L: 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 as described in *VOLUME 2: ELECTRICAL WORKS*.

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.

3.2. The rainwater harvesting system which is located outside the building shall fall under civil scope.

4. Rainwater Goods

4.1. Flashing

4.1.1. Unless otherwise shown in 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 in 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. Unplasticised Polyvinyl Chloride 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 M.S. 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 on 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.

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

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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 trap and everything else required.

4.3.1.2. Outlets in 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 Superintending Officer (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 L: WATER RETICULATION and SECTION X: INTERNAL COLD WATER AND SANITARY PLUMBING SYSTEM.

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1. General

1.1. 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..

1.2. 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 N/1**.

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 and 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

3.1. Glass thickness indicated on the Drawings and specified within this standard specification are the minimum thicknesses required. The Contractor shall confirm glass thicknesses by analyzing Project Loads and In-Service conditions. The glass units provided for the various sized openings, thicknesses and strengths, shall meet or exceed the following criteria:

3.1.1. Glass deflection shall be limited to the lesser of 1:200 or the flexure limits of glass with full recovery of glazing materials.

3.1.2. If not tested and accepted in advance the Contractor shall submit a certificate to confirm compliance with the above stated requirement.

4. Glazing

4.1. All doors and windows, et cetera 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 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.

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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.

6. Safety Glass

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

6.1.1. Tempered Glass

A single piece's 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 two or more layer of glass with one 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 SIRIM standard and JBPM approval. Wire glass which 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 of both in visible and infra-red (light and heat) range of the

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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/sq.m.K for 6mm thickness.

8. Low Emission Glass

8.1. Low-E glass units shall be permanently marked with appropriate certification label of the SIRIM Ecolabel.

8.2. The minimum U-Value for tropical design shall be 0.65W/sq.m.k for 6mm thick (6mm air space) to 0.56 w/sq.m.k for 6mm thick (12.9mm air space). This glass shall be used as safety fire rated glass for door and window.

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 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 H: 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.

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

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headed galvanized 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 frame 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 to the manufacturers' instructions.

13.3. The Contractor shall submit method statement 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.

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 be filled with non-hardening compound and finished with detailed in the Drawings or as approved by the S.O..

15.4. Approved expanded metal reinforcement shall be provided at every forth course. Unless otherwise or 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.

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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 on to 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 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.

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 N/1

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 eg. Front doors, display etc.
4.	Grey/Tinted Figured Glass	5	• Windows • Furniture, display bases, house fittings, partitions etc. • Decoration eg. 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.
		15	• Curtain wall of high-rise building, airport.
6.	Laminated Glass	6	• Skylights, glass roofs and the like • High security places eg. Burglar resistant showcases and the like. • Places where safety necessary eg. 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
		10	• Vertical/sloped glazing, building facade
11	Double glaze Glass	4	• Laboratories window/door. • Server room, external window, cool storage, train window.
		8	• Sound proof window/ acoustic window

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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 paints/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 conform 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 three (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 five (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 O/1 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 specification and manufacturer's instructions.

1.3. 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.

1.4. Paints shall not be adulterated and any paint that has deteriorated shall not be used and shall be removed from the Site forthwith.

1.5. Unless otherwise specified in the Drawings, the types of paints to be sued for the work on exposed surfaces shall be as stated in the `Schedule of Paint Finish' attached hereinafter.

1.6. The colours and tints of paints shall be selected by the S.O. and the priming, undercoats and finishing coats shall be of approved differing tints and shall be obtained from the same manufacturer.

1.7. No painting shall be done under conditions which may jeopardize the quality of finish paintwork.

1.8. During painting, care shall be taken to prevent stain or damage to other works.

1.9. 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.

1.10. 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.

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1.11. All priming to shop fabricated components shall be done at shop.

1.12. All prime surfaces shall be inspected and approved by the S.O. before commencement of painting works.

1.13. Finish surfaces shall be uniform in finish and colour and be free from brush marks or other defects.

1.14. 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, et cetera 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 undercoat (alkyd undercoat) and shall be finished with two 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 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 sand paper 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 sand paper to the approval of the S.O.. Then one 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 coat aluminum 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 sand paper 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 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 Galvanized Ironwork

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

3.4. Repainting Existing Galvanized Ironwork

3.4.1. Where repainting to existing galvanized ironwork is specified, the following procedure shall be adhered to. If the surface is not corroded, it shall be slightly 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 coat approved metallic primer, unless otherwise specified, shall be finished with two 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 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 base 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 version).

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.

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

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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 drive way 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 sub-station 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 sand paper 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 sand paper 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.

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.

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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

10.1. 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 aluminum 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 sand paper. 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.

12. Varnishing

12.1. Varnishing to New Timberwork

12.1.1. The surfaces to be varnished shall be smoothened with fine sand paper 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 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

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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 gloss 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 or described in the B.Q., the surface shall first be thoroughly scuffed to remove the existing varnish. The surface shall then be smoothened with fine sand paper, 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 to 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 resisting acrylic wall sealer, followed with two (2) coats of low volatile organic compounds (VOCs), alkylphenolethoxylate (APEO) free, formaldehyde free acrylic premium emulsion paint of approved colour applied strictly in accordance to manufacturer's instruction.

13.3. Mild steel shall be applied with one (1) coat of zinc rich epoxy, one (1) coat of surface tolerance epoxy mastic and followed with two (2) coats of polyurethane topcoat.

13.4. Galvanized steel shall be applied with one (1) coat of surface tolerance epoxy mastic and followed with two (2) coats of polyurethane topcoat.

13.5. Roofing sheet coatings for marine environment 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..

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 to 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.

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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.

14.5. Painting to Health Facility (Ministry of Health) Buildings shall also adhere to *Garis Panduan Skema Warna Luaran Bangunan Fasiliti Kesihatan* KKM.

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 O/1

PAINT PERFORMANCE WARRANTY (SPECIMEN)

1. Coverage of Performance Warranty

We …..…….. the paint Manufacturer hereby warrants that for a period of **five (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 micro-organisms 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.

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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 falls 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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1. General

1.1. The construction of roads and hardstanding shall generally be carried out only after completion of all drainage systems, services and ducts which may affect the Works, unless otherwise agreed by the S.O..

2. Flexible Pavement

2.1. Subgrade

2.1.1. Subgrade means that part of the embankment or existing ground in cutting which is immediately below the sub-base or lower sub-base of the road pavement and shoulders.

2.1.2. Material for the top 300mm of subgrade shall have a minimum soaked laboratory California Bearing Ratio (CBR) as shown on the Drawing when compacted to 95% of the maximum dry density determined in the *MS 1056* Compaction Test (4.5kg Rammer Method). In the event CBR value not mentioned on the Drawing, a minimum CBR value of 10% shall be adopted.

2.1.3. Throughout the top 300mm of subgrade, the materials shall be compacted to not less than 95% of the maximum dry density determined in the *MS 1056* Compaction Test (4.5kg Rammer Method).

2.1.4. In cut area, the top 300mm of the subgrade shall be scarified and recompacted to 95% of the maximum dry density determined in the *MS 1056* Compaction Test (4.5kg Rammer Method). If the S.O. is fully satisfied that the subgrade in its natural state possesses a density exceeding the requirements, then the surface of the subgrade shall be trimmed and rolled to obtain a smooth finish.

2.1.5. Where the material in cut area is found to be unsuitable for use in the top 300mm of subgrade or to a suitable level to be determined by the S.O., it shall be removed and replaced with suitable material which shall be compacted as indicated above. Alternatively, stabilizing agent may be used subjected to the S.O.'s approval.

2.1.6. The subgrade shall be finished in a neat and workmanlike manner, and the widths of embankments and cuts shall be everywhere at least of those specified or shown in the Drawings on both sides of the centre line. The top surface of the subgrade shall have the required shape, superelevation, levels and grades and shall be finished everywhere to within + 10mm and - 30mm of the required level.

2.1.7. Where subgrade construction encounters rock surfaces:

2.1.7.1. Rock surfaces extend over the whole width of the formation:

The rock surface shall be trimmed to a free draining profile, at or below formation levels. No high spot shall protrude above the formation level. Any voids or cavities more than 0.5m below the formation level shall be filled up with approved crusher run, gravel or lean concrete having cube strength greater than C8/10N/mm^2. The rock surface shall then be brought up to the formation levels with approved crushed rock or gravel, regulated and blinded.

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2.1.7.2. Rock outcrop occurs over part of the formation only:

The rock outcrop shall be cut down to a level not less than 300mm below the formation level. The surface shall then be brought up to level with suitable subgrade material.

2.2. Drainage Layer

2.2.1. This work shall consist of furnishing, placing, compacting and shaping drainage layer on a prepared and accepted subgrade in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections as shown on the Drawings and/or as directed by the S.O..

2.2.2. Coarse aggregate shall be screened crushed hard rock and fine aggregate shall be screened quarry dust or sand. The aggregate shall be well graded and lie within the limits as shown in **Table P1.**

Table P1. Gradation Limits for Drainage Layer

B.S. Sieve Size (mm)	Percentage Passing by Weight
75.0	100
37.5	75 - 100
20.0	60 - 90
10.0	25 - 75
5.0	10 - 45
2.00	0 - 20
1.18	0 - 10

2.2.3. Notwithstanding any earlier approval of finished subgrade, the surface of the subgrade shall be, on completion of compaction and immediately before placing drainage layer, well closed and free from movement under the compaction plant and from ridges, cracks, loose material, pot holes, ruts or other defects. Any damage to or deterioration of the subgrade shall be made good in accordance with sub-section 2.1..

2.2.4. The material shall be transported, laid and compacted at a moisture content within the range + 1% to - 2% of the optimum moisture content determined in compliance with *BS 5835* and without drying out or segregation.

2.2.5. The drainage layer shall be placed and compacted to the required width and thickness as shown on the Drawings, in one single layer.

2.2.6. The material shall be spread and lightly compacted with tracked spreading plant or other approved equipment with consideration given to the protection of the subgrade.

2.3. Sub-base

2.3.1. This work shall consist of furnishing, placing, compacting and shaping sub-base material on a prepared and accepted subgrade in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections as shown on the Drawings and/or as directed by the S.O..

2.3.2. Sub-base shall be a natural or artificial mixture of locally available materials such as sand, gravel, crushed aggregate, et cetera, free from organic matter, clay lumps and other deleterious materials. It shall be well

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graded and conform to **Table P2** and the following quality requirements:

2.3.2.1. The CBR of the sub-base shall not be less than 30% or as shown on the Drawings when compacted to 95% of the maximum dry density determined in the *BS 1377* Compaction Test (4.5kg rammer method) and soaked for 4 days under a surcharge of 4.5kg. This shall involve carrying out a series of CBR tests at various dry densities, using the field moisture content. The field density must then be measured at a number of points using the sand replacement method and the CBR deduced from the mean of the field density measurements.

2.3.2.2. If more than 10% of the material is retained on the BS Sieve Size 20.0mm, the whole material can be assumed without test to have a CBR value of 30% or more.

2.3.2.3. The plasticity index when tested in accordance with *BS 1377* shall be not more than 12.

2.3.2.4. The 10% fines value when tested in accordance with *MS 30* shall be not less than 30kN.

2.3.2.5. The sand equivalent of aggregate fraction passing the No. 4 (4.75mm) sieve when tested in accordance with *ASTM D 2419* shall be not less than 45%.

Table P2. Gradation Limits for Sub-Base

BS Sieve Size (mm)	Percentage Passing by Weight
75.0	100
37.5	85 - 100
20.0	65 - 100
10.0	45 - 100
5.0	25 - 85
0.600	8 - 45
0.075	0 - 10
The particle size shall be determined by the washing and sieving method of *BS 1377*.	

2.3.3. Prior to placing any sub-base material, the underlying subgrade (particularly the top 300mm of the subgrade) shall have been shaped and compacted in accordance with the provisions of sub-section 2.1. or sub-section 2.2. as appropriate. Notwithstanding any earlier approval of finished subgrade, the surface of the subgrade shall be, on completion of compaction and immediately before placing sub-base layer, well closed and free from movement under the compaction plant and from ridges, cracks, loose material, potholes, ruts or other defects. Any damage to or deterioration of the subgrade shall be made good in accordance with sub-section 2.1..

2.3.4. Sub-base material shall be transported, laid and compacted at a moisture content within the range + 1% to - 2% of the optimum moisture content without drying out or segregation.

2.3.5. Sub-base material shall be placed over the full width of the formation to the required thickness as shown on the Drawings or directed by the S.O. in one layer or more, each layer not exceeding 200mm compacted thickness. Where two or more layers are required, they shall be of

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approximately equal thickness and none shall be less than 100mm compacted thickness.

2.3.6. Each layer of sub-base shall be processed as necessary to bring its moisture content to a uniform level throughout the material suitable for compaction and shall then be compacted using suitable compaction equipment approved by the S.O. to not less than 95% of the maximum dry density determined in the *BS 1377* Compaction Test (4.5kg rammer method). Compaction shall be carried out in a longitudinal direction along the roadbed, and shall generally begin at the outer edge and progress uniformly towards the crown on each side in such a manner that each section receives equal compactive effort, all to the satisfaction of the S.O..

2.3.7. All loose, segregated or other defective areas shall be removed to the full thickness of the layer, and new sub-base material laid and compacted.

2.3.8. The sub-base shall be finished in a neat and workmanlike manner and shall have an average thickness over any 100m length not less than the required thickness. The top surface of the sub-base shall have the required shape, superelevation, levels and grades, and shall be everywhere within the tolerances as specified in sub-section 3.2..

2.4. Crushed Aggregate Roadbase

2.4.1. This work shall consist of furnishing, placing, compacting and shaping crushed aggregate roadbase material on a prepared and accepted subgrade or sub-base in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections as shown on the Drawings and/or as directed by the S.O..

2.4.2. Crushed aggregate roadbase material shall be crushed rock, crushed gravel or a mixture of crushed rock and gravel, which shall be hard, durable, clean and essentially free from clay and other deleterious materials. The material shall conform to the following physical and mechanical quality requirements:

2.4.2.1. The plasticity index when tested in accordance with *BS 1377* shall be not more than 6.

2.4.2.2. The aggregate crushing value when tested in accordance with *MS 30* shall be not more than 25%.

2.4.2.3. The flakiness index when tested in accordance with *MS 30* shall be not more than 25%.

2.4.2.4. The weighted average loss of weight in the magnesium sulfate soundness test (5 cycles) when tested in accordance with *AASHTO Test Method T 104* shall be not more than 18%.

2.4.2.5. The material shall have a CBR value of not less than 80% when compacted to 95% of the maximum dry density determined in the *BS 1377* Compaction Test (4.5kg rammer method) and soaked for 4 days under a surcharge of 4.5kg.

2.4.2.6. The sand equivalent of aggregate fraction passing the No. 4 (4.75mm) sieve when tested in accordance with *ASTM D 2419* shall be not less than 45%.

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2.4.2.7. The gradation shall comply with the envelope as shown in **Table P3.**

Table P3. Gradation Limits for Crushed Aggregate Roadbase

B.S. Sieve Size (mm)	Percentage Passing by Weight
50.0	100
37.5	85 - 100
28.0	70 - 100
20.0	60 - 90
10.0	40 - 65
5.0	30 - 55
2.00	20 - 40
0.425	10 - 25
0.075	2 - 10
The particle size shall be determined by the washing and sieving method of *BS 1377*.	

2.4.3. Prior to placing any crushed aggregate roadbase material, the subbase shall have been constructed in accordance with the provisions of sub-section 2.3..

2.4.4. Crushed aggregate roadbase shall be placed to the required width and thickness as shown on the Drawings or directed by the S.O. in one layer or more, each layer not exceeding 200mm compacted thickness.

2.4.5. Where two or more layers are required, each layer shall be of approximately equal thickness and none shall be less than 100mm compacted thickness.

2.4.6. The material shall be spread using a motor grader of sufficient capacity or other approved mechanical spreader, at the optimum moisture content ± 1%.

2.4.7. Compaction shall be carried out using suitable approved equipment, in a longitudinal direction, and begin at the lower edges and progress towards the crown, or in the case of superelevation towards the upper edge, in such a manner that each section receives equal compactive effort, sufficient to produce a density of not less than 95% of the maximum dry density as determined by *BS 1377: Test 13*.

2.4.8. Throughout the placing, adjustment of moisture content and compaction of crushed aggregate roadbase material, care shall be taken to maintain a uniform gradation of the material and prevent its separation into coarse and fine parts, all to the satisfaction of the S.O..

2.4.9. The crushed aggregate roadbase width shall be everywhere at least that specified or shown on the Drawings on both sides of the centre-line; and its average thickness over any 100m length shall be not less than the required thickness.

2.4.10. The surface of the roadbase shall on completion of compaction and immediately before placing bituminous surfacing be well closed and free from movement under the compaction plant and from ridges, cracks, loose material, pot holes, ruts other defects.

2.4.11. All loose, segregated or otherwise defective areas shall be removed to the full thickness of the layer, and new material laid and compacted. The

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addition of fine material will not be permitted.

2.4.12. The surface shall be to the required level and grade and comply with the tolerances as specified in sub-section 3.2..

2.5. Wet-Mix Roadbase

2.5.1. This works shall consist of furnishing, placing, compacting wet-mix roadbase on a prepared and accepted sub-base in accordance with this Specification and the lines and levels as shown on the Drawings and/or as directed by the S.O..

2.5.2. Aggregate for wet-mix roadbase shall be crushed rock, crushed gravel or a mixture of crushed rock and gravel, which shall be hard, durable, clean and essentially free from clay and other deleterious materials.

2.5.3. The aggregate shall conform to the following physical and mechanical quality requirements:

2.5.3.1. The flakiness index when tested in accordance with *MS 30* shall be not more than 25%.

2.5.3.2. The aggregate crushing value when tested in accordance with *MS 30* shall be not more than 25%.

2.5.3.3. The weighted average loss of weight in the magnesium sulfate soundness test (5 cycles) when tested in accordance with *AASHTO Test Method T 104* shall be not more than 18%.

2.5.3.4. The sand equivalent of aggregate fraction passing the No. 4 (4.75mm) sieve when tested in accordance with *ASTM D 2419* shall be not less than 45%.

2.5.3.5. The gradation shall comply with the limits shown in **Table P4.**

Table P4. Gradation Limit for Wet-Mix Roadbase

B.S. Sieve Size (mm)	Percentage by Weight Passing
50.0	100
37.5	95 - 100
20.0	60 - 80
10.0	40 - 60
5.0	25 - 40
2.36	15 - 30
0.060	8 - 22
0.075	0 - 8
The particle size shall be determined by the washing and sieving method of *BS 1377*.	

2.5.4. Notwithstanding any earlier approval of finished sub-base, prior to placing wet-mix roadbase material, any damage to or deterioration of the sub-base shall be made good in accordance with sub-section 2.3..

2.5.5. Wet-mix roadbase material shall be placed to the required width and thickness as shown on the Drawings or as directed by the S.O. in one layer or more, each layer not exceeding 200mm compacted thickness. Where two or more layers are required, they shall be of approximately

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equal thickness and none shall be less than 100mm compacted thickness.

2.5.6. The material shall be laid using a paving machine at moisture content + 0.5% of the optimum which shall be maintained during the compaction operation.

2.5.7. Compaction shall be carried out using suitable approved equipment in a longitudinal direction, and begin at the lower edges and progress towards the crown, or in the case of superelevation towards the upper edge, in such a manner that each section receives equal compactive effort, sufficient to produce a density of not less than 95% of the maximum dry density as determined by *BS 1377: Test 13.*

2.5.8. Throughout the placing, and compaction of wet-mix roadbase material, care shall be taken to maintain a uniform gradation of the material and prevent its separation into coarse and fine parts.

2.5.9. All loose, segregated or otherwise defective areas shall be removed to the full thickness of the layer, and new wet-mix roadbase material laid and compacted, the addition of fine aggregate only shall not be permitted.

2.5.10. The wet-mix roadbase width shall be everywhere at least that specified or shown on the Drawings on both sides of the centre-line. The average thickness measured over any 100m length shall be not less than shown on the Drawings or specified and the minimum thickness measured at any one point shall be not less than the thickness shown on the drawing or specified **Table P5.**

2.5.11. The surface of the wet-mix roadbase shall, on completion of compaction and immediately before placing bituminous surfacing, be well closed and free from movement under the compaction plant and from ridges, cracks, loose material, pot holes, ruts or other defects.

2.5.12. The surface shall be to the required level and grade and comply with the tolerances specified in sub-section 3.2..

2.6. Bituminous Pavement Courses

2.6.1. Bituminous Prime Coat

2.6.1.1. This work shall consist of the careful and thorough cleaning of the surface of a prepared and accepted unbound roadbase and cement-treated base (CTB), and the furnishing and application to the cleaned roadbase and CTB surface of a bituminous prime coat, all in accordance with this Specification and the lines, dimensions and cross-sections as shown on the Drawings and/or as directed by the S.O..

2.6.1.2. The materials, equipment and construction methods shall be in accordance with *Standard Specification for Roadworks Section 4: Flexible Pavement JKR Specification No. JKR/SPJ/2008-S4.*

2.6.2. Bituminous Tack Coat

2.6.2.1. This work shall consist of the careful and thorough cleaning of the surface of a prepared and accepted bituminous or bitumen primed pavement course, and the furnishing and application to the cleaned surface of a bituminous tack coat prior to the

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construction of an overlying bituminous pavement course, all in accordance with this Specification and the lines, dimensions and cross-sections as shown on the Drawings and/or as required by the S.O..

2.6.2.2. The materials, equipment and construction methods shall be in accordance with *Standard Specification for Roadworks Section 4: Flexible Pavement JKR Specification No. JKR/SPJ/2008-S4.*

2.6.3. Asphaltic Concrete

2.6.3.1. This work shall consist of furnishing, placing, shaping and compacting asphaltic concrete binder course and/or wearing course on a prepared and accepted bituminous or bitumen primed pavement course, and shall include the careful and thorough cleaning of surfaces which are to be covered prior to the application of bituminous prime coat and tack coat. The work shall be carried out all in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections as shown on the Drawings and/or as required by the S.O..

2.6.3.2. The materials, mix design, equipment and construction methods shall be in accordance with JKR Specification No. *JKR/SPJ/2008-S4*.

3. Horizontal Alignment, Surface Levels and Surface Regularity Of Pavement Courses

3.1. Horizontal Alignment

3.1.1. The horizontal alignment shall be determined from the centerline of the pavement surface shown on the Drawings. The edges of the pavement as constructed and all other parallel construction lines shall be correct within a tolerance of + 50mm and - 0mm from the centre-line, except for kerbs, channel blocks and edge lines which shall be laid with a smooth alignment within a tolerance of + 25mm and - 0mm from the centre-line.

3.2. Surface Levels of Pavement Courses

3.2.1. The design levels of pavement courses shall be calculated from the vertical profile, crossfall and pavement course thicknesses shown on the Drawings. Crossfall for hardstanding shall be constructed at a minimum of 2.5% gradient from the highest point of the area or as approved by S.O.. The level of any point on the constructed surface of a pavement course shall be the design level subject to the appropriate tolerances given in **Table P5.**

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Table P5. Tolerances in Surface Levels of Pavement Courses

Pavement Course	Tolerance
Wearing Course	± 5mm
Binder Course	± 5mm
Roadbase	+ 0mm to - 20mm
Sub-base	+ 10mm to - 20mm

3.2.2. The combination of permitted tolerances in the levels of different pavement courses shall not result in a pavement thickness less than that shown on the Drawings. Each pavement course shall have an average thickness not less than that shown on the Drawings.

4. Shoulders

4.1. This work shall consist of furnishing, compacting and shaping earth, gravel or paved shoulder material on a prepared and accepted sub-base or subgrade, all in accordance with this Specification and the lines, levels, grades, dimensions and cross-sections as shown on the Drawings and/or as required by the S.O..

4.2. Materials

4.2.1. Paved Shoulders

The bituminous surfacing and underlying pavement courses shall be constructed as described in the appropriate sections of this Specification.

4.2.2. Gravel Shoulders

Gravel shoulder material shall conform to the requirements for gravel surfacing material set forth in *Standard Specification for Roadworks Section 4: Flexible Pavement JKR Specification No. JKR/SPJ/2008-S4.*

4.2.3. Earth Shoulders

Earth shoulder material shall be suitable material as described in *Standard Specification for Roadworks Section 2: Earthworks JKR Specification No. JKR/SPJ/2013-S2.*

4.2.4. Construction

4.2.4.1. Shoulders shall be constructed in stages or in one operation as directed or approved by the S.O., but in no instance shall a shoulder be built up to a level higher than that part of the abutting carriageway structure which has been completed and accepted.

4.2.4.2. Prior to placing any shoulder material, the underlying sub-base or subgrade shall have been shaped and compacted in accordance with the provisions of *Standard Specification for Roadworks Section 2: Earthworks JKR Specification No. JKR/SPJ/2013-S2*. respectively, and the abutting carriageway structure course or courses shall likewise have been shaped and compacted in accordance with the provisions of the appropriate sub-sections of this Specification. Notwithstanding any earlier approval of the underlying and abutting pavement courses, any

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damage to or deterioration of these underlying and abutting pavement courses shall be made good to the satisfaction of the S.O. before shoulder construction proceeds.

4.2.4.3. Shoulders shall be placed to the required width and thickness as shown on the Drawings or as directed by the S.O. in one layer or more, each layer not exceeding 200mm compacted thickness at the point of maximum thickness. Where two or more layers are required, they shall be of approximately equal shape and thickness, and none shall be less than 100mm compacted thickness at the point of maximum thickness.

4.2.4.4. Each layer of shoulder material shall be processed as necessary to bring its moisture content to a uniform level throughout the material suitable for compaction and shall then be compacted using suitable compaction equipment approved by the S.O. to not less than 95% of the maximum dry density determined in the *BS 1377* Compaction Test (4.5kg rammer method). Compaction shall be carried out in a longitudinal direction along the shoulder and shall generally begin at the outer edge and progress uniformly towards the carriageway, except on super-elevated curves where rolling shall begin at lower edge and progress uniformly towards the higher edge. In all cases, compaction shall be carried out in such a manner that each section receives compactive effort appropriate to its thickness, all to the satisfaction of the S.O..

4.2.4.5. Throughout the placing, adjustment of moisture content and compaction of shoulder material, care shall be taken to maintain a uniform gradation of the material and prevent its separation into coarse and separate parts, all to the satisfaction of the S.O..

4.2.4.6. Where shown on the Drawings or directed by the S.O., earth shoulders shall be turfed in accordance with *Standard Specification for Roadworks Section 2: Earthworks JKR Specification No. JKR/SPJ/2013-S2.*

4.2.4.7. Shoulders shall be finished in a neat and workmanlike manner. The total width of carriageway and shoulder shall throughout be at least as specified or shown on the Drawings on both sides of the centre-line. The top surface of each shoulder shall throughout have the required shape, super-elevation, levels and grades, within 10mm of the required plane, and shall provide a flush joint with the carriageway surface and shall be uniformly free draining away from the carriageway, all to the satisfaction of the S.O..

5. Concrete Pavement

Concrete Pavement works shall be in accordance with *Standard Specification for Road Works JKR Specification No. JKR/SPJ/1988 Section 5: Portland Cement Concrete Pavement.*

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6. Road Furniture

6.1. Corrugated Sheet Steel Beam Guardrail

The supply and method of installation of guardrails shall be in accordance with *Standard Specification for Road Works Section 6: Road Furniture JKR Specification No. JKR/SPJ/2017-S6.*

6.2. Traffic Signs

The supply and method of installation of traffic signs shall be in accordance with *Standard Specification for Road Works Section 6: Road Furniture JKR Specification No. JKR/SPJ/2017-S6.*

6.3. Road Markings

The supply and application of road markings shall be in accordance with *Standard Specification for Road Works Section 6: Road Furniture JKR Specification No. JKR/SPJ/2017-S6.*

6.4. Concrete Kerb

The supply and installation of concrete kerb shall be in accordance with *Standard Specification for Road Works Section 6: Road Furniture JKR Specification No. JKR/SPJ/2017-S6.*

7. Street Lighting

The supply and installation of street lighting shall be in accordance with *Standard Specification for Road Works Secgtion 7: Street Lighting JKR Specification No. JKR/SPJ/2011-S7.*

8. Traffic Signal System

The supply and installation of traffic signal system shall be in accordance with *Standard Specification for Road Works Section 8: Traffic Signal System JKR Specification No. JKR/SPJ/2008-S8.*

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1. General

1.1. Unless otherwise as shown on the Drawings, fencing shall be of chain link type as specified hereunder.

1.2. Unless otherwise as shown on the Drawings, the height of the fence shall be 1500mm from the ground up to the full height of the chain link.

1.3. The fence shall be erected to the extent and location as shown on the site plan. Where fencing is to be located on the boundary of the Site, the Contractor shall ensure that its construction shall not infringe the adjoining properties.

1.4. All trees, bushes, or other obstacles which interfere with the construction of the fence shall be removed prior to commencing fence construction.

2. Post and Bracings

2.1. Mild Steel Post

2.1.1. Unless otherwise as shown on the Drawings, mild steel angle posts and bracings shall be of size 60mm x 60mm x 6mm. All steel members for fencing and gates shall be free from rust, scales and other defects and shall be to the approval of the S.O.. Previously used steel members shall not be used in the construction of new fencing and gates. Before delivery to the Site, the steel members for fencing and gates shall be pre-cut and assembled at the Contractor's workshop and painted with one coat of approved metallic primer.

2.1.2. Where three strands of barbed wires are required, a mild steel angle arm 430mm long, of the same cross-sectional dimension as the post shall be welded at the top of the post at 450 inclinations. Where six strands of barbed wires are required, two pieces of mild steel angle arms as specified hereinbefore shall be welded to the top of each post forming the shape Y with each arm having three strands of barbed wires. The welding used shall be of continuous fillet welds. Necessary holes shall be made in the posts, arms and bracings for insertions of fixing bolts and clips.

2.2. Concrete Post

2.2.1. Concrete post and struts for fencing shall be of size 150mm x 150mm precast using Prescribed Mixes Grade 25P and shall be erected at 3000mm centres commencing from the gate post and the posts shall be embedded plumb in Prescribed Mixes Grade 25P concrete footings of size 250mm x 250mm x 600mm deep. The finish to the formed surfaces shall be Class F2 and the finish to the unformed surfaces shall be Class U2. The tops of the posts and all arises shall be rounded of chamfered.

2.2.2. Reinforcement for concrete posts and struts shall be Grade 250 plain round steel bars.

2.2.3. Post should be holed to allow the fixing of line wires, etc. the hole for top line wire shall be approximately 75mm below the top of the post. Holes for bolts shall allow the bolt to be freely inserted. All holes shall be free from obstructions and accurately positioned within ± 5mm.

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3. Chain Link Fencing

3.1. Chain Link Mesh, Straining

3.1.1. Chain link fences shall comply with *BS 1722: Part 1 Specification for Chain Link Fences.*

3.1.2. Chain link mesh, straining wires and barbed wires shall be made of galvanized steel and of approved quality. The mesh shall be of size 64mm made up of 3.25mm (10 gauges) diameter wire. Straining wires shall be of 4.06mm (8 gauges) diameters and barbed wires shall be of 2.64mm (12 gauges) diameters.

3.2. Fencing

3.2.1. Unless otherwise as shown on the Drawings, the mild steel angle posts shall be erected at 3000mm centres commencing from the gate post and the posts shall be embedded plumb in Prescribed Mixes Grade 25P concrete footings of size 250mm x 250mm x 600mm deep. Mild steel angle bracings of the same cross-sectional dimensions as the post shall be fixed at all corners, bends, junctions, gate posts and at every five bays of straight fencing.

3.2.2. The posts shall be set in holes to the required depth and stamped in a plumb and firm position to the line and spacing shown on the drawings or as directed by the S.O.. Post holes shall be large enough to allow for proper tamping. Backfill shall be placed in layers not exceeding 150mm, and compacted by hand tampers, machine tampers or other suitable equipment. Compacted backfill shall be crowned slightly to permit drainage away from the post.

3.2.3. The bracings shall be fixed at an inclination of 45^0 to the horizontal with top end bolted to the post, 300mm below the top of the post and the bottom end encased in concrete footing as described hereinbefore.

3.2.4. The chain link mesh shall be stretched or pulled tightly across the post with hand stretcher, or tensioning apparatus capable of adjustment and secured in place using approved fencing clips. The end of chain link fencing abutting mild steel gate posts shall be fixed by means of 19mm x 3mm mild steel flat straps drawn through the mesh and bolted using 10mm diameter mild steel bolts to 25mm x 25mm x 6mm mild steel plates welded to the posts at equal intervals of 300mm. Where gate posts are non-metal, the termination of the fencing at the gate shall be by means of another mild steel angle post fixed to one side of the gate post and strengthened by bracing as described hereinbefore. The chain link mesh shall then be strained by three strands of 4.06mm (8 gauges) diameter galvanized steel straining wires threaded through the mesh and fixed to the posts.

3.2.5. Each line wire and each line of barbed wire shall be secured to each intermediate post by one of the following methods;

3.2.5.1. A hairpin staple shall be passed through a hole in the post and secured to the wire by three complete turns on each side of the post.

3.2.5.2. The wire shall be threaded through a hole in the post.

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3.2.6. Where shown on the Drawings, the bottom of the chain link mesh shall be buried in continuous Prescribed Mixes Grade 25P concrete curbs. Unless otherwise detailed in the Drawings, the cross-sectional dimension of curbs shall be 125mm wide x 375mm high with 150mm protruding above the ground. The portion of the curb above the ground shall be rendered with 13mm thick 1:6 cement render to a wood float finish.

3.2.7. The ground surface around post shall be made good with the same material as the adjoining area.

4. Security Fencing

4.1. The security fencing shall be constructed and/or installed as shown on the Drawings and comply to requirement of relevant Authority.

4.2. All components shall be manufactured only by reputable licensed suppliers and approved by the S.O.. The supplier shall include special requirement such as mount CCTV Camera, lighting, barbed wire, razor wire etc. (if any) and responsible for the analysis, design, detailing, drawing, manufacture, material, handling and erection of the fence members and their ancillary fixing components.

4.3. All component shall be of hot dipped galvanised comply to *BS EN ISO 1461*.

5. Sports Fencing

5.1. The sports fencing shall be constructed and/or installed as shown on the Drawings and comply to requirement of Certified Body.

5.2. All components shall be manufactured only by reputable licensed suppliers and approved by the S.O.. The supplier shall include special requirement such as mount CCTV Camera, lighting, barbed wire, razor wire etc. (if any) and responsible for the analysis, design, detailing, drawing, manufacture, material, handling and erection of the fence members and their ancillary fixing components.

6. Gates

The gates shall be constructed and/or installed as shown on the Drawings.

7. Storage of Fencing

7.1. Gates, steel post and struts for fencing shall be stored off the ground on level supports and in manner which will not result in damage or deformation to the materials.

7.2. Fencing shall be protected from damage and damaged fencing shall not be use in the permanent works.

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8. Painting of Fence and Gates

The metallic primer previously applied to the steelwork at the workshop shall be touched up where necessary. Unless otherwise specified, the posts, bracings and gates shall be finished with two (2) coats of approved aluminium paint.

9. Re-erecting, salvage and dispose of existing fencing.

9.1. Taking Down and Re-Erecting of Existing Fencing

Where specified, existing fences shall be taken down, the materials carefully salvaged, and the fence re-erected, to the satisfaction of the S.O..

9.2. Remove and Salvage of Existing Fencing

Where removal and salvage of existing fences is specified, the Contractors shall carefully take down the fence, roll the wire, and place the material at locations as directed by the S.O.. Material that are not suitable for salvage shall be disposed of at locations as directed or acceptable to the S.O..

9.3. Remove and Dispose of Existing Fencing

Where removal and disposal of existing fences is specified, the Contractor shall completely remove the fence and dispose of all materials at locations acceptable to the S.O..

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1. General

1.1. All landscaping works shall be as shown on the Drawings. Turfing works and tree planting shall be carried out in such a manner as to minimize risks of damage to turfs and plants, and stunted growth. Turfing on all slopes shall be carried out immediately after slopes are formed. Tree planting shall be carried out as soon as practicable.

1.2. All landscaping works shall start as early as possible so that trees and plants are well- grown, and fully adapted to the new environment when the project concerned is handed over upon completion.

1.3. All landscaping works shall be furnished, installed and maintained by the Contractor as specified herein, or as shown on the Drawings, using the best horticultural management, giving special attention to planting practices, soil mixtures, and application of agricultural chemicals.

1.4. Existing water elements such as lakes, ponds and streams shall be incorporated into the landscape design. Unless otherwise specified, mature existing trees shall be retained and incorporated into the landscape design. Replantation and relocation of the trees removed shall be considered as part of the landscaping works.

2. Classifications and Characteristics of Plants

2.1. Plants shall mean trees, palms, shrubs, ground covers, and plants of other descriptions to be provided by the Contractor, as shown on the Drawings or listed in the plant schedules.

2.1.1. Each tree shall possess characteristics of its variety and growth typical to such tree. All trees shall be well-branched, with straight trunks characteristic of the species, with well-shaped top and intact leader. The height shall be measured from the stem's earth line to the top of the tree.

2.1.2. Palms shall have vigorous root system, crown of new leaves, proper color of leaves of adult palms, and sufficient hardlines. The height of palms shall be measured from the stem's earth line to the base of the first frond.

2.1.3. Shrubs and vines shall possess characteristics and growth habits typical of their species. All shrubs shall be well-shaped and bushy, with well-spaced branches, and not skinny. The height of shrubs or vines shall be measured from the stem's earth line to the top branches.

2.1.4. Ground cover is defined as any plant or groups of plant, other than grasses, which shall satisfactorily cover the ground, forming a compact and attractive cover.

2.2. All plants shall be in healthy growth condition, free from pests and diseases, and shall be representatives of their normal species or variety. All plants shall have well-branched heads and vigorous root systems and shall be injury-free. Unless otherwise shown or specified in the Drawings, only nursery-grown plants shall be used. Plants which are potted or plastic-bag-grown shall not be root-bound.

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3. Size of Plants

3.1. The size of plants refers to plant table size that is the size that is required for planting out on sites. All plants shall have the following sizes:

3.1.1. Ground Covers

Ground cover plants can be supplied in plastic bags. If supplied in 150mm - size bags they shall have at least nine (9) cuttings per bag, and not less than 150mm long.

3.1.2. Shrubs

Height of shrubs shall range between 150mm and 1000mm.

3.1.3. Trees

3.1.3.1. Trees shall be either container grown or grown on the open ground. They shall be of the following three types:

(i) Tree saplings

Tree saplings shall mean grown from seedlings or cuttings. They shall have straight main stems of not less than 1200mm in height from the soil level to the lowest branch, and a stem diameter of not less than 12mm, and a well-branching system.

(ii) Rooted Stump Cutting

These refer to plants which can be easily grown from stem cuttings instead of from seeds. They shall have straight main stems of 2400mm to 3000mm in height, with a diameter ranging from 37mm to 50mm.

(iii) Instant Trees

An instant tree is generally referred, to the semi-mature tree with a minimum trunk height of 2000mm for palms (measured from earth line to first frond) and 3000mm for other which shall have well-spread branches.

3.1.4. Palms

3.1.4.1. Palms shall be either container-grown on the open ground, and shall be of two types:

(i) Single-Stem Palm

These refer to palms with single main trunk. Their trunk height shall be not less than 1200mm measured from the earth line to the base of the first front.

(ii) Cluster Palms

The Palms referred to are those which grow in clusters. They shall have a minimum of three (3) palms clustered

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together, measuring 750mm to 1000mm from the earth line to the base of the first frond.

4. Handling and Planting

4.1. Handling

Plants shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination. All plant materials shall be carefully protected and, if necessary, wrapped with hessian or gunny cloth during lifting, transportation, unloading and storage on site.

4.2. Planting

4.2.1. Pits/Holes

4.2.1.1. Generally, all pits for palms and trees shall not be less than 1000mm x 1000mm or 1/3 size bigger than the root ball, spaced at intervals as shown on the Drawings or approved by the S.O..

4.2.1.2. For shrubs, the pit size may be reduced to 500mm x 500mm deep (for big shrubs), or 300mm x 300mm x 300mm deep (for medium shrubs). Alternatively, continuous trench 500mm x 300mm deep respectively, shall be formed where required.

4.2.1.3. The bottom of all pits and trenches shall be forked loose to a depth of 300mm prior to backfilling with approved soil mixture before transplanting. All pits and trenches shall be soaked with water before planting.

4.2.1.4. Flower beds or trenches shall be made to the size as shown in the Drawings, and to a depth not exceeding 200mm.

4.2.1.5. The distance for planting trees and palms shall be between 3000mm to 5000mm unless otherwise specified.

4.2.1.6. The distance for planting shrubs shall be between 150mm to 300mm unless otherwise specified.

4.2.1.7. For ground covers, planting works shall be carried out in zig-zag manner at distance between 100mm to 150mm unless otherwise specified.

4.2.1.8. To install a minimum of 1000mm (H) x 750mm (L) x 750mm (W) of Polyethylene root barrier for trees planting at pavement/ hardscape area. eg parking, walkway and sidewalks.

4.2.2. Transplanting

4.2.2.1. Transplanting shall not be carried out in very hot, dry weather conditions which may result in initial drying out of the root system and/or scorching of leaves.

4.2.2.2. Immediately before transplanting, the plants shall be carefully removed from the nursery bags or pots. The plants shall be placed into the pits and the surround filled with approved black earth making sure that the roots are not excessively disturbed.

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The earth around the base of the stems shall be recessed slightly to facilitate watering.

4.2.3. Plants Supports

All newly plants shall be supported either by staking, tying or guying. Stakes shall be of wood, still or plastic of an approved type, driven into the ground before planting so as not to damage the root ball or aerial parts of plants. Stakes shall be long enough to the plants, with one (1) tie per stake set 150mm from the bottom.

5. Soil Mixture, Soil Conditioners and Chemical Fertilizers

5.1. Soil Mixture

Soil mixture for ground planting and backfill shall be in the ratio of 1:3, i.e. 1 part to soil conditioner or organic materials to three (3) parts of top soil. Planter box soil mixture shall be in the ratio of 1:2:3, i.e. one (1) part of sand of sand to two (2) parts soil conditioner or organic materials to three (3) parts top soil.

5.2. Top Soil

Top soil shall consist of fertile and friable topsoil obtained from a well-drained flood-free site excavated from not more than 300mm deep from ground level. It shall be of medium texture and without admixture of stones, lumps, plants or roots, and other extraneous matter. Topsoil material shall be obtained from excavated topsoil sourced or, if not available, from other sources as approved by the S.O..

5.3. Soil Conditioners (Manure and Compost)

Soil Conditioners shall be organic materials such as composed coconut, fiber, peat or other approved materials which shall be composed in a stable condition, free from toxic impurities and containing no substance injurious to plants. The organic matter with 45% - 55% moisture content and with Ph adjusted to 5.5 - 6.5 shall be used. All manure or compost used as additive to the soil mixture shall be procured from an approved source.

5.4. Chemicals Fertilizers

Chemicals fertilizers shall be granular slow release compound fertilizers with a minimum four (4) months release period at 32^0C. They shall be stored in waterproof sealed bags and kept under shelter. The Contractor shall submit manufacturer's technical data on the proposed fertilizer for the S.O.'s approval prior to the application of the fertilizer.

6. Turfing

6.1. Unless otherwise shown in the Drawings, turfing shall be provided to all exposed earth surfaces throughout the site. All surfaces to be turfed shall be completely cleared of all incidental Contractor's debris, stone and other obstructions.

6.2. The ground to be turfed shall be graded to fall toward surface water discharge line as shown in the Drawings, or approved by the S.O..

6.3. On level ground, minimum gradient of 1:60 shall be provided to eliminate ponding

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hollows. Any undesirable vegetation, debris, stumps or roots shall be grubbed up and removed from the site.

6.4. Top soil shall be provided on a prepared surface and compacted to provide a suitable tilt for the growth of the turf. Before spreading the topsoil, the ground is to be trimmed and leveled and all roots of bushes and undesirable growth grubbed up and removed from the site.

6.5. All turfs shall be of good, healthy, dense indigenous cow grass (Axon Opus Compresses) from an approved source. The grass shall be of even density, vigorous growth and green in color, forming a turf sufficiently fibrous to hold together when installed. They shall be free from mimosa, weeds or other foreign vegetation.

6.6. Each turf shall be approximately 300mm x 300mm x 50mm thick with roots still attached to the soil. They shall be kept moist and in shade and shall be planted within 24 hours of lifting. Samples of turfs to be used shall be submitted to the S.O. for approval before any turfs are brought in for use. The sources of material shall be stated by the Contractor.

6.7. Unless otherwise shown in the Drawings, close turfing shall be provided to slopes, and extending 2 m of the platform at the top and bottom of the slope, 1 m the sides of all drains, and 2 m wide of road shoulders, so that they cover the whole area without any space/gap between them.

6.8. Each sod shall be pegged in place with wooden/bamboo pegs 12mm diameter and 200mm long through the sod and into the soil base. These pegs shall be removed after the turf have firmly established. On steep slopes, netting in shall be laid onto the turfed areas for protection.

6.9. Unless otherwise shown in the Drawings, spot turfing shall be carried out on all level ground. The turf shall be laid at 450mm center, embedded 25mm in the top soil.

6.10. Turf shall be fertilized with approved slow release fertilizers high in Nitrogen content, one (1) month after planting at the rate of 60 gm/m^2 and evenly spread over the whole area. Turfs shall be well watered after each fertilizer application which shall be done once in every three months after grass cutting.

6.11. Grass cutting shall be done every three weeks after one (1) month growth/establishment by grass cutter/mover as often as in required to give a well trimmed sod not more than 25mm in height for flat surface and not less than 50mm on slope. All clippings shall be removed from the site before watering is carried out.

7. Football and Playing Fields

7.1. General

7.1.1. Unless otherwise specified hereinafter, turfing for football and playing fields shall be as specified hereinbefore. Turfing works shall start as soon as possible and shall be completed and fully established not later than three (3) months before the date of completion of the works.

7.1.2. The Contractor shall supply and install sub-soil drains as specified hereinafter at the locations and accordance with the lines, levels and grades shown in the Drawings and/or as directed by the S.O..

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7.2. Materials

7.2.1. Sub-soil Drain Pipes

Subsoil drain pipes shall be of high-Density Polyethylene (HDPE) perforated corrugated drainage pipe to DIN 16961 PT 1 and 2:1989 or equivalent, or Polyvinyl Chloride (PVC) pipes for subsoil drains complying with AS Specification 2439.1 or BS 3656 or equivalent, of diameter and lengths of pipe as shown on the Drawings.

7.2.2. Filter Materials

Filter Materials shall consist of an angular, clean, hard and durable crush rock with uniformly sized particle of 14mm, free form lumps of clay or organic matter.

7.2.3. Geo Textile Fabric

Geo textile fabric shall be of non-woven type thermally bonded with minimum weight of 100 g/m² or equivalent and shall be of approved manufacturer.

7.3. Site Preparation

The site area shall be completely cleared of all debris, large stones, discarded gravel and other unacceptable materials. The site shall then be graded to form a crown at the centre of the field with a minimum gradient of 1:300. The soil shall be of good texture and structure with the majority of the crumbs of size 1mm to 2mm and not contaminated with seeds, stolon or rhizomes of noxious weeds.

7.4. Trenching for Sub-soil Drain Pipes

Trenches shall be excavated and trimmed clean true to grade and alignment and the geo textile fabric shall be laid as shown on the Drawings. The fabric shall overlap the full width of the trench at the top. Where the fabric requires jointing along the trench, it shall overlap a minimum of 500mm at the joint.

7.5. Laying and Jointing Subsoil Drain Pipe

Subsoil pipe shall be laid and bedded as shown on the Drawings. Subsoil drain pipe shall be jointed according to the manufacturer's recommendations.

7.6. Backfilling

The trench shall be backfilled with the filter material in layers not exceeding 150mm loose thickness and uniformly compacted by suitable method approved by the S.O. to the level as shown in the Drawings. Care shall be taken that the pipe is not damaged or displaced.

7.7. Outlets

Outlets shall be constructed as shown in the Drawings and to the S.O.'s approval.

7.8. Laying of Sand and Turf Mixture

7.8.1. The prepared surface of the field shall be laid with a first layer of 100mm thick river sand or other suitable course grained granular materials and a second layer of 100mm thick turf mixture before receiving the turf.

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7.8.2. The Contactor surface shall carry out final gradient check prior to the turfing works.

7.8.3. Before turfing works commence, the Contractor shall submit samples of the turf mixture for the approval of the S.O.. The turf mixture shall be laid to the required formation level and gradient.

7.8.4. The turf mixture shall have the following composition by weight of 4% - 5% organic matter, 12% - 15% clay and 81% - 85% river sand. The PH value for the root zone medium shall be 5 to 7.5.

7.9. Inspections

7.9.1. The Contractor shall give not less than twenty-four (24) hour notice prior to the commencement and upon completion of the under mentioned works. The Contractor shall not proceed with the next succeeding operation until specific approval has been given for the following:

7.9.1.1. Trench excavation.

7.9.1.2. Trench lining with geo textile fabric and laying of subsoil drain pipe

7.9.1.3. Filter material backfill

7.9.1.4. Sand laying

7.9.1.5. Turf mixture

7.9.1.6. Turfing work

7.10. Levelling of Field

7.10.1. The Contractors shall water the turf at least twice a day or as instructed by the S.O.. The rate of application and frequency of watering shall be sufficient to maintain the turf mixture in a moist condition to ensure proper and healthy growth of the turf even during the dry weather.

7.10.2. Water shall be applied as fine spray by means of suitable pumps and hose or sprinkler or any other method approved by the S.O. so as not to disturb the turf mixture.

7.11. Weed Control

Weeding shall be carried out on the newly turfed area about ten (10) days after planting to get rid of foreign species and maintain a pure culture of Axonopus Compressus (Cow Grass). Weeding on a Continuous basis shall be carried out to prevent weeds from growing.

7.12. Fertilization

The first fertilization shall be carried out two (2) weeks after planting, using mechanical spreader. Subsequently, the fertilizer shall be applied at three (3) weeks interval.

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7.13. Mowing

7.13.1. Mowing shall be carried out using properly sharpened and adjusted machine tools so that the turf is out cleanly, and no tearing takes place.

7.13.2. The first cut shall be carried out when the turf reaches 50mm – 70mm in height. The turf shall be cut to 25mm – 30mm in height. Subsequently, mowing shall be done at least once in every two (2) weeks.

7.14. Top Dressing

The Contractor shall, from time to time or whenever directed by the S.O. check the flatness of the field and if found uneven, rectify by top dressing with turf mixture and followed by proper compaction.

7.15. Maintenance during Defect Liability Period

7.15.1. The Contractor shall be responsible for carrying out full-time intensive maintenance of the turfing works for the entire duration of the Defect Liability Period of the Works.

7.15.2. The maintenance includes watering, weed control, fertilization, moving and top dressing, all as specified hereinbefore.

7.16. Handing Over of the Works

On handing over of the works, the field shall be in good playable condition with all the full line markings to the dimensions as shown on the Drawings.

8. Relocation and Protection of Existing Tress

8.1. Relocation of Trees

8.1.1. Where shown in the Drawings or if directed by the S.O., all existing trees having girth of 300mm and below identified and marked for relocation, shall not be cut, but shall be dug up, prepared for, and relocated by the Contractor to other areas within, or in the vicinity of the site. In the event of any such trees being accidentally cut or damaged, the same shall be replaced with trees of equivalent size and species by the Contractor.

8.1.2. The Contractor shall protect and maintain the relocated trees by fencing to a height of 1.2m, watering, manuring, pruning, and other necessary treatments throughout the contract period (including the Defects Liability Period) until satisfactory, growth is established. Any relocated trees which damage are accidentally or fail to re-grow satisfactorily within the Defect Liability Period, shall be replaced accordingly at the Contractor own cost.

8.2. Protection of Trees Retained on Site

8.2.1. All existing trees having girth of 800mm and above identified and marked by the S.O. or as shown in the Drawings to be retained on site, shall be protected and maintained by fencing to a height of 1.2m, watering manuring, pruning and other necessary treatments throughout the contract (including the Defects Liability Period) so as not to jeopardize their growth.

8.2.2. The ground around the tree spread shall be protected to prevent contamination from materials and chemicals detrimental to plant growth.

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Method of protection shall be to the approval of the S.O. in the event of any such trees being accidentally or otherwise out or damaged, the same shall be replaced by the Contractor with trees equivalent size and species at his own cost.

9. Maintenance of Plant and Turf

9.1. General

9.1.1. After planting and prior to the onset of the maintenance period, the Contractor shall be responsible for carrying out all necessary measures to ensure that all plant materials and turfing thrive and become established, and that the landscaped areas are kept in a clean and tidy condition.

9.1.2. The Contractor shall protect and maintain the plants and turfing from any damage and destruction, by way of watering, manuring and tilling, any by staking and fencing, where necessary, to support and protect the plants, until the end of the Defects Liability Period. All plants and turfs which are defective and/ or fail to grow within the Defect Liability Period or as instructed by the S.O. shall be replaced immediately and/ or replanted accordingly, at the Contractor's own cost.

9.1.3. Unless otherwise specified, all maintenance works shall be carried out complying to the minimum standard as detailed out in the *`Garis Panduan Pengurusan Dan Penyelenggaran Projek Landskap' (latest edition)* by Jabatan Perancang Bandar & Desa, Kementerian Perumahan Dan Kerajaan Tempatan. During the Defects Liability Period, the Contractor is required to implement the maintenance works as follows:

9.1.3.1. Water the plants twice (2) per day.

9.1.3.2. Feeding the plants with fertilizers (NPK Green) 15:15:15 once (1) every month for the first six (6) months and as needed after six (6) months onwards. Application of the fertilizer shall be as specified hereinafter, and as recommended by the fertilizer manufacturer.

9.1.3.3. Weeding/Hoeing and Site Cleaning

9.1.3.4. Disease and Pest Control

9.1.3.5. Plants Replacement

9.1.3.6. Mulching

9.1.3.7. Trimming/Pruning

9.1.4. The Contractor shall provide persons who are competent and experienced for organizing and running the maintenance programs during the Defects Liability Period, at the Contractor's own cost.

9.1.5. The Contractor shall be responsible for the use of all materials, labour and equipment. Any injury to plants caused by such materials, labour and equipment shall be corrected and repaired at the Contractor's own cost.

9.1.6. The Contractor shall carry out all necessary measures to ensure that all plants thrive and become established within this period. All landscaped

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areas shall be inspected at monthly intervals and lists of remedial works shall be issued upon each inspection within seven (7) working days. All items on the remedial work list shall be executed before the next scheduled inspection.

9.2. Weeding and Hoeing

Weeding and hoeing shall be done frequently, depending on weed growth or whenever directed to do so by the S.O.. The Contractor shall be responsible for maintaining areas close the base of trees or shrubs. Weeding shall be done manually either by hand, hoe or garden tools at least once a month, with care taken not to wound plant stems.

9.3. Fertilizers and Application Rate

9.3.1. Feedings to plants shall be done with approved organic manure or slow release fertilizers at regular intervals to maintain healthy growth. The S.O. reserves the right to request the Contractors to use any kind of fertilizer, let it be straight mixture, complex or slow release, at the Contractor's own cost.

9.3.2. Six (6) applications shall be required during the maintenance period. The first shall be carried out during the second (2nd) month after planting. The second and subsequent applications shall be worked into the soil above the roots and lightly watered in. the fertilizer shall be applied, preferable, when the plants are in their active stage of growth.

9.3.3. Slow release fertilizers shall be applied strictly in accordance with the manufacturer's directions and recommendations.

9.3.4. The Contractor shall take note that plant feeding shall be carried out only after all other maintenance works like weeding, hoeing and trimming or pruning have been carried out.

10. Final Handing Over

10.1. Two weeks before the expiry of the Defects Liability Period a joint final inspection shall be held with the S.O. to review the requirements for any alteration or replacement in order to gain approval for Final Handing Over.

10.2. At the time of Final Inspection, all areas under this contract shall be free from weeds, neatly cultivated and raked, and all plant boxes in good order. Grass shall be neatly cut and all clippings removed. No bare patches of earth shall be visible in turf or planting areas unless otherwise specified.

10.3. If any portions of the works are found to be not acceptable, under the terms and intent of the Drawings and specifications, the Contractor shall carry out immediate remedial works to S.O.'s acceptance before the date of Final Handing Over. The cost of all remedial works shall be borne by the Contractor.

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1. General

1.1. All drainage works shall be in accordance with the *JKR Standard Specification for Drainage Works in Building Projects No. 20601-0195-13* and conform to the requirements of the *Urban Stormwater Management Manual for Malaysia (MSMA)* and *MS 2526*.

1.2. The works shall include the construction of surface drains, sumps, culverts, subsoil drains, and other drainage structures in accordance with the above requirements or as directed by the S.O..

1.3. Drainage works shall be constructed to the lines, levels, grades and cross-sections shown on the Drawings or to suit the site as approved by the S.O..

1.4. Final discharge point shall be identified and approved by the relevant Local Authorities. Where necessary, the existing drainage system shall be upgraded in order to ensure they are fully functional.

2. Excavation and Backfilling

2.1. All general excavation works shall be as specified in SECTION B: EXCAVATION AND EARTHWORKS.

2.2. The Contractor shall notify the S.O. sufficiently in advance of the beginning of any excavation so that cross-section elevations and measurements shall be taken of undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the S.O.. The excavation works shall be carried out so as not to cause any danger or obstruction to the traffic or public.

2.3. All excavation shall be inspected and approved by the S.O. prior to further work being carried out.

2.3.1. Excavation of Hard Materials/Rock

2.3.1.1. Hard materials/rock encountered in the trench excavation shall be removed to the approval of the S.O.. Layer of rock encountered along the bottom of the excavation shall be cut and trimmed to the required level.

2.3.1.2. Voids formed at bottom of the trench due to the removal of rocks shall be backfilled to the required level with 20mm Grade 20P concrete or other suitable materials, well rammed and compacted all to the approval of the S.O..

2.3.1.3. Jagged surfaces of rocks at the bottom of the excavation due to the trimming shall be levelled and smoothened with sand blinding to the approval of the S.O..

2.3.2. Excavation of Soft Materials

When, in the opinion of the S.O. the foundation material is soft or otherwise unsuitable, the Contractor shall remove and insert foundation fill material or concrete as specified or shown on the Drawings or directed by the S.O.. It shall be placed and compacted in layers not more than 150mm thick or as directed by the S.O..

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2.4. Excavation for Drain Trenches

2.4.1. The trench shall be excavated to a depth intended or shown on the Drawings. The blinding material shall be laid immediately after the excavation.

2.4.2. Should the bottom of the trench be inadvertently excavated below the specified level, it should be brought back at the Contractor's expense to the correct level with good selected earth or sand, carefully rammed into place.

2.5. Excavation for Culvert

2.5.1. The earthworks at the required location shall be constructed to a level at least 600mm above the top of culverts design levels or to the top of subgrade levels, whichever is lower. The culverts specified to be constructed in trench conditions shall be excavated in accordance with sub-section 2.6..

2.5.2. Where drainage conditions or other circumstances so require, the S.O. shall direct the Contractor to construct the culvert without first constructing the earthworks to the level specified above, in which case excavation, and foundation preparation shall be in accordance with sub-section 2.7..

2.6. Trench Method

2.6.1. The trench to receive culvert shall have sufficient width and depth to enable the placing of bedding material. The bottom of the trench shall be trimmed to suitably smooth plane surface which shall be kept free from water, all to the satisfaction of the S.O..

2.6.2. Rock or other hard material encountered shall be excavated to a depth as directed by S.O.. The excavated hard material shall be replaced with suitable material uniformly compacted in layers of not more than 150mm compacted thickness to provide satisfactory support for the culvert, all to the satisfaction of the S.O..

2.7. Open Ground Method

2.7.1. Where existing ground levels are above top bedding material design levels and firm foundation materials are encountered, excavation and foundation preparation shall be similar to the described in trench method above. Otherwise a firm foundation plane shall be prepared, which shall be essentially free draining along the line of the culvert by trimming the existing ground, or such fill as it is necessary to place and compact, over a width sufficient to permit satisfactory construction of the pipe bedding, all to the satisfaction of the S.O..

2.7.2. Where soft or unstable soil is encountered in the foundation, it shall be excavated over a width of at least 1.5 times the outside of each side of the culvert centre-line to the depth directed by the S.O., and replaced with suitable material uniformly compacted in layers of not more than 150mm compacted thickness to provide satisfactory support for the pipe, all to the satisfaction of the S.O..

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2.8. Backfilling

2.8.1. Drainage trenches shall be backfilled immediately after completion of drain laying or installation of culverts and as soon as the S.O. has inspected and given his approval.

2.8.2. Backfilling with approved fill materials shall be placed evenly in layers not exceeding 150mm. To provide uniform support, loose thickness of fill materials on both sides of the drain shall be thoroughly compacted with mechanical rammers. This procedure shall be followed for the whole depth of drain section.

2.8.3. All spaces excavated under this Specification and not occupied by a permanent structure shall be backfilled with material free from large lumps, wood and extraneous material.

3. Materials

3.1. Basic construction materials shall comprise the following;

3.1.1. Granular Bedding Material

The foundations shall be of granular bedding material suitably graded broken rubble, crushed stone, crushed gravel, sand or other material as shown on the Drawings or as directed by the S.O..

3.1.2. Concrete

Concrete for blinding, bedding and cast-in-situ drains shall be as shown in the Drawings and as specified in SECTION D: CONCRETING.

3.1.3. Ordinary Backfill Material

3.1.3.1. Ordinary backfill material shall be of suitable material as defined in SECTION B: EXCAVATION & EARTHWORK.

3.1.3.2. Materials from swamps, peats or top soils and other highly organic clay or silt, materials containing logs, stumps or boulders, which are susceptible to combustion, and any other materials which, by virtue of their physical or chemical composition or at their moisture content will not compact properly, shall not be used for filling.

3.1.4. Granular Backfill Material

3.1.4.1. Granular backfill material shall be sand, crushed stone, crushed gravel or a mixture of crushed and natural aggregates, shall be essentially free from vegetative and other organic matter and clay, and shall not contain lateritic or concretionary materials. The material shall conform to the following physical and mechanical quality requirements:

(i) The fines shall be non-plastic;

(ii) Sand shall have a gradation conforming to the envelope shown in **Table S1**;

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(iii) Material other than sand shall have a gradation conforming to one of the envelopes shown in **Table S2**.

Table S1. Grading Limits for Sand Backfill

B.S. Sieve Size	% Passing by Weight
10.0mm 5.0mm 1.18mm 300 µm 150 µm	100 90 - 100 45 - 80 10 - 30 2 - 10

Table S2. Grading Limit for Granular Backfill other than Sand

B.S Sieve Size	% Passing by Weight		
	A	B	C
37.5mm 28.0mm 20.0mm 10.0mm 5.0mm 2.0mm 425 µm 75 µm	100 70 -100 60 - 90 45 - 75 30 - 60 20 - 50 10 - 30 0 - 2	- 100 70 - 100 45 - 75 35 - 65 25 - 50 10 - 30 0 - 2	- - 100 - 45 - 75 30 - 60 15 - 35 0 - 2

3.1.4.2. The granular backfill shall be placed in layers not to exceed 150mm in depth and each layer shall be thoroughly compacted by means of packers or mechanical tampers to a relative compaction of not less than 95% Standard Proctor Density for the backfill material at optimum moisture content.

4. Surface Drainage

4.1. Surface drains shall be constructed with regard to both operation and ease of maintenance and adequate gradient shall be provided to enable self-cleansing flow.

4.2. Where gradient designed is not practical or above the finished level, the Contractor shall submit their proposal for the approval of the S.O..

4.3. Reinforced concrete struts shall be provided for all drain side walls exceeding 0.9m height. Handrails shall be provided for open drains more than 1.2m width and / or maximum depth as specified in **Table S3**.

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Table S3. Maximum Depths of Open Drain

Cover/Handrail Fence Condition	Maximum Depth (m)
Without protective covering	0.6
With solid or grated cover	1.2

4.4. Types of Surface Drains

4.4.1. Surface drains of all types shown on the Drawings shall be constructed either unlined or lined using cast in situ concrete, precast or porous concrete drain sections or stone pitching.

4.4.2. Unlined (Earth) Drains

4.4.2.1. The Contractor shall refer to approved plans for location, extent and construction details as shown on the Drawing, or otherwise directed by the S.O..

4.4.2.2. Excavation for unlined/earth drains shall be trimmed to form a smooth, firm surface to the required lines, levels, grades and cross-sections as shown on the Drawings or as directed by the S.O..

4.4.2.3. Any areas of over excavation shall be made good to the satisfaction of the S.O., all at the contractor's own cost.

4.4.2.4. The sides of cut drain shall not be steeper than 1:1.5 (V:H), while fill slopes shall not be steeper than 1:2 (V:H). The surface water shall be discharges to a stable outlet such that soil erosion is prevented from occurring.

4.4.3. Lined Drain

4.4.3.1. Lined drains shall be constructed from material proven to be structurally sound and durable and have satisfactory jointing systems. Unless otherwise stated in the Drawings, the maximum steepness of the side slopes for lined open drains shall be as indicated in **Table S4**.

Table S4. Maximum Steepness of the Side Slopes

Drain lining	Maximum steepness of the maximum side slopes (V:H)
Concrete, brickwork and blockwork	Vertical
Stone Pitching	1:1.5
Grassed/Vegetated, rock riprap	1:2

4.4.3.2. All concrete works shall conform to the requirement in SECTION D: CONCRETING of this Specification or unless otherwise specified.

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4.4.3.3. Lined drains shall be constructed by the following means;

(i) Cast In Situ Concrete Drains

a) Cast in-situ concrete drains shall be Grade 25P concrete unless otherwise stated. Weep holes shall be cast in-situ as shown on the Drawings or as directed by the S.O..

b) Where the concrete grade is found to be of the lower grade, the S.O. shall request the Contractor to do the rectification work according to the requested proper method.

(ii) Precast Concrete Drain

a) Precast concrete block inverts shall be of the shapes and dimensions as shown on the Drawing and shall be of Grade C20/25 concrete or unless otherwise specified.

b) The joint shall be grouted with cement mortar (1:3) and weep holes shall be provided as shown on the Drawing or as directed by the S.O..

c) The S.O. shall have access to the casting yards where the proprietary precast concrete product are being utilized. A copy of the manufacturer's test certificate shall be provided to the S.O..

d) All inspections shall be conducted in the present of the S.O. and any rectification works shall be carried out any accordance to the method as approved by the S.O..

(iii) Cascade Drains

Cascade drains shall be constructed from precast concrete drain units and laid stepping on a 150mm thick bed of mass concrete of Grade 20P or as shown on the Drawings or as approved by the S.O..

5. Subsoil Drain

5.1. This work shall include supply and installation of subsoil drains, constructed in accordance with these Specifications at locations and in accordance with the lines, levels and grades as shown on the Drawing and/or to suit the site as approved by the S.O..

5.2. Minimum gradient of 1:200 shall be provided for the drain to discharge into existing stormwater system, open drain, creek or pond in the area unless otherwise stated on the drawings. The discharge shall not create an unwanted bog.

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6. Sumps

6.1. Sumps shall be constructed as accordance to the Drawing or as directed by the S.O. to facilitate changes in level and flow within a drainage system. All sumps shall be covered either by concrete slab or galvanized steel grating hinged to the seating frame on the sumps for safety purposes.

6.2. Unless otherwise as shown on the Drawings, sumps of depth less than 1.5m (internal depth) shall be made up of brickwalls of minimum 225mm thickness. Sump of depth (internal depth) more than 1.5m shall use reinforced concrete Grade 20P or otherwise specified in the Drawings.

7. Culverts

7.1. The work shall comprise of supply and installation of either reinforced concrete pipe culverts or precast box culverts, including the end treatment components such as headwall, wingwalls, aprons and sumps and channel protection works, all in accordance with these Specifications and details as shown on the Drawings.

7.2. Culvert Bedding

7.2.1. Type A bedding shall consist of Grade 20P concrete otherwise stated on the drawings and complying with SECTION D: CONCRETING.

7.2.2. Type B bedding shall consist of clean, natural sand or gravelly sand of suitable gradation and quality with maximum particle size of not more than 20mm.

7.3. Culvert Components

Culvert shall be constructed with barrel and end treatments including headwalls, endwalls, wingwalls, outlet protection, inlet improvement and debris control structures.

7.4. Pipe Culverts

7.4.1. Reinforced concrete pipes shall conform to the requirement of *MS EN 1916* and shall be approved by the S.O..

7.4.2. The S.O. reserves the right to request for test certificates and further tests to be carried out on samples, all at the Contractor's own cost.

7.5. Precast Box Culverts

7.5.1. Precast box culverts shall conform to the requirement of *MS 1293-1* and shall be approved by the S.O..

7.5.2. Unless otherwise shown on the Drawings, the precast box culvert shall be capable of withstanding a proof load test of 112.5kN applied over an area of 320mm x 320mm at any position on the cover slab.

7.5.3. The S.O. reserves the right to request for test certificates and further tests to be carried out on samples, all at the Contractor's own cost.

7.5.4. Individual sections of the precast box culvert shall be rejected because of such defects specified herein before for pipe culverts.

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7.5.5. Precast box culverts shall be laid on Type B bedding with layer of crushed aggregate of maximum particle size not exceeding 50mm as shown on the Drawings or directed by the S.O..

7.5.6. The maximum gap between each culvert shall not be more than 13mm and the difference in level shall less than 3mm. The gap shall be filled with cement mortar (1:3) with smooth finished.

7.5.7. To ensure uniform bearing, a layer of cement grout shall be spread along the top of the walls of the invert where the lid shall sit.

8. On-Site Detention

8.1. On-site detention (OSD) facilities shall be constructed in accordance to the Drawings and conform to the requirements of *MSMA* and *MS 2526*.

8.2. The construction of OSD facilities shall include the system components at the inlet, storage and outlet zone to cater outflow discharges without causing adverse effects on downstream properties. Fencing and warning signs shall be provided as shown on the Drawings.

8.3. Maintenance shall be done periodically or as and when the silt has accumulated to 0.3m thick. The desilted material shall be transported to disposal site approved by S.O..

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1. General

1.1. All interior architectural signage shall be of acrylic plastic as approved by the S.O. unless otherwise specified in the Drawings. All panel sign surfaces shall be flat and smooth, constructed to remain flat under installed conditions within tolerance of plus or minus 1mm measured diagonally.

1.2. All external architectural signage shall be aluminium panel fabricate as approved by the S.O. unless otherwise specified in the Drawings. All panel sign shall be off corrosion free material.

1.3. All road signage shall be well coordinated and in accordance with *Arahan Teknik (Cawangan Jalan JKR)* latest edition.

1.4. All fire signages shall be complied to the *requirements of Jabatan Bomba dan Penyelamat Malaysia.*

1.5. All signage works shall comply with the regulatory requirements currently enforced and shall comply with MS 1184: *Universal Design and Accessibility in The Built Environment - CP* and *Government Immoveable Asset Code System* (*Sistem Kod Aset Tak Alih - SKATA*) as referred to sub-section 10.

1.6. Unless otherwise stated in the Drawings, the panel and lettering size, profiles and dimensional requirements of interior panel signage shall be as follows:

1.6.1. The standard thickness of cast-acrylic matt clear sheets shall be not less than 4mm.

1.6.2. Raised lettering and graphic symbols shall be of 0.8mm thickness obtained by using acrylic applique and chemically welded to sign panels.

1.6.3. The type of panel material and size of letterings shall be as indicated in the Schedule of Signage prepared by the manufacturer to the S.O.'s approval.

1.7. Graphic content and style of signage shall be in accordance with the Schedule of Signage, Shop Drawings and comply with the requirements indicated below:

1.7.1. Panel material shall be acrylic with machine-routed raised copy applied to surface of panel, along with "raster-method" Grade 2 braille beads, or pictograms and other artwork to be reverse applied vinyl or silk-screened process in colours as indicated.

1.7.2. For background colours, provide Pantone Matching System (PMS) coloured coatings, including inks and paints, that are recommended by acrylic manufacturer for optimum adherence to surface, and that are non-fading for application intended.

1.7.3. Raised copy shall be machine routed copy, provide manufacturer's full range of solid to applique colours to the S.O.'s approval.

1.8. Pictogram/Symbol shall be provided where required with S.O.'s approval.

1.9. Visual scale shall apply to the signages based on distances, colours used and font types. Consideration shall be given to legibility and vividness to aid the visually impaired visitors.

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1.10. Location, accessories and mounting positions of signs shall comply with MS 1184, manufacturer's recommendations and as approved by the S.O..

1.11. Wall mounted panel signs shall be mounted to wall surfaces using methods indicated below:

1.11.1. Vinyl-tape mounting: use double-sided very high bond (VHB) tape to adhere signs to smooth, non-porous surfaces.

1.11.2. Silicone-adhesive mounting: Use liquid-silicone adhesive recommended by manufacturer to attach signs to porous, irregular, or vinyl-coated surfaces. Use double-sided foam tape to hold sign in position until silicone adhesive has fully cured.

1.11.3. Mechanical fasteners: Use non-removable mechanical fasteners placed through pre-drilled holes in sign face, or through shim plate. Use proper anchors at masonry walls as recommended by manufacturer. Attach sign panel to shim plate using vinyl-tape method as described above.

1.11.4. Where signs are scheduled or indicated to be mounted on glass, to provide matching acrylic back plate at reverse-side of glass to conceal mounting materials.

1.11.5. After installation, soiled sign surfaces shall be cleaned and protected from damage.

1.12. All suspended signages shall be 2-sided with metal frame of 5mm clear acrylic and spray-painted with silkscreen finish or equivalent. The size of the panel signage shall be not less than 120mm (height) x 600mm (width) unless otherwise specified in the Drawings. Suspended panel signs shall be hung to soffit of slab or others approved structure using stainless steel rod or cable.

1.13. During the Contractor's drawings preparation phase, the Contractor shall provide full size mock-up samples of each type as required for inspection and subsequent approval by the S.O..

2. Copper Plating

2.1. Surface preparation of the copper plate is to be done before plating process. Cleaning process should include, degreasing, spray washing, immersion washing, stripping and or coating removal. Copper plate is to be pre-treated to receive plating treatment. Thickness of copper plating is to be of minimum 3-5µm. All copper plating should be a thick film coating with excellent levelling to cover all surface irregularities to improve the general aesthetics.

2.2. Where grainy texture is required, the copper plate should be allowed to run in copper sulphate bath or copper cyanide-based solution bath for a longer period.

3. Aluminium

3.1. Aluminium sign panels shall be preferably supported by extruded aluminium extrusions for both internal and external signs complying with the requirements of MS 2289: Aluminium and Aluminium Alloy - Extruded Shapes.

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3.2. Aluminium sheets where otherwise stated for construction shall be of minimum 3mm thick with welded angles for support. The sub-contractor is to ensure that no tin-canning or deflection effect on the sign-face. Where tin-canning effect appears on the sign face, the nominated sub-contractor is to remove and replace the sign panel.

3.3. Aluminium sheets used shall comply with the requirements of MS 2040: Aluminium and Aluminium Alloys - Sheets and Coiled Sheets - Specification. The alloy selected will be of a temper suitable for cutting.

3.4. Where signs required more than one standard size aluminium panel, the jointing shall be performed in accordance to BS 1473 by using rivets or screws with welded angles to the main panels. The joint shall than be fine sand, smoothen to be flushed to be seen as one and no butt-line joint, division or separation is to be seen.

3.5. All aluminium sections shall be fabricated from aluminium alloy B6063-T5 complying with the requirements of MS 2289: Aluminium and Aluminium Alloy-Extruded Shapes.

3.6. The aluminium shall be electronically anodized in matte finish for etched aluminium required for the fire door sign.

4. Paint Finish

Unless otherwise specified, all painting works shall be carried out as specified in SECTION O: PAINTING.

5. Screen Printing Works

5.1. Applications of screen-printing works shall be in accordance with the Drawings. The Contractor shall ensure high accuracy in printing registration and workmanship.

5.2. Silkscreen ink shall be of two (2) pack-serical poly-screen with Ultra Violet protective agents against colour fading. All finished screen-printed text or graphics shall be coated with a layer of 2-pack polyurethane clear coat matte finish.

6. Vinyl Graphic Stickers

6.1. Unless otherwise specified in the Drawings, vinyl graphic stickers shall be used as recommended by the manufacturer and approved by the S.O..

6.2. Unless otherwise specified in the Drawings, all illuminated graphics shall be of translucent graphic films and non-illuminated signs shall be translucent opaque graphic films as approved by the S.O..

6.3. All vinyl graphics shall be precision cut by computers with no jagged edge. Minimum performance of vinyl stickers shall be to the approval of the S.O..

7. Stainless Steel

7.1. Stainless steel shall be austenitic, non-magnetic, using grade 304 or 316 to BS EN 10088 and BS 1449 Part 2 for plate, sheet and strip and BS 970 where relevant. Stainless steel plate and component with hairline finish for all internal signs shall be of grade 304 4B.

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7.2. Stainless steel plate and component for all external signs shall be of marine grade 316 with alloy addition of molybdenum to prevent specific forms of corrosion.

7.3. Stainless steel fasteners, bolts, screws, bolts, washers and other fixing components shall be of Grade A2 or Grade A4 to BS EN ISO 3506.

8. Acrylic

Acrylic used for the external signage shall be of high impact acrylic. Extruded acrylic shall not be acceptable. The Contractor shall comply with the required thickness of the acrylic as shown on the Drawings.

9. Installation and Fixing Works

9.1. The Contractor shall submit a works programme and method statements for the installation of all internal and external signs. The Contractor is to include in their method statement on safety processes, measures to be taken and procedures while erecting the external signs.

9.2. Unless otherwise shown on the Drawings, all base plates for external signs shall be galvanized steel plates with drawings and calculation certified by P.E.

10. Labeling For Registration of Immoveable Asset Components

10.1. The code and format for labelling of components shall be as stipulated in the Government's:

10.1.1. Asset Code System (*Sistem Kod Aset Tak Alih – SKATA*) and

10.1.2. Asset Data Collection Guidelines *(Garis Panduan Pengumpulan Data Aset Tak Alih – PeDATA).*

10.2. All labels for the registration of the asset components shall comply with the regulatory requirements currently enforced and shall comply with the relevant International and/or Malaysian Standards.

10.3. Labels for the assets must be durable and withstand exposure to extreme conditions such as chemicals, temperature, weather, oils and detergents. The labels must also be able to withstand the rigour of cleaning schedule, maintenance and repairs.

10.4. Unless otherwise stated in the Drawings, minimum requirements for asset component labels shall be as follows:

10.4.1. Normal Condition – vinyl stickers.

10.4.2. Extreme Condition - steel / aluminium plate.

10.5. Asset component labels shall be affixed to the asset in a position that is easily accessible for readability while the asset is in normal operating position (*Refer to PeDATA).*

10.6. Labels shall be located on clean, smooth, flat surfaces where possible, and on surfaces that provide direct visual access to a label scanner and its operator.

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1. Horizontal Drains Installation

1.1. General

This work consists of furnishing and installing horizontal drain pipe. This includes drilling of holes, furnishing, and construction of jointed and end sections, as needed, to grades shown on the drawings or established on the ground. The Contractor shall furnish all necessary labour, equipment, and materials and perform all operations necessary for the installation of the horizontal drains in accordance with the details shown on the plans and with the requirements of these specifications. The drains shall consist of a Polyvinyl Chloride (PVC) pipe wrapped in a suitable filter cloth and shall be spaced and arranged as shown on the plans or as otherwise directed by the S.O..

1.2. Materials

1.2.1. Polyvinyl Chloride (PVC) Pipes

1.2.1.1. The horizontal drains shall be a prefabricated type made up of Polyvinyl Chloride (PVC) pipe of high-impact strength, Schedule 80, Type II and Grade 1, in accordance with the specification of ASTM D 1785 and shall be wrapped in a filter cloth.

1.2.1.2. The Contractor shall submit drain samples and indicate the source of the proposed materials prior to delivery to the site and shall allow sufficient time for the S.O. to evaluate the material.

1.2.1.3. At least two weeks prior to the installation of drains, the contractor shall submit to the S.O. for his review and approval, details of the sequence and method of installation. Approval by the S.O. will not relieve the Contractor of his responsibility to install drains in accordance with these specifications.

1.2.2. Filter Cloth

The synthetic filter cloth shall be a non-woven type of approved manufacture having the following properties:

1.2.2.1. Chemical Composition Requirements

Fibres used in the manufacture of the engineering fabric shall consist of a long chain synthetic polymer, composed of at least 85% by weight of polypropylene, and shall contain stabilisers and/or inhibitors added to the base plastic (as necessary) to make the fabric resistant to deterioration from ultraviolet and heat exposure.

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1.2.2.2. Physical Property Requirements

The physical properties of the filter cloth shall comply with **Table U1.**

Table U1. Physical Property Requirements for Filter Cloth

Physical Properties	Strength
Grab Strength (ASTM D1682)	0.9kN
Puncture Strength (ASTM D3787 - 80a)	0.4kN
Burst Strength (ASTM D3786 - 80a)	2100kN/m^2

1.2.2.3. Filtration Requirement

Equivalent opening size of the filter cloth determined by sieving as described in ASTM D422 is less than the 85% size of the adjacent soil.

1.2.3. Perforations

1.2.3.1. Perforations consist of two rows of slots on 120-degree centres cut around the circumference of the pipe. A special type of cutter or disc cutter shall be used to cut slots in the PVC pipes. Unless otherwise shown on the drawings, or directed by the S.O., each slot shall be between 3 to 5mm wide with a minimum of 1600 square mm of slot opening per linear m of the slotted pipe.

1.2.3.2. The slotted perimeter of the pipe shall be positioned at the top to allow inflow of underground water into the pipe and the uncut section of the pipe shall be laid at the bottom to drain the water out from the hole.

1.3. Construction

1.3.1. Requirements

1.3.1.1. The location, number and length of horizontal drains shall be decided by the designer. Unless otherwise stated, the distance between horizontal drains shall be between 1 to 3m.

1.3.1.2. The location of the drains shall not vary by more than 150mm from the locations indicated on the drawings or as directed by the S.O..

1.3.1.3. Drains that are out of their proper location by more than 150mm or drains that are damaged in construction or drains that are improperly completed shall be rejected by the S.O., and no compensation will be allowed for any materials furnished or for any work performed on such drains.

1.3.1.4. The contractor shall provide the S.O. with suitable means of making a linear determination of the quantity of drain material used.

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1.3.2. Drilling

The Contractor shall deploy suitable drilling equipment plus skilled operator and supervisor that have adequate capacity and experience to produce the drill hole according to the size, length and accuracy as shown in the Drawings and as specified in this specification

1.3.2.1. The position of each horizontal drain shall be marked and pegged clearly on the ground/slope before the commencement of drilling works. If necessary, survey equipment shall be used to locate the position of horizontal drains.

1.3.2.2. The temporary drilling platform shall be erected firmly on the ground/slope, such that no excessive movements or sway occurs during drilling.

1.3.2.3. The drain holes shall be drilled at an inclined angle into the ground/slope. The minimum angle of inclination shall be at least 2.5° upwards from the horizontal.

1.3.2.4. Dry rotary drill, auger or down-the-hole hammer shall be used. Suitable drill bit slightly larger than PVC pipe shall also be used. In ground likely to collapse, the drilled shaft shall be protected by suitable temporary casing. Drill holes shall be flushed clean on completion of drilling and the opening protected or sealed to prevent the entry of any foreign matter. A drilling record for each horizontal drain shall be carried out as specified in sub-section 1.3.5..

1.3.2.5. Drilling for the whole design length of horizontal drain shall be carried out uninterrupted and completed with necessary hole cleansing within one hour. To ensure reliable and effective cleansing of the drill holes, an additional drilled length of about 0.3m to the design length shall be provided so that cleansing of cuttings and debris towards the bottom of the drill holes by the compressed air through the drill rods can be effectively and eventually carried out. All drill rods shall be properly jointed without leakage. Alignment of drill holes shall not deviate more than 25mm in 3m in any direction.

1.3.3. Pipe Installation

1.3.3.1. Splices or connections in the drainage material shall be done in a workmanlike manner and so as to ensure continuity of drain material. Where joints are required between the pipes, the smaller end of one pipe shall be slotted into the bigger end of the other and securely bonded with a bonding material recommended by the pipe manufacturer. Slotted PVC pipe shall then be tightly wrapped in filter cloth such that the entire length of the pipe is covered by the cloth, inclusive the inner end of the pipe. All joints of the cloth shall have an overlap of at least 100mm. The entrance end of the pipe shall be securely plugged with wood, plastic, or other nonporous material. The perforated plastic pipe shall be installed in the drilled hole with the perforations on top, unless otherwise directed by the S.O..

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1.3.3.2. Non-perforated plastic pipe shall be installed at the mouth or outlet end of all horizontal drains. The non-perforated plastic pipe shall be such inside diameter that it can be slipped over the perforated plastic pipe.

1.3.4. Control of Water

Water for drilling and water encountered during the drilling operation shall be controlled to ensure that siltation or damage will not occur to adjacent roads and streams.

1.3.5. Submittals

1.3.5.1. The Contractor shall keep records for each horizontal drain installation and shall submit one signed copy to the S.O. not later than noon of the next working day after the horizontal drains have been installed. The record for each horizontal drain shall include horizontal drain reference number, date/time of commencement and completion of drilling and inserting of pipe, names of supervisor and operators, plus the necessary drilling details, etc.

1.3.5.2. Drilling records shall include:

(i) Description of drilling debris returns

(ii) Observed exceptions & peculiarities

(iii) Size, length and Class of PVC pipe

(iv) Type of filter cloth

(v) Drill hole diameter and total drilled length

(vi) Time of start & completion of drilling

1.3.6. Installation of Horizontal Drain Near Soil Nail/Ground Anchor/Rock Bolt

In case the horizontal drains are to be installed together with soil nails/ground anchors/rock bolts on the same slope, the installation of soil nails/ground anchors/rock bolts shall be completed first before the commencement of horizontal drains.

1.3.7. Concrete Lined Chutes

Where necessary, Grade 20 concrete lined chute with minimum thickness of 75mm shall be constructed to drain the water from the mouth of the horizontal drain to nearby drain.

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2. Geocell

2.1. General

2.1.1. Scope

This specification covers the general and technical requirements for the supply and installation of geocell as described herein. All materials used and the works shall meet the requirements of this specification and details shown on the contract drawings.

2.1.2. Contractor's Responsibilities

2.1.2.1. The Contractor shall provide all the necessary resources including materials, skilled workers, and plants/equipment to execute and complete the works related to supply and laying of geocell as shown on the drawings.

2.1.2.2. The Contractor shall be responsible for the true and proper setting-out of the areas to which the geocell is to be placed and for the correctness of the lines, widths, levels and slopes as shown on the contract drawings.

2.2. Material Properties

2.2.1. Product and Applications

2.2.1.1. The geocell is a flexible three-dimensional mattress and shall be made from high-density polyethylene (HDPE) strips, which are ultrasonically bonded to form multiple cellular openings.

2.2.1.2. The structure provides lateral confinement of the infill materials. The enhanced system works on the principle of friction between the infill materials and the cell walls as well as the lateral confinement forces generated by the applied load thus minimising deformation and subsequently improving the stability of the overall structure. The newly filled structure acts to redistribute the load, sustain the erosive forces to protect the underlying soil layers and reinforce the fill materials. When the geocell is applied with suitable infill materials, it offers cost-effective solutions to the following applications:

(i) Load Support
- By improving the bearing capacity of the sub-grade.

(ii) Slope Protection
- By providing a cost-effective slope protection solution where vegetation growth is difficult or impossible such as in the case of acidic soils or rocky edges, etc.

(iii) Earth Retention
- By providing confined stiffness with its cellular structure.

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(iv) Channel and Pond Bank Protection
- By enhancing vegetation growth, providing confined support and preventing the downward migration of soil particles.

2.2.2. Technical Properties

The properties of the geocell shall meet or exceed the minimum values corresponding to the respectively test methods as shown in **Table U2** and **Table U3.**

Table U2. Properties of Geocell (General)

Physical Properties	Test Method	Test Value/Data
Base Polymer	ASTM D 1505	HDPE
Polymer Density		0.938-0.960 g/cc
Colour	-	Black
Carbon Black Content	ASTM D 1603	1.3% - 2%
Env. Stress Crack Resistance	ASTM D 1693	> 2000hr
Wall Thickness	ASTM D 5199	> 1.30mm

Table U3. Properties of Geocell

Property	Units	Type		
		CRS4	CRS6	CRS8
Cell Height, H	mm	100	150	200
Minimum Cell Seam Peel Strength	N	1450	2140	2850
Dimension: Expanded Piece				
Width	m	2.2	2.4	2.8
Length	m	3.05, 6.1 or as specified		
Dimension: Expanded Cell				
Width	mm	203	203	203
Length	mm	244	244	244
Area	mm	248	248	248

2.2.3. Locally Produced Products

The geocell to be used in this contract shall be fully of Malaysian origin unless otherwise approved by the designer. The geocell shall be produced by factory with ISO certification and equipped with testing laboratory, where sampling and testing can be readily carried out.

2.2.4. Product Quality Assurance

The contractor must provide a Certificate of Approval from the Manufacturer to confirm that their Local Manufacturing Factory's production and management system are certified to be operating at least

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under Quality Management System (QMS) ISO 9001: 2008 or equivalent.

2.3. Testing

2.3.1. General

2.3.1.1. Prior to the procurement of materials, the contractor shall provide a sample and the Manufacturer's Independent Test Report (ITR), showing full compliance of the proposed geocell to all the above-specified property values corresponding to their respective test methods, for the approval of the S.O.. The S.O. reserves the right to carry out sampling at the factory to verify the test results.

2.3.1.2. All tests shall be carried out in accordance with the codes of Practices and Standards as provided within this specification, unless otherwise approved by the S.O.. The independent test report and tests shall be prepared and carried out at reputable institutions or accredited independent laboratories approved by the S.O..

2.3.1.3. Routine sample testing, when required and specified, shall be carried out at factory or at reputable institutions or independent laboratory witnessed by the S.O.'s representative. Test certificates from reputable or accredited laboratories approved by the S.O., showing the material's compliance to the specification, shall be submitted to the S.O. for verification and approval.

2.3.2. Consignment Certificate

2.3.2.1. For the purpose of ascertaining that each consignment of geocell supplied to site is of the approved type and quality and are fully from the same Manufacturer and batch as indicated, the contractor must furnish with every consignment, an original Consignment Certificate from the Manufacturer giving the following information:

(i) Name and Address of the Manufacturer

(ii) Contact telephone/fax/email address of the manufacturer

(iii) Consignment Certificate Reference Number and Date

(iv) Title of the Contract and Name of Project Owner

(v) Name and Address of the Purchaser

(vi) Product Types and Quantities, Corresponding to each consignment

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2.4. Packaging and Storage

2.4.1. Product Labelling

The geocell shall be supplied with the Manufacturer's Label/Logo on each roll showing the following identifications:

2.4.1.1. Product Brand Name

2.4.1.2. Product Type

2.4.1.3. Panel Width and Length

2.4.1.4. Batch Serial Number

2.4.2. Product Packaging

The geocell shall be supplied in panels, labelled and wrapped in packaging materials to protect against water and photo-degradation by ultraviolet light.

2.4.3. Storage at Site

2.4.3.1. The Contractor shall ensure that the geocell is properly stored in a covered area at the worksite. If no covered area is available, the geocell may be stored on raised platform and covered with waterproof canvas.

2.4.3.2. The Contractor is solely responsible for the good condition of the geocell stored at the worksite and in the event of damages or deteriorations of the geocell due to improper storage, he shall be liable to replace the affected materials at his own cost when directed to do so by the S.O..

2.5. Installation

2.5.1. General

Installation of geocell shall be carried out by qualified and experienced workers under the supervision of a qualified engineer.

2.5.2. Installation of Geocell

The geocell shall be installed in accordance with the Manufacturer's instructions. This also includes the earthworks preparation before the installation of geocell. All jointing and anchorage dowels on slopes shall be constructed according to Manufacturer's instructions.

2.5.3. Infill Material Placement

2.5.3.1. Suitable infill materials shall be as specified on contract drawings or shall consist of one of the following:

(i) Well graded aggregates with maximum size not exceeding 50mm

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(ii) Fertilised soil

(iii) Concrete Grade 25

2.5.3.2. The infill materials shall be well compacted within the cells, in accordance with the requirements of the Works Specifications and the Manufacturer's instructions as shown on the contract drawing.

3. Soil Nailing

3.1. General

3.1.1. This works specification for soil nailing shall cover all the necessary resources and materials for the supply, installation, testing and completion of soil nails in accordance with this Specification and the details shown in the Drawings or as directed by the S.O..

3.1.2. The contractor shall inspect the site, study soil investigation results and design details before preparation and submission of the method statement to the S.O. for prior approval (at least 14 days) before the commencement of works. The method statement shall describe how to execute the works to comply with the specifications and contain among other things the details of sequence of works, specific type of machines plus necessary staging to be deployed for drilling and grouting, estimated daily works output rate, necessary quality control tests/measurements/observations plus their respective frequency and acceptance criteria. Remedy or rectification shall also be proposed for cases where the acceptance criteria is not met or achieved. Specific operators/ supervisors (name, IC and CV, etc), full details of specific type of rebars plus their protection system, centralisers, spacers, grout mix details and admixtures and any other materials to be used, etc., including catalogues, test certificates and photos of the equipment and materials to be used plus the proposed machines layout for drilling, grouting and pull-out test shall be shown on drawings (A3 size) and shall also be included in the method statement. The proposals in the method statement shall meet the requirements shown on the Engineer's drawings and this specification hereafter.

3.1.3. The contractor shall be fully responsible to provide all necessary and suitable resources and materials to complete all the soil nails strictly according to this Specification. The contractor shall install the trial or preliminary soil nails and carry out the verification pull-out test as per sub-section 3.8. at locations selected by the S.O..

3.2. General Requirements

3.2.1. Setting Out

Setting out shall be as shown in the Drawing or as directed by the S.O.. Immediately before drilling or installation of soil nail, the nail head position shall be marked with suitable identifiable pegs or markers on the slope/wall for necessary inspection by the S.O..

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3.2.2. Position

The maximum allowable deviation for drill hole entry point shall not exceed 75mm in any direction.

3.2.3. Alignment of Nail

The drilling machine shall be attached with suitable alignment control devise set to attain the finished nail direction or inclination shown on the drawing and the maximum permitted deviation of alignment shall not exceed 1 in 20. Deviation from straight shall not exceed 20mm in any 3m length of drill hole.

3.2.4. Nail Out of Position or Alignment

The contractor shall demonstrate to the S.O. that the position and alignment of soil nails is within the tolerance limits specified. Any nail found out of the tolerable position or alignment shall be rejected and the S.O. shall order to add additional nails at the contractor's own costs.

3.2.5. Submittals

3.2.5.1. The contractor shall keep records for each soil nail installation and shall submit one signed copy to the S.O. not later than noon of the next working day after the soil nails have been installed. The record for each soil nail shall include soil nail reference number, date/time of commencement and completion of drilling and grouting, names of supervisor and operators, plus the necessary drilling and grouting details, etc.

3.2.5.2. Drilling records shall include:

(i) Type & model of drilling machine

(ii) Type & size of drill rods

(iii) Description of drill rate

(iv) Description of drilling debris returns

(v) Observed exceptions & peculiarities

(vi) Checking on straightness, cleaning & alignment

(vii) Total drilled length

(viii) Time of start & completion of drilling

3.2.5.3. Grouting records shall include:

(i) Type & model of colloidal mixer & paddle mixer

(ii) Type & model of pump

(iii) Grout mix design details (W/C ratio, admixture, etc)

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(iv) Results of bleeding, flow cone efflux time and strength tests

(v) Conditions of pull-out check on centralisers (photos and description as per sub-section 3.5)

(vi) Time of start & completion of grouting

(vii) Volume of grout consumed

(viii) Observed exceptions (loss of grout, etc)

3.2.5.4. Format and details of record and layout of nail shall be approved by the S.O.. Other important submittals are method statement [sub-section 3.1.1], test certificates [sub-section 3.3.1.3], pull-out test reports (sub-section 3.8.), quality control tests as specified, as-built drawings (showing nail layout plan, nail reference number, length, date completed, etc.) and project completion report, which shall include the following chapters:

(i) Table of contents

(ii) Introduction

(iii) Design drawings and finalized BQ

(iv) Method Statement

(v) Works programme

(vi) Drilling & Grouting records

(vii) Quality control tests results for drilling, grouting, guniting, etc.

(viii) Catalogues test certificates for rebar, centralisers, coupler HDPE sheath, etc

(ix) Pull-out test results, including test layout, drawings, photos, calibration records & certificates

(x) As-built drawings

(xi) Photos showing drilling layout, drill rod, head, drilling operation, etc.

(xii) Photos showing grouting layout, colloidal mixer, paddle mixer, pump, etc.

(xiii) Photos showing how the rebar is fixed with centralisers etc.

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3.3. Materials

3.3.1. Reinforcement

3.3.1.1. Reinforcement for soil nails shall be high yield steel reinforcing bars complying with M.S. 146, threaded and hot-dip galvanized to BS EN ISO 1461. The nail bars shall be threaded at the ends for a sufficient length (minimum 150mm long) to facilitate fixing of galvanized washer, overlap locking washer and nut at the exposed end and fixing of galvanized coupler at the other end, if required.

3.3.1.2. The tensile strength and galvanized rebar quality of the coupled nail bar shall be not less than 410N/mm^2 or specified on Drawings.

3.3.1.3. Only soil nails of more than 12m long shall have rebars spliced or coupled. The tensile strength of the coupler shall be capable to develop at least 95% of the tensile strength of the rebar as tested and certified by the manufacturer. Test certificates from reputable or accredited laboratories approved by the S.O., showing the material's compliance to the specification, shall be submitted to the S.O. for verification and approval.

3.3.2. Cement Grout

3.3.2.1. Cement for grouting shall be Ordinary Portland Cement complying with MS 522.

3.3.2.2. Grout shall consist of cement and water. Water cement ratio shall be 0.45 to 0.50 and minimum cube strength of 7-day strength and 28-day strength shall be 20MPa and 30MPa respectively (BS 1881). Sand shall not be used unless approved by the S.O.. Water shall be from approved public water supply and shall comply with the quality specified in MS 28. Suitable admixtures shall be used to improve flowability and bleeding or shrinkage problem. Admixtures shall comply with the requirements of BS 5075: Part 1 and Part 3 and shall only be used with the prior approval of the S.O.. Grout shall be thoroughly mixed by suitable high speed colloidal mixer (> 1000rpm) until a homogeneous grout free from undispersed cement, lumps and bleeding is obtained. The grout after mixing for a few minutes shall be transferred through a 5mm sieve into a storage tank attached with paddle agitator.

3.3.2.3. The following important quality control tests shall be carried out:

(i) Crushing strength of 100mm cubes at 7-days and 28-days (BS1881) shall be minimum 20 and 30MPa respectively.

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(ii) Bleeding test (<0.5 % by volume 3 hours after mixing or 2 % (maximum) when measured at 20°C in a covered glass cylinder of 100mm diameter and with a grout depth of 100mm). In addition, the water shall be re-absorbed within 24 hours. Free expansion shall not exceed 10 %.

(iii) Flow cone efflux time test (<15 seconds, ASTM C939-87).

3.3.2.4. If any of the above results falls below the acceptable limits, at least one or 1% of grouted working nails shall be subject to pull-out test (sub-section 3.8.) at the contractor's own cost.

3.3.3. Centralisers

3.3.3.1. Centralisers shall be tightly fixed to the rebar at the spacing as shown on the Drawing. The centralisers shall be firm and as small as possible (not more than 50 % of the nail section) so that the blockage of grout flow is minimum. Centralisers shall be fixed inside and outside of the protective sheath, if applicable, and shall be spaced at not more than 2m. Centralisers shall be sized to position the rebar within 25mm of the centre of the drill holes; and to allow tremie pipe (about 30mm diameter) insertion to the bottom of the drill hole. The centralisers shall be produced by reputable manufacturer or specialist using galvanized steel strips or PP (polypropylene) or PVC (polyvinyl chloride) and comply with following properties:

(i) Tensile strength (BS 2782: Part 3, Method 320°C) > 30Mpa

(ii) Hardness (BS 2782: Part 3, Method 365B) > 65

(iii) Brittleness temperature (ASTM D746-79) < 5°C

(iv) Environmental Stress Cracking Resistance (ASTM D1693-70): 200 hours (no cracking)

3.3.3.2. Test certificates from reputable or accredited laboratories approved by the S.O., showing the material's compliance to the specification, shall be submitted to the S.O. for verification and approval.

3.3.4. Corrugated HDPE Sheath

3.3.4.1. The size, shape and length of the sheath to protect the rebar shall be as shown on the Drawing or as directed by the S.O. The sheath shall consist of HDPE (high density polyethylene) tube with wall thickness not less than 1.0mm and shall be at least 5mm of grout cover over the nail rebar within the sheath. The thickness of grout between the HDPE sheath and the sides of drill hole shall be not less than 25mm. Other important properties that shall be complied are as follows:

(i) Tensile strength (BS 2782: part 3, method 320C) > 25Mpa

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(ii) Softening point (BS 2781: Part 3, method 120A) >110°C

(iii) Environmental stress cracking resistance (ASTM D1693-70): 200 hours (no cracking)

(iv) Hydrostatic pressure resistance (BS 6437): no localized swelling, leaking or weeping

3.3.4.2. Test certificates from reputable or accredited laboratories approved by the S.O., showing the material's compliance to the specification, shall be submitted to the S.O. for verification and approval.

3.3.5. Materials Handling and Storage

3.3.5.1. Cement shall be stored properly to prevent moisture degradation and partial hydration. Cement that has been caked and lumpy shall be rejected and discard. Rebars shall be stored on firm supports to prevent the steel from contacting the ground. Damage to the rebar as a result of abrasion, cuts, nicks, welds and weld splatter shall be cause for rejection. Rebars shall be protected from dirt, rust and other deleterious substances prior to installation. Heavy corrosion or pitting of rebars shall be cause for rejection. Anchorage end of rebars to which bearing plate and nuts will be attached shall be protected by some protective wrap during handling, installation, grouting and guniting.

3.3.5.2. Pregrouted rebars in HDPE sheaths shall not be moved or transported until the grout has reached sufficient strength to resist damage during handling. The pregrouted rebars shall be handled with care and with sufficient supports to prevent large deflections, distortions or damage. Conditions of the pregrouted rebars shall be checked first before inserting into the drill holes. Damaged pregrouted rebars shall be rejected.

3.4. Drilling

3.4.1. The contractor shall deploy suitable drilling machine and tools plus skilled operator and supervisor that have adequate capacity and experience to produce the drill hole according to the size, length and accuracy as shown in the Drawings and as specified in this specification.

3.4.2. Unless otherwise directed or approved by the S.O, only dry rotary percussion method by top hammer or down-the-hole hammer shall be used. Suitable drill bit of not less than 100mm diameter shall be used. In ground likely to collapse, the drilled shaft shall be protected by suitable casing. Drill holes shall be flushed clean on completion of drilling and the opening protected or sealed to prevent the entry of water or any foreign matter. A drilling record for each soil nail shall be carried out as specified in sub-section 3.2.5..

3.4.3. Drilling for the whole design nail length shall be carried out uninterrupted and completed with necessary hole cleansing within one hour. To ensure reliable and effective cleansing of the drill holes, an additional drilled length of about 0.6m to the design length shall be provided so that cleansing of cuttings and debris towards the bottom of the drill holes by

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the compressed air through the drill rods can be effectively and eventually carried out. All drill rods shall be at least N size and can be properly jointed without leakage. Alignment of drill hole shall not deviate more than 20mm in 3m in any direction. At least 1% of the drilled holes shall be selected for straightness test by inserting 100mm diameter tube to the designed length. Drilled holes that cannot pass the test shall be redrilled and the suitability of the drilling machine be reassessed.

3.4.4. Adequate temporary or permanent site drainage or temporary tarpaulin shall be provided to prevent infiltration from surface run-off into the slope where soil nailing is carried out.

3.5. Insertion of Reinforcement

3.5.1. The galvanized rebar fixed with centralisers as shown on the drawing shall be checked before inserting into the drill hole. The rebar shall be carried by experienced workers at spacing not greater than 3m.

3.5.2. After inserting about 75% of the total design length, the rebar shall be withdrawn to check the conditions of the centralisers and contamination of rebar. Such pull-out check shall be carried out on at least 1% of the nails especially for those drill holes that have been left for more than 2 hours after completion of drilling. If collapse of drill hole is suspected, redrilling and flushing have to be carried out as directed by S.O. Damaged centralisers shall be replaced immediately and rechecked.

3.6. Grouting

Grout mix shall be prepared and tested according to sub-section 3.3.2. Layout of machine plus the capacity, etc, shall be as shown in method statement and approved by the S.O before mobilization. Grout shall be pumped into its final position in drill hole through a grouting tube of about 25mm diameter by tremie method under gravity or low pressure (< 5 bars) as soon as possible/immediately after the completion of hole drilling and is not more than 30 minutes after mixing. Grouting shall be carried out within two hours after drilling and cleansing of drill hole are completed. Grouting shall be carried out promptly and continuously in one operation without interruption to avoid any disturbance caused by sedimentation within the grout and to reduce air bubble entrapment. Full operation shall continue until injected grout of the same composition and consistency as that mixed emerges from the drill hole outlet for at least one minute. Failure to comply with these requirements may result in either the works being rejected or recleansing plus proof pull-out test at the contractor's own costs.

3.7. Nail Head Construction

3.7.1. All the disturbed, loose or soft soil around nail head shall be removed and replaced by non-shrink mortar of grade 30 strength or approved equivalent by the S.O..

3.7.2. Nail head with steel plate shall be in a plane normal to the nail axis clamped down with galvanized nut and washers to the clamping down forces of 5kN (min) or as shown in the Drawings, using a calibrated torque wrench. Clamping shall be carried out with a thin layer (< 25mm) of fresh non shrink mortar (grade 30) behind the steel plate to ensure proper seating. Nail head construction shall only be carried out after the grout and the mortar have reached at least 7-days strength (>20MPa).

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3.8. Pull-Out Tests

3.8.1. The contractor shall provide all necessary resources including all torque wrenches, jacks, gauges, reaction frame, pump, load cell, bearing plates, and other equipment required to carry out the pull-out test of the soil nails specified. Measurement of nail head movement shall be made using at least 2 dial gauges capable of measuring to 0.025mm accuracy.

3.8.2. The contractor shall also present up-to-date test (not more than 1 year ago) and calibration certificates to the S.O for the equipment that are proposed for testing for approval before the test commences. Method statement and layout of pull-out test as specified in sub-section 3.1. shall also be submitted. The location of soil nail to be tested shall be selected by the S.O..

3.8.3. Purpose of pull-out test up to 2.0 times the design pull-out resistance/load or as specified on drawings is to verify the designed pull-out resistance or designed bond strength between the grout and the soil/rock and also to verify the adequacy and suitability of drilling, installation and grouting techniques. The design/allowable pull-out resistance, Q_d (kN/m) shall be as shown on the drawing or determined by the S.O at site.

3.8.4. Pull-out test shall be carried out at least 72 hours after grouting or when the grout has achieved at least the specified 7-days strength (> 20MPa). Testing equipment including dial gauges, gauge supports, jack and pressure gauge, load cell, etc., shall be sufficiently rigid and shall be protected from sunlight and rain by some canvas. The complete jacking system including hydraulic jack, pump, and pressure gauge should be calibrated as a single unit before use to an accuracy of not less than 5% of the applied load. The center and bearing plates of the jack system shall be properly arranged so that the test nail will not carry the weight of the testing equipment. The gauge used to measure the nail head movement shall be aligned parallel with the axis of the nail and the support of the gauges shall be independent from the jack and the reaction frame. Load cell is important to maintain constant load hold during the creep test load hold increment. The jack and pressure gauges shall have a pressure range not exceeding twice the anticipated maximum test pressure. Jack ram travel shall be sufficient to allow the test to be done without resetting the equipment.

3.8.5. At least 2 preliminary pull-out tests or verification or sacrificial tests up to 2.0 times the design pull-out resistance, Q_d or as specified on drawing shall be carried out for different soil/rock unit or for different drilling/grouting method for each nailed slope/hill or as specified and directed by the S.O..

3.8.6. For the soil nails selected for pull-out test, the temporary unbonded length (L_u) of the test nail shall be at least 1m, i.e. the bonded length (L_b) of the soil nail selected for pull-out test shall be $L_b = L - L_u$, where L = total soil nail length. To prevent collapse of the unbonded drill hole during the test, a temporary GI pipe of about 1m long near the slope surface shall be installed. In case the drill hole is fully grouted, a GI pipe of about at least 600mm long and slightly larger than the grouted hole shall be driven to ensure the reaction force is not transmitting to the grouted hole near the slope surface. L_b shall be at least 3m.

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3.8.7. The loading schedule for verification test is as shown in **Table U4.**

Table U4. Verification Test Loading Schedule

Load	Holding Time (Minimum)
(5% DTL), alignment load	1 minutes
0.25 DTL	10 minutes
0.50 DTL	10 minutes
0.75 DTL	10 minutes
1.00 DTL	10 minutes
1.25 DTL	10 minutes
1.50 DTL (Creep Test)	60 minutes
1.75 DTL	10 minutes
2.00 DTL (Max test Load)	10 minutes

DTL = Design Test Load (kN) = L_b x Q_d

L_b = Pull-out test bonded length

L_b = Design nail length - unbonded length

L_b shall not exceed $0.9f_y A_s$ / 2.0 Q_d, where f_y and A_s are yield stress and area of rebar respectively.

Q_d = f_a x πd
= Design allowable pull-out resistance (kN/m) specified in the Drawing or by the Designer. f_a=design allowable bond stress (kN/m^2), d=diameter of nail in m.

3.8.8. The alignment load shall be the minimum load required to align the testing apparatus. Dial gauges shall be set to zero after DTL is applied. At least 2 calibrated dial gauges of 0.025mm accuracy shall be used to measure nail head movement. Each load increment shall be held for at least 10 minutes. Nail movement at creep test (1.50 DTL) shall be taken at 1, 2, 3, 5, 6, 10, 20, 30, 50 and 60 minutes. The load during the creep test shall be maintained within 2% of the intended load by use of a calibrated load cell.

3.8.9. For working pull-out tests or proof tests, the testing procedure including creep test is similar to verification test except that the max test load (MTL) = 1.5 x DTL.

3.8.10. A pull-out test is deemed satisfactory and acceptable when all the following criteria are met:

3.8.10.1. For verification tests, the total creep movement is less than 2mm between the 6 and 60 minute readings measured during the creep test and the creep rate is linear or decreasing throughout the creep test load hold period.

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3.8.10.2. For proof tests, the total creep movement is less than 1mm measured between the 1 and 10 minute readings or the creep movement is less than 2mm during the 60 minute readings and the creep rate is linear or decreasing throughout the creep test load hold period.

3.8.10.3. The total measured movement at the maximum test load (MTL) exceed 80% of the theoretical elastic elongation (l_e) of the test nail unbonded length ($l_e = 0.8P\ (L_u)\ (10^6)/\ A_s\ E$, where P = max applied load (kN), L_u = length from the back of nail to jack connection to the top of the bond (m), A_s = rebar cross-sectional area (mm^2) and E = rebar's modulus = 200,000 MPa).

3.8.11. A pull-out failure does not occur at the maximum test load. Pull-out failure is defined as the load at which attempts to further increase the test load simply result in continued pull-out movement of the test nail.

3.8.12. The contractor shall submit the results of pull-out tests to the S.O for final interpretation and necessary design review immediately after the test. Full formal report of pull-out test including all plotting, method statement, test length, photos, test certificates, etc. shall be submitted to the S.O within 1 week after the test.

3.8.13. For verification test nails, the S.O shall evaluated the results and make necessary design review after consultation with the designer. Installation methods that do not satisfy the nail testing requirements shall be rejected and replacement test nails shall be installed and tested at no additional cost.

3.9. Calibration

Calibration of gauges for pull-out test shall be submitted together with calibration record and testing certificate and the validity must be not more than 1 year.

4. Guniting

4.1. General

4.1.1. This works specification for guniting covers the technical requirements for gunite mix, machine and plant, surface preparation, method of operation, quality control and works acceptance criteria.

4.1.2. The Contractor shall apply gunite to the excavated slope surfaces at locations shown on the drawings or at locations directed by the S.O..

4.1.3. "GUNITE" is a mixture of cement, sand or aggregate and water projected at high velocity from a suitable nozzle onto slope to produce a dense homogeneous protective layer. The maximum aggregate size shall be less than 10mm.

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4.1.4. "Dry Process" is a mixture of cement, aggregate and sand weighted or volume batched, thoroughly mixed 'dry' and fed into a purpose-made machine where the mixture is suitably pressurized, metered into a dry air stream and conveyed through hoses or pipes to a nozzle before which water is introduced to hydrate the mix and is projected without interruption onto slope surfaces.

4.1.5. "Rebound" is a term used for all material having passed through the nozzle which does not conform to the definition of gunite as defined above.

4.2. Materials

4.2.1. Cement

Cement shall be Ordinary Portland Cement and comply with the requirements of MS 522.

4.2.2. Sand / Aggregate

Sand or aggregate shall be clean and durable, and free from clay or organic matters and other impurities. The sand and aggregate shall be not more than 10mm and shall comply with the requirements of MS 29 and MS 30. The grading limits for the sand and aggregate mixture shall be as shown in **Table U5:**

Table U5 Grading Limits for Sand / Aggregate

Sieve Size	Percentage Passing (%)
10.0mm	100
5.0mm	90-100
2.36mm	75-100
1.18mm	55-90
600μm	35-59
300μm	8-30
150μm	0-10

4.2.3. Water

Water for mixing shall be clean and free from harmful matter. Where tests are required, they shall be in accordance with the requirements of MS 28.

4.2.4. Reinforcement

Unless otherwise stated in the drawings steel fabric reinforcement shall be hard-drawn steel wire reinforcing fabric with minimum wire diameter of 6mm pitch of 200mm in each direction (wire mesh A6) and comply with the requirements of MS 145.

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4.2.5. Mix

4.2.5.1. The gunite shall have a minimum cement content of 350kg per cubic meter and with water/cement ratio of not exceeding 0.5 by mass. Mix proportions shall be designed by the Contractor to achieve minimum grade 30 or the specified grade of strength as shown on the Drawing and shall be approved by the S.O. before commencement of works.

4.2.5.2. Mixed dry aggregate and cement, which are not applied on slope surfaces within 30 minutes after mixing, shall be discarded.

4.2.5.3. Admixtures shall be added at 3 – 5% by weight of cement to speed the setting rate of cement, when directed by the S.O..

4.2.5.4. All constituents shall be uniformly dispersed throughout the mix. Mixing by hand is **NOT** allowed.

4.3. Plant and Equipment

Before commencement of work, the Contractor shall submit to the S.O. for approval, the type, make and number of plant and equipment to be used. A drawing showing the proposed plant and works arrangement with brief description about the equipment, the method of operation and mix proportion, etc., shall be included in the method statement as specified in subsection 4.10.1..

4.4. Preconstruction Test Panels

4.4.1. The purpose of preconstruction tests panels is to assess the quality of guniting with respect to density, uniformity, thickness, strength, and works output rate to ensure the resources for guniting works are satisfactory with respect to skill and quality.

4.4.2. Preconstruction testing shall be carried out using plant identical to that proposed for the works and shall be undertaken in such time before the commencement of the works as to allow approval by the S.O..

4.4.3. Trial mixes of each mix design proposed shall be carried out by the Contractor. For each mix design, 3 number of test panels of minimum size 750mm x 750mm x 100mm thick shall be sprayed from each position required in the works, such as down-hand, vertical and overhead positions, with layer thickness appropriate to that position. Panel moulds shall be formed from 20mm thick plywood adequately braced and held rigidly in position.

4.4.4. Where required by the S.O., test panels of minimum size 750mm x 750mm x 100mm thick shall be sprayed from each position required in the works.

4.5. Interface Preparations

4.5.1. Earth or natural surfaces other than rock shall be compacted, trimmed and graded according to the design grade before guniting. The newly excavated or trimmed slope shall be immediately and adequately protected against infiltration by immediate guniting or protected by tarpaulin sheet or other method approved by the S.O.. The earth surface

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shall be maintained at equilibrium moisture, as directed by the S.O. (not too wet or too dry before guniting). Gunite shall **NOT** be applied on surfaces with loose or soft or wet materials.

4.5.2. Rock surfaces shall be cleaned and free from loose materials, mud or foreign matters. After washing down with water, the rock surfaces shall be damp but exhibiting no free water prior to guniting.

4.5.3. Where flow of water interferes with the application of gunite or cause leaching of cement, the flowing water shall be directed by appropriate drainage channels to convenient locations where plugging can be carried out.

4.5.4. The reinforcement shall be cleaned and free from loose mill scale, loose rust, oil or other coating prior to the application of gunite. All reinforcement shall be stored under cover and clear of the ground. Any reinforcement that is pitted with rust shall be rejected. The reinforcement fabric shall be securely and firmly fastened with the dowels shown on the drawing and supported with approved spacers at about 1.6m spacing to provide 50mm clearance cover between the fabric and the slope surface.

4.6. Normal Guniting Procedure

4.6.1. Before starting work, the Contractor shall submit to the S.O. for approval a detailed schedule of the entire guniting operation and method statement of works. Approval of such schedule and method statement shall not relieve the Contractor of its responsibility to provide a fully satisfactory installation. The Contractor shall include with his submission evidence that he has successfully completed a gunite installation using the procedures similar to those proposed.

4.6.2. All reinforcement shall be firmly fixed with the dowels, weep holes and spaces to give the required cover, clearance, or laps as described or specified. Guniting shall commence from the top or upslope downwards to ensure no ingress of runoff below the gunite. Guniting shall be carried out by directing the nozzle perpendicularly to the surface to be gunited.

4.6.3. Guides shall be set-up to establish good finish surfaces. Gunite shall only be applied in the presence of the S.O. or his representative and shall be built up in successive layers, each layer generally not exceeding 50mm in thickness, such that sagging, and bleeding do not occur. Gunite shall be applied evenly without any sags or slumps. All reinforcement shall be completely surrounded by gunite.

4.6.4. Whenever the spraying operation becomes irregular, the nozzle shall be directed away from the works area and all spraying shall stop.

4.6.5. The Contractor shall be required to monitor closely the progress of the guniting works. Daily site records of all materials delivered to the concrete mixer shall be properly maintained and made available to the S.O. when required.

4.6.6. All gunite shall be cured continuously for 7 days or by approved curing compound or equivalent.

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4.7. Rebound

4.7.1. All rebound and loose materials shall be removed by air jets or other means from the surface of each layer as work proceeds. Rebound shall not be worked into the sprayed area or re-used in the works.

4.7.2. All surfaces which are not to receive gunite shall be protected by approved methods.

4.8. Construction Joints

The type and positions of all construction joints shall be approved by the S.O.. Construction joints shall be formed by placing or trimming the sprayed gunite layer to an angle of approximately 30°.

4.9. Weep Holes

Before starting works, the Contractor shall submit to the S.O. for approval a detailed proposal for the construction of weep holes. The location and spacing of weep holes shall be as shown on drawings.

4.10. Quality Control

4.10.1. Method Statement

The contractor shall submit method statement of works to the S.O. for prior approval by at least 7 days before commencement of works. The method statement shall contain details of material of specified quality, machines of specific model and capacity, operator and technician and his CV plus the estimated daily output to ensure the works can be completed within the scheduled work programme required. Quality control tests with respect to type and frequency plus the respective acceptance criteria shall also be included in the method statement. Remedial measures shall also be described in the method statement in cases where the acceptance criteria cannot be complied. In brief, method statement shall clearly describe how the guniting work will be carried out with particular reference to sequence of works, realistic work output, quality control and resources requirements, etc., to ensure the guniting work can be completed within the stipulated or agreed time frame according to the specification and approved programme. Method statement shall be prepared by experienced engineer who has extensive and intensive working experience and also is knowledgeable about the characteristics, capacity and efficiency of the resources available to his disposal. In addition, the engineer shall have inspected the site and surrounding conditions thoroughly and assesses how the specific conditions will affect the output of his resources.

4.10.2. Rebound hammer test has to be carried out on pre-construction test panels at locations selected by the S.O. (at least 30 points). The Contractor has to redesign the mix and change equipment or nozzleman if the results of any cube or any rebound hammer test are below the specified strength shown on the drawing.

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4.10.3. For every 300m^2 of completed gunite works, a series of rebound hammer test (30 test point per series) has to be carried out to verify the strength (28 days strength). The S.O. reserves the right to reject the gunite work if the average test result is below the specified strength.

4.10.4. All the weep holes shall be marked by red paint to show the required effective thickness of gunite specified on the drawings.

4.10.5. Prior to spraying of gunite, the Contractor shall request inspection by the S.O. and a photo (minimum one photo for every 300m^2) shall be taken to show the thickness markings. In addition to the markings, coring to check the thickness of gunite shall be subsequently carried out. Coring (100mm diameter) shall at a rate of one core per 500m^2 at locations selected by the S.O. for checking the thickness and quality of gunite (void/honeycomb). The drilled holes shall be backfilled with dry-packed compressive (1:3) mortar. Documental evidence by photo for each core shall be carried out. The S.O. reserves the right to reject the gunite works if the thickness of gunite is found inadequate or the gunite is found porous or low strength (less than the specified value). Further coring (1 core per 200m^2) shall be carried out at Contractor's own costs if defective works are detected.

4.10.6. The Contractor shall engage a specialist geotechnical engineer accredited by BEM or ACEM/IEM, to study and propose rectification works, when defective works are identified and directed by the S.O.. The Contractor shall be fully responsible for the costs, time delay in works and other incidental consequences for the defective works. The proposed rectification works, if accepted by the S.O., shall be carried out at the Contractor's own costs.

5. Rock Bolts and Rock Dowel

5.1. Description

This works consists of furnishing and installing rock reinforcing bolts and rock reinforcing dowels, complete with component parts, at locations shown or designated.

5.2. Work Plan

The Contractor shall submit a detailed work plan to the S.O at the preconstruction conference. Details to be included are as follows:

5.2.1. Proposed construction schedule and sequence.

5.2.2. Proposed drilling methods and equipment.

5.2.3. Proposed components for rock reinforcing bolts and rock reinforcing dowels, couplers, bearing plates, rock reinforcing bolt mechanical anchorage system, flat washers, and beveled washer specifications including the manufacturer's data sheets.

5.2.4. Proposed drill hole diameter.

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5.2.5. Proposed grout mix design, with polyester, resin, or epoxy specifications including manufacturer's data sheets. Include the procedures for placing the grout.

5.2.6. Proposed corrosion protection for the rock reinforcing bolt and rock reinforcing dowel systems.

5.2.7. Proposed installation, stressing procedures, torque wrench, test jack, and pressure gauge to be used.

5.2.8. Calibration data for each torque wrench, test jack, and pressure gauge to be used. An independent testing laboratory shall have performed the calibration tests within 60 calendar days of the date submitted. The torque wrenches shall have a capacity at least 20% greater than the rock reinforcing bolt manufacturer's recommended torque to achieve the design and test loads. The torque wrench shall have an accuracy of at least ± 2% of the full-scale reading, and a resolution of at least 1% of the full-scale reading.

The S.O will respond within 21 days after receipt of the submittal. The Contractor shall not proceed with the work until the S.O has approved the submittal in writing.

5.3. Material

5.3.1. The Contractor shall provide rock reinforcing bolts, corresponding hardware, and grout from the manufacturer approved by the S.O.. Provide rock reinforcing dowels, corresponding hardware, and polyester or epoxy resin from a manufacturer regularly engaged in the manufacturer of rock reinforcing dowels. Additionally, all portions of rock reinforcing bolts and rock reinforcing dowels, accessories, and hardware shall have an approved corrosion protection coating. All non-exposed portions of rock reinforcing bolts and rock reinforcing dowels, accessories, and hardware shall be coated prior to installation. The use of cement grout for rock reinforcing bolts and polyester or epoxy resin for rock reinforcing dowels will not substitute for the required protective coatings.

5.3.2. The Contractor shall use proven non-shrink epoxy and polyester resin for rock reinforcing dowels capable of permanently developing the bond and internal strength between the rock reinforcing dowel and rock. Use a single speed cartridge system to anchor the dowel in rock. Select the cartridge diameter according to the recommendations of the manufacturer to ensure complete encapsulation of the rock reinforcing dowel and satisfactory in-hole mixing. An epoxy or polyester resin shall be selected with a gel time which is consistent with rapid installation. Epoxy or polyester resin to be incorporated into the rock reinforcing dowel installation shall be within the shelf-life period stated by the manufacturer. Provide samples of the epoxy or polyester resins for testing upon request of the Engineer. Store polyester or epoxy resins according to the manufacturer's recommendations.

5.4. Equipment

The Contractor shall provide all equipment necessary for drilling and placement of rock reinforcing bolts and rock reinforcing dowels at the locations and depths designated by the S.O.. For rock reinforcing dowels, provide equipment to spin

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the dowel into place and properly mix the epoxy or polyester resin according to the manufacturer's recommendations.

5.5. Labour

5.5.1. The Contractor shall furnish personnel skilled in the installation of rock reinforcing bolts and rock reinforcing dowels. Experience shall be relevant to anticipated rock conditions and size of rock reinforcing bolts and rock reinforcing dowels being installed. The foreman and drill operator shall have no less than two years of demonstrated experience in rock reinforcing bolt and rock reinforcing dowel installation. The Contractor shall submit documentations relating its experience on similar jobs to the S.O. at the preconstruction conference. Details of the documentation shall include reference names and phone numbers, project names, locations, the year actually constructed.

5.5.2. The S.O will respond within 21 days after receipt of the submittal. If, after checking references submitted by the Contractor, it is in the judgment of the S.O that the proposed employees are not qualified; they will not be permitted to work on the Project. The Contractor shall not proceed with the work until the S.O has approved the submittal in writing.

5.6. Construction

5.6.1. Protection of Material

The Contractor shall protect rock reinforcing bolts and rock reinforcing dowels at all times from damage and corrosion. Corrosion, pitting or damage to the rock reinforcing bolt or rock reinforcing dowel may be cause for rejection. Damage includes, but is not limited to, abrasions, cuts, nicks, welds, and weld splatter. Prior to installation, remove all mill scale, flaking rust, and grease.

5.6.2. Installation

The Contractor shall drill holes to the diameter and depth recommended by the manufacturer. Unless otherwise directed, align drill holes normal to the rock face or as specified. The drill holes shall be cleaned of all drill cuttings and debris prior to installing the rock reinforcing bolt or rock reinforcing dowel.

5.6.2.1. Rock Reinforcing Bolt

The Contractor shall install and tension each rock reinforcing bolt to the design load before grouting. The Contractor shall conduct proof testing of each bolt as described in sub-section 5.7.1. Grout shall be placed in the drill hole to ensure the filling of the entire space between the bolt and sides of the drill hole, and the full encapsulation of the bolt. The grout shall be pumped to the far end of the drill hole and continue pumping until grout is forced out of the de-airing tube at the face of the hole. After testing and grouting, cut the bolt off, if necessary, so that no more than 75mm extends beyond the nut.

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5.6.2.2. Rock Reinforcing Dowel

The Contractor shall place the resin cartridges in the drill hole at a sufficient spacing to cause excess resin to be forced out the face of the hole when the rock reinforcing dowel is spun into place. Failure of resin to be extruded from the face of the hole may be cause for rejection of the bolt installation. After installation of the plate and nut, torque the nut to a nominal 73.8 Joules to ensure proper seating against the rock surface. The Contractor shall conduct proof testing of rock reinforcing dowels as described in sub-section 5.7.2.. After testing, cut the bolt off, if necessary, so that no more than 75mm extends beyond the nut.

5.7. Proof Testing

Perform proof testing according to the following:

5.7.1. Rock Reinforcing Bolts

The Contractor shall tension each production rock reinforcing bolt installed to 120% of the design load using a calibrated hollow ram hydraulic jack and hold that tension for a minimum of 10 minutes. The S.O. will analyse the rock reinforcing bolt test results and determine whether the rock reinforcing bolt is acceptable. If no loss of load occurs in this time period, the rock reinforcing bolt is accepted. If a rock reinforcing bolt fails this test, the rock reinforcing bolt will be rejected, and a replacement bolt installed in a separate hole adjacent to the failed bolt. The Contractor shall test the new rock reinforcing bolt. The S.O. may require additional proof testing if any rock reinforcing bolts fail. No additional payment will be made for failed rock reinforcing bolts or for additional proof testing. After tensioning and testing, the Contractor shall lock off at 100% of the design load and grout the bolt. Grouting shall be carried out within 3 days of tensioning the rock bolt to provide corrosion protection and lock the tension stress permanently into the system.

5.7.2. Rock Reinforcing Dowels

The Contractor shall proof test up to 5%, but not less than 3 of installed rock reinforcing dowels. The proof test shall be conducted by the Contractor and the Engineer will interpret the results. The Contractor shall tension the rock reinforcing dowel to 44.5kN with a calibrated hollow ram hydraulic jack and hold the load for 10 minutes with no loss of load. A rock reinforcing dowel will be considered to have failed if any movement of the dowel occurs. The S.O. may require additional proof testing beyond the 5% if any rock reinforcing dowels fail. Failed rock reinforcing dowels shall be replaced with a separate rock reinforcing dowel installed in a separate hole. No additional payment will be made for failed rock reinforcing dowels or for additional proof testing.

6. Ground Anchor

6.1. General

6.1.1. This specification deals with ground anchors and shall be read in conjunction with the conditions of contract and the Specification for

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Earthwork. The Contractor shall comply fully with the requirements of this specification in the design, erection and installation of ground anchors.

6.1.2. Where works are ordered to be performed by the Contractor but are not specified in this specification, the Contractor must carry them out with full diligence and expedience as are expected for works of this nature and shall comply with the relevant clauses of the British Standard Code of Practice for Ground Anchorages, BS 8081:1989.

6.2. Scope of Works

The contract comprises the provision of all labour, tools, plants, materials, transportation and all necessary equipment for the following works:

6.2.1. Design, supply, construct, install and test ground anchors as part of a permanent ground retaining system to support with safety the sides of open excavations.

6.2.2. Any other incidental works necessary to ensure the safety and satisfactory performance of the permanent earth retaining system.

6.3. Responsibility of the Contractor

6.3.1. The Contractor shall be experienced in ground anchor design (compression anchorage) and construction and shall have equipment and manpower suitable for the work and available for the entire operation of the work. The Contractor shall be wholly responsible at all times for the safety of works. He shall instruct his workers and all other personnel about the danger zones during the stressing of the anchors.

6.3.2. The Contractor is expected to study and place his own interpretation on the geotechnical data provided as well as obtain further data if he feels necessary. The Contractor shall give due consideration to existing underground utilities and limit of boundary in the design and installation of anchors.

6.3.3. The Contractor shall engage a licensed surveyor to set out benchmarks and reference points from which to layout his work. It is the responsibility of the Contractor to acquire necessary permits and documents from the relevant authorities to carry out the work.

6.4. Designed by Specialist Contractor

6.4.1. The Contractor shall include in the submission of the tender, for the S.O.'s review, his proposed design of ground anchors in connection with the permanent earth retaining system. Unit rates of ground anchors shall be based on the allowable anchor forces required for the safe and adequate performance of the permanent retaining system. The Contractor's submission of calculations and shop drawings shall include the following information:

6.4.1.1. Anchor layout

6.4.1.2. Anchor design details

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6.4.1.3. Anchor structural and geotechnical design capacity

6.4.1.4. Grade and properties of the tendon material

6.4.1.5. Percentage of tendon ultimate load at working load

6.4.1.6. Method and details of anchor fabrication

6.4.1.7. Details of double corrosion protection for permanent applications

6.4.1.8. Method and details of proposed grouting procedure

6.4.1.9. Grout/concrete - cement type, strength, additives

6.4.1.10. Anchor load, length, and bond diameter

6.4.1.11. Anchor free stressing length and de-bonding details

6.4.1.12. Initial pre-stress of anchor

6.4.1.13. Anchor bond design details

6.4.1.14. Endorsement by the Contractor's Professional Engineer

6.4.1.15. Any other information required by the S.O. in his review of the Contractor's design

6.4.1.16. Anchor head protection

6.4.1.17. Waller Beam design and details (if required)

6.4.2. The Contractor's design calculations and specifications shall comply fully with the relevant recommendations of BS 8081: 1989: British Standard Code of Practice for Ground Anchorages, the requirements of the S.O.'s specifications, the Contractor's design shall be in accordance with accepted principles of good engineering practice. It shall be the Contractor's responsibility to clearly itemised those matters.

6.4.3. The review of the Contractor's design by the Engineer does not in any way absolve or reduce the duties and responsibilities of the Contractor to ensure the safety and adequacy of his works.

6.5. Method Statements for Construction Operations

6.5.1. Prior to commencement of works, the Contractor shall submit to the S.O. detailed method statements for the installation of ground anchors. For the purpose of this sub-section, a method statement shall be a document containing:

6.5.1.1. A detailed construction sequences

6.5.1.2. Proposed drilling method

6.5.1.3. Proposed installation method

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6.5.1.4. Proposed stressing method and equipment

6.5.1.5. Proposed provisions for stressing or distressing

6.5.1.6. Material, plant and labour requirements at each construction stage

6.5.1.7. Rate of production output based on resour ces allocated, such as the average output in lineal metres of installed anchors per drilling frame per normal working day of 8 working hours per day

6.5.1.8. Shop drawings showing, among other things, details of all special requirements for the construction activities

6.5.1.9. Methods of testing: The S.O. shall during the execution of the works require the Contractor to submit detailed method statements of other construction operations. If requested by the S.O., the Contractor shall submit, within such times and in such detail as the S.O. may reasonably require, such information pertaining to the methods of construction (including the use of construction plant) which the Contractor proposes to use, and such calculations of the stresses and deflections that will arise in the permanent works or any part thereof during construction from the use of such methods, as will enable the S.O. to decide whether the permanent works can be executed with safety and in accordance with the contract if the methods are adhered to, and without detriment to the permanent works when completed.

6.5.2. The S.O. shall inform the Contractor in writing **within 14 days** after receiving the Contractor's method statement either:

6.5.2.1. The Contractor's proposed methods have the consent of the S.O.; or

6.5.2.2. In what respect, in the opinion of the S.O., the proposed methods fail to meet the requirements of the contract.

6.5.3. In latter event, the Contractor shall take such steps or make such changes in the proposed methods as may be necessary to meet the S.O.'s requirements and to obtain his consent. The Contractor shall not change the methods that have received the S.O.'s consent without further consent in writing of the S.O., which shall not be unreasonably withheld. Works shall commence at such times when and not before the S.O. has given his consent to the method of construction.

6.5.4. Consent by the S.O. of the Contractor's proposed methods of construction in accordance with this sub-section shall not in any way relieve the Contractor of any of his duties or responsibilities under the contract.

6.6. Equipment and Labour

6.6.1. The Contractor shall provide all frames, equipment, lifting devices and labour necessary for the installation and grouting of anchors.

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6.6.2. The Contractor shall satisfy the S.O. regarding the suitability, efficiency and operational capability of the anchor installation equipment. The Contractor shall be required to provide adequate numbers of operational drilling frames to ensure that the works are completed within the time period stipulated in the approved construction programme. The Contractor is deemed to have made provision for the availability of standby plant at all times to allow for the contingency of equipment failure.

6.6.3. The S.O. shall order the removal or replacement of any equipment or staff whenever he is of the opinion that such equipment and staff are not suitable for the works. Equipment found to have a consistent record of breakdowns shall be removed from the site.

6.7. Inspection and Testing

6.7.1. The S.O. shall inspect the installation of anchors and will monitor anchor stressing acceptance tests to ensure that the Contractor's anchor design and construction method will produce the suitable anchorage system in the soil/rock conditions encountered on site.

6.7.2. The testing of concrete and grout shall be in accordance with the provisions for works concrete in the General Concrete Specification.

6.8. Compliance Inspection

The S.O. shall carry out inspection to ensure that the Contractor follows the approved shop drawings and good engineering practice.

6.9. Acceptability

Acceptance test shall be carried out on all permanent ground anchors in accordance to BS 8081. Failure of any anchor to meet acceptance test criteria will result in rejection of the anchor in question. Consistent failure of a given anchor type require reassessment of the anchor design and installation practices.

6.10. Materials

6.10.1. General Requirements

6.10.1.1. The requirements listed in the following sub-sections shall apply, wherever relevant, to materials used in all anchors except when otherwise agreed by the S.O.. The handling, storage and use of materials shall comply with manufacturers' instructions.

6.10.1.2. An anchor shall not contain materials that are mutually incompatible with each other and the surrounding environment.

6.10.1.3. All anchors shall have a double corrosion protection.

6.10.2. Tendons

6.10.2.1. Pre-stressing tendons shall comply with the following:

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(i) High tensile steel wire and wire strand with a minimum tensile strength of 1860 N/mm^2 to BS 5896: 1980

(ii) Wire steel strand to BS 4757: 1971

(iii) Hot rolled or hot rolled and processed high tensile alloy steel bars to BS 4486: 1980

6.10.2.2. Steel wire and wire strand shall be in coils of sufficiently large diameter to ensure that the steel wire and wire strand payoff straight.

6.10.2.3. Alloy steel bars shall be straight.

6.10.2.4. A certificate shall be submitted to the S.O. containing the following particulars on the pre-stressing tendons:

(i) The manufacturer's name and the date and place of manufacture

(ii) Cast analysis

(iii) Diameter, cross sectional area and unit mass

(iv) Results of test for mechanical properties, including the characteristic breaking load, characteristic 0.1% proof load, elongation at maximum load, relaxation and modulus of elasticity

(v) Results of tests for ductility of pre-stressing wires

6.10.3. Cement Grout

6.10.3.1. Cement used for grouting anchors shall comply with MS 522.

6.10.3.2. Grout shall consist of Ordinary Portland Cement and water with a water/cement ratio of 0.40/0.45. Sand, PFA and High alumina cement shall not be used unless approved by the S.O..

6.10.3.3. Water shall be taken from the public supply of potable water and shall be at least to the quality specified in MS 28.

6.10.3.4. Admixtures shall comply with the requirements of BS 5075: Part 1: 1982 and BS 5075: Part 3: 1985 and shall only be used with the prior agreement of the S.O..

6.10.3.5. The total sulphate (SO_3), chloride and nitrate contents of the grout shall not exceed 4%, 0.1% and 0.1% expressed as a percentage between the respective ion content and the cement content by mass in the grout. The total sulphate (SO_3) and chloride contents shall be determined by the method described in BS 1881: Part 6: 1971. The total nitrate content shall be determined by the method described in ASTM D 4327-84.

6.10.3.6. Grout cubes of 100mm size shall be prepared and cured in accordance with BS 1881: Part 3: 1970 and the strength of grout cubes shall be tested in accordance with BS 1881: Part

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4:1970. The grout shall have a minimum compressive strength measured on 100mm cubes 20N/mm^2 at 3 days and 35N/mm^2 at 28 days. Collection of grout shall be from the grout overflowing from the drill holes unless otherwise agreed by the S.O..

6.10.3.7. Admixture, if used, shall be provided at the Contractor's own expense. Admixtures shall impart to the grout the properties of low water content, good flow ability, minimum bleeding and controlled expansion. Its formulation shall contain no chlorides or other chemicals in quantities that may have harmful effects on the cement or pre-stressing steel. The Contractor shall submit to the S.O. the manufacturer's literature indicating the type of admixture and the manufacturer's recommendations for mixing the admixture with the grout. All admixtures shall be used in accordance with the instructions of the manufacturer.

6.10.4. Greases

6.10.4.1. The greases used shall be formulated and manufactured for the specific purpose of corrosion protection and to provide lubrication to pre-stressed high tensile steel tendons. Greases shall be water displacing, self-healing, and shall be resistant to microbiological degradation. The properties of the grease shall be such that, in the process of pumping, voids are filled and intimate contact is established between the grease and all the steel surfaces of a strand or tendon.

6.10.4.2. Greases, including any used by the manufacturer of the tendons, shall comply with the requirements set down in **Table U6**. The Contractor shall provide the following information:

(i) Product identification details (including name of manufacturer, brand name, type and date of manufacture), and

(ii) Nature of the soap used (if any)

6.10.4.3. Any grease to be used in the Contract shall be accompanied by test certificates which show that it complies with the requirements stated in **Table U6**. Grease shall be used in accordance with the manufacturer's instructions.

6.10.4.4. Different types of grease shall not be allowed to come into contact with each other in any part of the anchor.

6.10.5. Plastics

6.10.5.1. Sheathing, ducting and other plastic components for tendon protection shall be made from high density thermoplastic material and the wall thickness shall be at least 1.0mm.

6.10.5.2. The finished internal and external surfaces of the sheathing and ducting shall be smooth, clean and free from flaws, pin holes, bubbles, cracks and other defects. The material used shall be homogeneous, thermally stable and chemically inert and shall be resistant to chemical, bacterial and fungal attack.

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Sheathing, ducting and other plastic protective components shall not contain any substances that will promote corrosion.

6.10.5.3. Plastic components shall be covered to prevent exposure to ultraviolet light from direct or indirect sunlight.

6.10.5.4. All plastics to be used in an anchor shall be accompanied by test certificates to show that the material complies with the requirements stated in **Table U7**. Plastics shall be used in accordance with the manufacturer's instructions.

6.10.5.5. All plastics used in an anchor shall be resistant to slip in the region of the fixed anchor length and shall be capable of withstanding the effect of load transfer.

6.10.5.6. The Contractor shall also provide the following information:

(i) Product identification details (including name of manufacturer, brand name, type and date of manufacture of product)

(ii) Outer and inner diameter

(iii) Wall thickness

(iv) Amplitude and pitch, in (mm), for corrugated sheathing or ducting

(v) Standard length in (m)

(vi) Jointing details

6.10.6. Metal Ducting

6.10.6.1. Metal ducting shall only be used with the agreement of the S.O..

6.10.6.2. Metal ducting shall be suitably protected against corrosion, resistant to slip in the region of the fixed anchor length, and capable of withstanding the effect of load transfer.

6.10.7. Rubber Rings

6.10.7.1. Rubber rings used in the corrosion protection system shall be manufactured from materials which comply with BS 2494: 1986.

6.10.7.2. Product identification details (including name of manufacturer, brand name, type and date of manufacturer of product), and evidence that the product complies with BS 2494: 1986, shall be provided.

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6.11. Corrosion Protection

6.11.1. General

6.11.1.1. Recommendations concerning some commonly used protective systems for anchorage components shall be followed in the Contractor's proposal on the corrosion protection unless otherwise agreed by the S.O..

(i) Tendon

(a) The tendon shall be given adequate corrosion protection which shall remain effective throughout the design service life of the anchorage. The effectiveness of the protection shall not be impaired during storage, transport, installation and stressing of the anchorage. The steel shall not suffer mechanical damage when the plastic sheathing is removed.

(b) In the zone defined by the free tendon length, the corrosion protection shall not affect the freedom of the tendon to expand.

(c) Before the corrosion protection is applied, any substances (e.g. dirt, grease, ice or loose rust particles) likely to impair the serviceability of the tendon (e.g. bond or corrosion resistance) shall be removed from its surface.

(d) Pre-stressing steel tendons shall not develop more than rust bloom up to the time the anchorage is installed. Pre-stressing steel and preassembled anchorages shall be stored in a dry place.

Note: Rust bloom is defined as a uniform layer of rust without wide pitting, visible to the naked eye and removable by wiping with a dry cloth.

(ii) Tendon Joint

The corrosion protective system applied to the joint assembly shall be at least equivalent to that given to the free tendon length and shall not hinder deformation of the tendon.

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(iii) Anchor Head

The anchor head shall be protected against corrosion. The end cap for protection of the anchor head shall be made of galvanised or stainless steel. The corrosion protection between anchor head and the proximal end of the plastic sheathing in the zone defined by the free tendon length shall include the seal at the proximal end. If anchorages require re-stressing or inspection during the service life, care shall be taken to ensure that re-grouting at the anchor head is possible.

(iv) Waler

All the steel components of waler beam, anchor head and bracket system shall be galvanised steel.

6.11.2. Corrosion Protection of Permanent Anchorages

6.11.2.1. Proof of suitability of the corrosion protection system shall be provided for permanent anchorages.

6.11.2.2. This proof shall, among other things:

(i) Provide information on whether the components of the corrosion protection system are compatible.

(ii) State that the system provides a degree of corrosion protection equivalent to that of proven systems

(iii) State the corrosion-protective agent will not adversely affect the properties of the tendon during its application or subsequently under service conditions

(iv) States that the protection of the tendon extends over the full length of the sheathing, and the tendon is tightly sealed

(v) State that in the anchored zone the corrosion protection does not affect the freedom of the tendon to expand.

6.11.2.3. Cementitious grout shall be deemed adequate corrosion protection if in close corrosion and does not permit the penetration of water. Normally, the minimum grout cover shall be 10mm; anchorage design and type of sheath may require a thicker cover.

6.11.2.4. The corrosion protection of the tendon and the anchorage components shall be factory applied.

6.11.2.5. Where a corrugated sheath is used, the grout cover in the anchorage zone shall be 10mm minimum, the same thickness being required in the case of compression anchorages.

6.11.2.6. Where the corrosion protection is applied in the form of a coating, the specifications of DIN 55 928 Parts 4 to 6 shall be observed. If grout sealing compounds are used for corrosion

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protection, loose particles need not be removed from the tendon prior to the corrosion protection treatment.

6.11.2.7. If the anchorage or part of it is protected against corrosion after installation (e.g. corrosion protection of anchor head after grouting), this work shall be supervised to ensure that proper workmanship is maintained.

6.11.2.8. If plastic compounds are used for corrosion protection, spacers shall be fitted to ensure an adequate thickness of the compound enclosing the tendon. Where the corrosion protection is applied in the form of a coating, a material shall be introduced into the space between the tendon and sheath so as to fill it completely and permanently unless it has been verified that the seals fitted between tendon and sheath are capable of maintaining their function after stressing of the anchorage. Where grouting material is used for corrosion protection purposes, the sheath shall be deemed adequate mechanical protection if it is made of a material that does not permit penetration of water.

6.12. System Components

6.12.1. General

The anchor shall be designed to provide an ultimate load holding capacity of not less than specified. The anchor shall be designed and constructed so that compressive forces within the free length will not damage the corrosion protection.

6.12.2. Free and Fixed Anchor Length

The free anchor length is the distance between the anchor head and the proximal end of the grout. The fixed anchor length is the length of anchorage over which the tensile load is capable of being transmitted to the surrounding ground. The fixed anchor length shall not be less than 3m for all anchors subjected to acceptance tests.

6.12.3. Spacers and Centralisers

6.12.3.1. Spacers shall be provided on multi-tendon anchors to ensure separation between the individual components, and to ensure individual tendons are positioned uniformly over the cross-section of the drill hole.

6.12.3.2. Centralisers shall be provided on multi-tendon anchors to ensure separation between the individual components, and to ensure individual tendons are positioned uniformly over the cross-section of the drill hole.

6.12.3.3. Centralisers shall be provided on the tendon at suitable intervals to meet the following requirements:

(i) Within the fixed anchor length, the tendon shall be positioned in the grout column so that a minimum grout cover to the tendon of 10mm is maintained.

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(ii) Within the design free anchor length, there shall be a minimum clearance of 10mm between the tendon and the sides of the drill hole or casing.

6.12.4. Anchor Head Components

6.12.4.1. The anchor head components which retain the force in the stressed tendon shall comply with the requirements of BS 4447:1973.

6.12.4.2. The anchor head shall be designed so as not to induce secondary stresses in the tendon. Wedges (or spherical washers) should be fitted between anchor head and support plinth, unless the anchor head permits compensation for angular deviations of the tendon from the axial position. A check shall be made whether, in addition to protection against corrosion, anchor heads should be given mechanical protection.

6.12.4.3. Proof of the suitability of the anchor head design shall be provided (e.g. by submitting an agreement). The anchor head design for permanent anchorages shall permit in-service tests to be made as long as such tests are required.

6.13. Submission of Alternative Systems for Approval

6.13.1. Alternative systems if any, shall be included in the submission of the tender for the S.O.'s review. If the design is agreed in principle, the alternative system shall be included in the contract documents.

6.13.2. In principle, acceptance of a design submission does not relieve the Contractor in any way from providing an anchor system of adequate performance and consistent with the specification.

6.14. Anchorages

6.14.1. Anchor plates and nuts shall be compatible with the pre-stressing system use. Anchorage components shall develop at least 95% of the minimum guaranteed ultimate strength of the tendon.

6.14.2. Both smooth and corrugated plastic sheathing shall terminate inside a metal sleeve attached to the back of the anchor plate. Enough unsheathed length of the tendon shall be left within the metal sleeve to allow tightening of the anchor nut when the tendon elongates during stressing. All free room inside the sleeve shall be filled with grease prior to stressing.

6.15. Equipment

6.15.1. General

6.15.1.1. All stressing equipment must be used in accordance with the specifications of the manufacturer and Clause 9 of BS 8081:1989 and must at all times be maintained in good condition.

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6.15.1.2. The pumps, jacks and all tensioning equipment shall be calibrated. All calibrations must be conducted by an approved laboratory with the necessary equipment and must be certified. The calibrations shall be carried out no longer than 3 months prior to using the equipment on site. If any incident occurs during transportation, handling or tensioning which may have caused damage, the equipment must be recalibrated. The S.O. will direct the use of load cell to recalibrate stressing equipment or reject the equipment if the calibration submitted is not acceptable.

6.15.1.3. Anchor stressing shall be in the manner specified in the approved shop drawings. Stressing shall not be carried out until the grout has reached its specific strength.

6.15.2. Fabricating and Placing

All equipment used for fabrication, handling and placing shall be such that it will not damage the anchor tendons.

6.15.3. Grouting Equipment

The grouting equipment shall be capable of continuous mechanical mixing to produce a grout free of lumps and un-dispersed cement. A manifold system with a series of valves and calibrated pressure gauge with a capacity of 10N/mm^2 shall permit continuous circulation and pumping of grouting with accurate control of grout pressure.

6.15.4. Stressing Equipment

Stressing equipment shall be capable of applying at least the specified test load to the anchor tendon. A calibrated pressure gauge indicating the hydraulic jack pressure should, as a minimum requirement, comply with Class 2 of BS 1780. They should be supplied with a calibration certificate and shall read to an accuracy of at least ± 3% of the load applied.

6.16. Anchor Fabrication

6.16.1. Anchors shall be either shop fabricated, or field fabricated in accordance with approved shop drawings, using personnel trained and qualified in this type of work.

6.16.2. Anchors shall be free of dirt, detrimental rust or any other deleterious substance.

6.16.3. Anchors shall be handled and protected prior to installation in such a manner as to avoid corrosion and physical damage thereto.

6.16.4. All field joints of the corrosion protection shall be made watertight by an epoxy bonding compound or equivalent.

6.17. Drilling

6.17.1. Holes for anchors may be formed by driving or drilling method. The drilling method used shall be subjected to the agreement of the S.O. Full

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temporary casing shall be installed to maintain a clean and open shaft and prevent wash out of fines outside the casing in all holes. Grouting shall be carried out with the temporary casing inside the hole and after fresh grout emerge from the hole, then only the temporary casing can be slowly retrieved while grouting continue. Any alternative method shall be approved by the S.O..

6.17.2. Drill holes for ground anchors shall be provided in accordance with the Drawings. The drill hole entry point shall be positioned within a tolerance of ± 75mm. Deviation in alignment shall not exceed 1 in 30. Deviation from straight shall not exceed 20mm in any 3m length of drill hole.

6.17.3. The Contractor shall keep a record of all drilling procedures and times, which shall be made available to the S.O.. No drilling through the reinforcement of contiguous bored pile is allowed.

6.18. Anchor Installation

6.18.1. General

6.18.1.1. The installation of the tendons shall be supervised by suitably qualified personnel familiar with this type of work. The curricular vitae of the personnel shall be submitted to the S.O. before commencement of work.

6.18.1.2. All equipment used for handling and insertion of the anchor shall be such that it will not damage the anchor tendon and corrosion protection. Grout tubes shall be flushed with water or compressed air to ensure that they are clear.

6.18.1.3. The anchor bonded lengths as indicated in the approved design submissions shall be considered the minimum bonded lengths and shall be located within the specified bond zone of the anchorage stratum.

6.18.1.4. All anchors shall be installed through the casing to avoid damage to the corrosion protection.

6.18.1.5. The Contractor shall maintain a record showing the anchor type, length, position and installation date for each anchor. The installation of anchor should be inspected or witnessed by the S.O. on the following stages:

(i) End of bore

(ii) Insertion of tendon

(iii) Grouting

(iv) Completion of installation

6.18.2. Water Testing and Pre-Grouting

6.18.2.1. The drill hole shall be subjected to a water test to determine the likelihood of grout loss around the fixed length. However, the S.O. may agree to omit this test in exceptional ground

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conditions and/or where the Anchor System installation method statement provides an alternative.

6.18.2.2. Subject to the agreement of the S.O., the Contractor may pre-grout the fixed length prior to the water testing.

6.18.2.3. The test shall be carried out by the application of a net water pressure of one atmosphere (100kPa), or a lower pressure agreed by the S.O., at the proximal end of the fixed length which shall be maintained for a period of ten minutes. The water loss in this period shall not exceed 50 litres. The net water pressure shall be the difference between the applied test pressure and the existing water pressure in the drill hole.

6.18.2.4. The test may be undertaken using a drill hole packer to seal off the section under test. Alternatively, it may be carried out by using the net pressure defined above through filling the drill hole with water. The volume of water required to maintain a constant head shall then be measured and shall not exceed 50 litres over ten minutes.

6.18.2.5. Should the test fail, the fixed anchor length shall be grouted under a pressure not exceeding a pressure agreed by the S.O.. The drill hole shall then be flushed or drilled out, and the water test re-applied.

6.18.2.6. A full record of the water test shall be submitted to the S.O..

6.18.3. Insertion of Anchor

6.18.3.1. The S.O. shall be given assistance in his inspection of the drill hole and shall be provided with the records for drilling and water testing prior to the Contractor seeking his approval.

6.18.3.2. If the drill hole proves unacceptable, the Contractor shall seek instruction from the S.O. as to whether the hole is to be grouted and re-drilled, re-provided as a drainage hole or grouted and abandoned. Once the drill hole has been accepted, the Contractor shall proceed to insert the anchor.

6.18.3.3. The anchor shall be inserted within 24 hours of completion of the drilling except where otherwise agreed by the S.O.. The anchor shall be handled with care. During insertion, it shall be installed at a controlled rate to avoid damage to itself and the drill hole.

6.18.3.4. The anchor shall be positioned in accordance with the requirements of sub-section 6.12.4. and shall be secured to prevent further movement.

6.19. Grouting

6.19.1. General

6.19.1.1. Grout shall consist of materials specified in sub-section 6.10.3. The grout shall not remain in the mixer for a period exceeding 45 minutes, failing which it shall be rejected. Pressure grouting

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to the bonded section of the anchor is required to ensure the grout will not be washed away from the tendon.

6.19.1.2. The primary grout shall be pumped into the anchor hole through a grout pipe provided for that purpose until the hole is filled to the top of the anchorage zone. The grout shall always be injected at the lowest point on the bond length. Provisions shall be made for determining the level of the top of the primary grout to assure adequate anchorage. After grouting, the hydrostatic pressure due to gravity of the grout body will be 0.02N/mm^2 per vertical metre and this shall be considered when assessing the effective grout pressure at the lowest point of the bond length

6.19.1.3. The free stressing length shall be flushed-out to remove any access grout above the bond length with specially provided flushing tubes. The void of the free-stressing length shall be filled with low strength bentonite cement grout.

6.19.1.4. After grouting, the anchors shall remain in an undisturbed condition until the necessary grout strengths have been achieved.

6.19.2. Bleeding, Free Expansion and Fluidity

6.19.2.1. The grout shall not be subjected to bleeding in excess of 0.5% by volume three hours after mixing or 1% maximum when measured at 20°C in a covered glass or metal cylinder of 100mm internal diameter and with a grout depth of approximately 100mm. In addition the water shall be re-absorbed within 24 hours. Free expansion of the grout shall not exceed 10% at the ambient temperature.

6.19.2.2. Fluidity of the grout shall be tested in accordance with methods agreed by the S.O.. Except with the prior agreement of the S.O., for grouts containing admixtures, the afflux time of the grout shall not be less than 15 seconds.

6.19.3. Sampling for Tests on Bleeding, Free Expansion, Fluidity and Strength

6.19.3.1. At least one sample of grout shall be obtained for each Acceptance Test anchor. In the case of Acceptance Test anchors, at least one sample shall be taken from each fresh grout batch used to grout the first five anchors. Thereafter, another sample shall be taken for every five additional anchors grouted with the same batch. The samples shall be taken not more than one hour after the grout has been mixed. If directed by the S.O., the grout may have to be sampled from the fresh grout flow out from the drill hole when the grouting process is near completion. Each sample of grout taken shall be divided into three specimens. Each specimen shall be tested to determine the amount of bleeding, free expansion and fluidity.

6.19.3.2. A set of three grout cubes shall be prepared for cube strength determination in accordance with sub-section 6.10.3. from each sample of grout taken.

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6.19.4. Trial Grout Mixes

6.19.4.1. A trial grout mix shall be carried out in accordance with sub-section 6.19.5. using the designed water-cement ratio and admixtures (if any) and the proposed grouting equipment to be used for the Contract.

6.19.4.2. One sample of the grout from the trial mix shall be divided into three specimens and each specimen shall be tested to show compliance with the bleeding, free expansion and fluidity requirements stated in sub-section 6.19.2..

6.19.4.3. One sample of the grout from the trial mix shall be taken for determination of the grout cube strength to show compliance with the requirements in sub-section 6.10.3..

6.19.4.4. One sample of the grout from the trial mix shall be divided into three specimens and each specimen shall be tested to show compliance with the total sulphate (SO_3), chloride and nitrate contents requirements stated in sub-section 6.10.3..

6.19.4.5. Results of the trial grout mix tests showing the degree of compliance with the Specification shall be submitted to the S.O. at least two weeks before the commencement of grouting.

6.19.5. Grout Mixing

6.19.5.1. Batching of the dry materials shall be by weight. The amount of water used shall be measured by a calibrated flow meter or a measuring tank.

6.19.5.2. The procedure to be followed for mixing the grout shall be that approximately two-thirds of the cement shall be added to the water, followed by the admixtures, if any, follow by the remaining third of cement.

6.19.5.3. The grout shall be mixed in a mechanical mixer capable of imparting a high shear action to the grout components so that a colloidal grout of uniform consistency is produced in a mixing time of less than five minutes.

6.19.5.4. The grout mixing process shall utilise a re-circulating system where the grout is continuously discharged and recharged into the mixing unit during the mixing period. After mixing, the grout shall be kept continuously agitated.

6.19.5.5. The grout shall be passed through a nominal 1.2mm sieve prior to injection. The grout shall be used as soon as possible after mixing and in any case within 30 minutes of adding cement unless otherwise agreed by the S.O..

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6.19.6. Grout Injection Equipment

The pump used for grout injection shall be of the positive displacement type, i.e. it shall be actuated by a piston or screw. A flow meter and a pressure gauge shall be provided. The S.O.'s approval of the equipment shall be obtained prior to its use.

6.19.7. Grouting Procedures

6.19.7.1. The grouting operation shall be undertaken within 24 hours of the anchor being inserted except where otherwise agreed by the S.O.. The procedure adopted shall ensure that there are no air or water inclusions left in the grouted zone.

6.19.7.2. The grouting pressure adopted shall be the minimum consistent with undertaking the operation and shall avoid damage to surrounding buildings, land, structure, street and services.

6.19.7.3. Grouting shall proceed at a slow, steady rate and shall continue until injected grout of the same composition and consistency as that mixed has been emerging from the outlet for at least one minute.

6.19.8. Grouting Records

A record giving full details of the grouting operation for each anchor shall be supplied to the S.O. prior to a request seeking his acceptance of the anchor.

6.20. Fitting Anchor Head

The anchor head and its associated components shall be fitted concentrically to the tendon within a tolerance of ± 5mm and perpendicular to the tendon within a tolerance of ± 3˚. Any leakage of water/fluid from the anchor hole or anchor head shall be sealed by approved method.

6.21. Anchor Testing

6.21.1. General

6.21.1.1. There are three classes of tests for all anchorages as follows:

(i) Proving tests

(ii) On-site suitability tests

(iii) On-site acceptance tests

6.21.1.2. Proving tests are required to demonstrate or investigate, in advance of the installation of working anchorages, the quality and adequacy of the design in relation to the ground conditions and material used and the levels of safety that the design provides.

6.21.1.3. On-site suitability tests are carried out on anchorages constructed under identical conditions as the working

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anchorages and loaded in the same way to the same level. These may be carried out in advance of the main contract or on selected working anchorages during the course of the construction. The period of monitoring should be sufficient to ensure that pre-stress or creep fluctuations stabilise within tolerable limits. These tests indicate the results that should be obtained from the working anchorages.

6.21.1.4. On-site acceptance tests are carried out on all anchorages and demonstrate the short term ability of the anchorage to support a load that is greater than the design working load and the efficiency of load transmission to the fixed anchor zone. A proper comparison of the short term results with those of the on-site suitability tests provides a guide to longer term behaviour.

6.21.1.5. Anchor testing shall be carried out in accordance with British Standard for Ground Anchorages BS 8081:1989. Testing of anchor shall not be carried out until the grout has reached its specified strength. For all testing, load cell shall be used to measure the load and measurement of displacement shall be carried out using both steel ruler and dial gauges unless otherwise agreed by the S.O..

6.21.2. Proving Tests

6.21.2.1. Before any anchorage is employed, proving tests shall be carried out on trial anchorages to demonstrate to the S.O. the suitability of materials, components, methods of construction and workmanship. The scope of the proving tests shall be sufficient to demonstrate the satisfactory performance of the anchorage for use under the conditions for which it is proposed.

6.21.2.2. Proving tests should be carried out to investigate the behaviour and performance working anchorage, the quality and adequacy of the design and the level of safety that the design provides. In particular, the tests should investigate such factors as the load capacity, load extension behaviour, relaxation and creep. Consideration should also be given to the corrosion protection and its resistance to physical damage during handling, storage, installation and stressing; together with an overall assessment of performance.

6.21.2.3. The suitability of all materials, components and methods of construction shall be demonstrated to the designer before acceptance of any anchorage scheme.

6.21.2.4. Proving tests shall be carried out and interpreted in accordance with British Standard Code of Practice for Ground Anchorages BS 8081: 1989 sub-section 11.2. unless otherwise agreed by the S.O.. The anchorages shall have structural capacities of at least three times the geotechnical working capacity.

6.21.3. On-Site Suitability Tests

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6.21.3.1. On-site suitability tests shall be carried out to prove the suitability of the anchorages for the conditions on site. On-site suitability tests may be applied to anchorages to be used in the works or they may be additional and provided under the contract. The anchorages shall be constructed in exactly the same way and located in the same ground conditions as the working anchorages and shall be used as reference anchorages against which the performance of the working anchorages can be judged.

6.21.3.2. At least three anchorages shall be subjected to suitability tests with further tests for each category of anchorages envisaged in the works.

6.21.3.3. Anchorages for suitability tests shall be proof loaded to 1.5 to 2 times the working loads subject to the agreement of the S.O..

6.21.3.4. Suitability tests shall be carried out and interpreted in accordance with British Standard Code of Practice for Ground Anchorages BS 8081: 1989 Clause 11.3 unless otherwise agreed by the S.O..

6.21.4. On-Site Acceptance Tests

6.21.4.1. All anchorages shall be subjected to acceptance test before locking off at transfer load. Acceptance tests shall be carried out and interpreted in accordance with British Standard Code of Practice for Ground Anchorages BS 8081: 1989 Clause 11.4 unless otherwise stated in this specification.

6.21.4.2. Acceptance tests shall include creep testing and lift off test.

6.21.4.3. The Contractor shall maintain access and have the capability to conduct lift off test and to re-stress or de-stress anchors at any location as requested by the S.O..

6.21.4.4. The anchors shall be capable of sustaining over the entire period of construction the design working load with a factor of safety of 2.0.

6.21.4.5. Failure to meet the acceptance criteria shall constitute a failure of the anchor installation. In this event, the Contractor shall submit his method of remedial work or replacement of anchor to the satisfaction of the S.O..

6.22. Monitoring

6.22.1. Requirements for Monitoring

6.22.1.1. All anchors shall be installed so that the residual load in the tendon can be monitored. All monitoring operations shall be undertaken so that there is no overloading or damage to the anchor. Specification of Instrumentation and Monitoring for Retaining Structures and Excavation shall be followed.

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6.22.1.2. The Contractor shall monitor the anchors up to the end of the Contract Period in accordance with the programme and procedure given in sub-section 6.22.3. and 6.22.4.

6.22.2. Load Measurement

6.22.2.1. Load cells shall be provided to monitor the residual loads of the anchor. The load cells shall be robust and appropriately protected for site work.

6.22.2.2. Load cells shall be provided with calibration certificates and, where appropriate, the effects of sustained loading on the cell shall also be recorded on the certificate. During monitoring period, detective load cells shall be replaced.

6.22.3. Programme

The contractor shall submit a programme of ground anchor installation to the S.O. for approval prior to commencement of work.

6.22.4. Procedures

6.22.4.1. The Contractor shall inspect the anchor pad, the protection cap, the anchor head and its corrosion protection, and shall report on their condition. A 150ml sample of the grease shall be recovered from the anchor head for subsequent submission to the S.O. for inspection. Upon completion of the inspection, the residual load in the anchor shall be measured. Finally, the corrosion protection and the anchor head protection shall be reinstated in accordance with the requirements of this Specification.

6.22.4.2. Should the variation in the residual load exceed ± 10% of that measured immediately after locking-off, the Contractor shall immediately inform the S.O. and await her/his further instructions.

6.22.5. Monitoring Records

A monitoring record shall be submitted to the S.O. within 72 hours of completion of monitoring.

Table U6. Properties of Grease (Sheet 1 of 2)

Property	Test Method	Acceptance Criterion
Base number	ASTM D 974 – 85 (modified) (2)	0.5 min
Water content	ASTM D 95 – 83	0.1% by mass max.
Chloride ion content	ASTM D 4327 – 84 (3)	5ppm by mass max.
Nitrate ion content	ASTM D 4327 – 84 (3)	5ppm by mass max.

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Sulphide ion content	APHA: Part 427:1985 (3)	5ppm by mass max.
Cone penetration (worked at 25˚C)	ASTM D 217 – 86	175 – 340 units (1 unit = 0.1mm)
Corrosion prevention (48 hrs at 52°C & 100% relative humidity)	ASTMD1743 – 73 (1981)	No corrosion is rated 1. Incipient Corrosion (no more than 3 spots of visible size) is rated 2. Max. rating = 2
Oil separation	ASTM D 1742 – 83	3% by mass max.
Evaporation loss	ASTM D 972 – 86	0.5% by mass max.
Flash point	ASTM D 93 – 85	150°C min.
Drop point	ASTM D 566 – 76 (1982)	60°C min.
Oxidation stability : 100 hrs 400 hrs 1000 hrs	ASTM D 942 – 78 (1984)	Max. loss : 70kPa 140kPa 210kPa
Effects if salt spray testing (1mm thick layer 500 hrs)	ASTM B 117 – 85	No corrosion

Table U6. Properties of Grease (Sheet 2 of 2)

Notes: (1) Manufacturer's certificates in respect of all the properties listed in the table shall be presented to show compliance with this Specification.

(2) Modified procedure for base number determination:

(a) Weigh accurately 1 to 1.5g of sample into a 500ml conical flask. Add 20ml isopropanol and 5ml toluene.
(b) Place a glass funnel on the top of the flask and heat the flask on a plate until the grease dissolves.
(c) Add about 100ml of distilled and de-ionized water and pipette 10ml of 1N sulphuric acid to the flask. Heat the solution for 30 min. at temperature 80 – 90°C.
(d) Add a few drops of phenolphthalein indicator solution and titrate with 1N sodium hydroxide solution until the sample solution turns pink. Record the volume of the titre added.
(e) Calculate the base number of the grease sample using the following equation:

$$\text{Base number} = \frac{56.1\,(10\text{-}V)}{M}\ \text{mg KOH/g}$$

where V = volume of 1N sodium hydroxide solution used (ml)
m = mass of sample (g)

(f) Apply correction factors to the volumes of the acid and alkali if they are not exactly 1N.
(g) Carry out a blank determination and correct the result accordingly.

(3) Procedure for extraction of water-soluble ions from grease for chloride, nitrate

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and sulphide ions contents determination:

(a) Weigh, accurate to 0.001g, about 5g of grease into a separating funnel, add 70ml of xylene and shake the mixture until the grease for chloride, nitrate and sulphide ions contents is determined.
(b) Add 30ml of distilled and de-ionized water the funnel, shake for 10 min, and allow the organic and aqueous layers to separate. Run the bottom aqueous layer (and emulsion if present) to a second separating funnel.
(c) Repeat step (b) using separately 30ml and 40ml of distilled and de-ionized water for further extraction.
(d) Add, to the second separating funnel containing the combined water extract,
About 20 – 30ml of xylene, gently swirl the mixture and again allow for complete separation of the 2 layers.
(e) To avoid inclusion of the organic solvent in the water extract, collect about ¾ of the bottom aqueous layer, filter through a 0.2pm filter paper and reserve the filtrate for determination of the contents of chloride, nitrate and sulphide.
(f) Carry out a blank determination, following the same procedure with the same number of reagents.

Table U7. Properties of Plastics

Property	Test Method	Unit	Acceptance Criterion		
			PVC	PP	HDPE
Density	BS 2782 : Part 6 : 1980, Method 620A	Kg/m^3	1350-1400	900-910	950-940
Tensile strength at yield at 23˚C (Straining rate 50mm/min)	BS 2782 : Part 3 : 1976, Method 320C	MPa	≥45	≥30	≥29
Softening point (Vicat)	BS 2782 : Part 1 : 1976, Method 120A	˚C	≥75	≥150	≥110
Hardness (Shore D)	BS 2782 : Part 3 : 1981, Method 365B	-	≥65		
Brittleness Temperature	ASTM D 746 - 79	˚C	≤5˚C		
Environmental Stress cracking resistance	ASTM D 1693 – 70 (1980)	hrs	200 (No cracking)		

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Fungal resistance	ASTM G 21 – 70 (1980)	-	Rating 1 or less (2)
Bacteria resistance	ASTm D G 22 – 76 (1980) Procedure 'B'	-	No bacterial growth on surface of specimen
Water absorption at 23 ± 1˚C	ASTM D 570 – 81 (Long term immersion)	% increase in weight	Max. 0.5%
Hydrostatic pressure resistance	BS 6437 : 1984	-	No localised swelling leaking or weeping

Note : (1) PVC = polyvinyl chloride ; PP = polypropylene;
HDPE = high density polyethylene
(2) Observed traces of fungal growth shall not cover more than 10% of the surface area.
(3) Manufacturer's certificates in respect of all the properties listed in the table shall be presented to show compliance with this Specification.

7. Reinforced Soil Structures and Slope

7.1. General

7.1.1. Scope

This specification covers the general and technical requirements for the construction of reinforced soil structures as described herein. All materials used and the works shall meet the requirements of this specification and details shown on the contract drawings.

7.1.2. Contractor's Responsibilities

The Contractor shall provide all necessary resources including materials, skilled workers, and plants/equipment to execute and complete the works as shown on the drawings. The Contractor shall be responsible for the true and proper setting-out of the areas to which the Reinforced Soil Structure is to be placed and for the correctness of the lines, widths, levels and slopes as shown on the contract drawings.

7.2. Materials

7.2.1. Facing Materials

Facing for reinforced soil structures utilising metallic components for reinforcement shall be constructed in units to retain the fill using one or more of the following materials:

7.2.1.1. Reinforced concrete conforming to BS 8110: 1990

7.2.1.2. Carbon steel strips or sheets conforming to BS 1449:1991; BS EN 10025: 1993 or BS EN 10130: 1999. The fabricated components shall be hot-dip galvanised in accordance with sub-section 7.2.3. of this Specification.

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7.2.1.3. Structural steel sections conforming to BS EN 10025: 1993. The fabricated components shall be hot-dip galvanised in accordance with sub-section 7.2.3. of the Specification.

7.2.1.4. Segmental block units conforming to the requirements of the Contract.

7.2.1.5. Proprietary product with reinforced fill product certificate.

7.2.2. Reinforcing Elements and Connections

7.2.2.1. Reinforcing elements shall be one of more of the following:

(i) Metallic reinforcing elements formed from carbon steel conforming to BS 1449: 1991 or BS EN 10130: 1999. The fabricated components shall be hot-dip galvanised in accordance with sub-section 7.2.3. of the Specification.

(ii) Proprietary polymeric reinforcing products covered by the manufacturer's certificate.

(a) Geogrids and High Strength Woven Geotextiles shall be manufactured from high tenacity polyester encased within polyolefin sheaths. The bond between the sheath and the high tenacity polyester shall be adequate to transfer the required loads to the elements. The geo-linear elements shall consist of continuous high tenacity polyester fibres encased within a polyolefine sheath.

The polyester fibres for geogrids shall be completely encased within a protective polyolefine sheath to completely prevent ingress of moisture. All free ends shall be sealed to completely prevent ingress of moisture. The minimum thickness of the protective cover shall be 1mm.

(b) The weft elements shall be the same quality material as the warp elements.

(iii) Any other materials as specified by the S.O..

7.2.2.2. Connections shall comprise one or more of the following:

(i) Precision hexagonal bolts, screw and nuts conforming to BS 3692:2001.

(ii) Black hexagonal bolts and nuts conforming to BS 4190: 2001.

(iii) Plain washers conforming to BS 4320: 1968.

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(iv) Dowels and rods which shall be made from either steel bar conforming to BS 4449: 1997 or steel conforming to BS EN 10025: 1999.

(v) Tie strips which shall be made from carbon steel strip conforming to BS 4449: Part 1: 1991; BS EN 10130: 1999 or BS EN 10025:1993.

(vi) Proprietary connections covered by a reinforced fill product certificate applicable to the polymeric reinforcing elements to be used.

7.2.2.3. Metallic connections between facings, between facings and reinforcing elements and between reinforcing elements shall electrolytically compatible such that corrosion will not be promoted through the use of dissimilar metals.

7.2.2.4. Where components for connections are made from steel, these components shall be hot-dip galvanised in accordance with sub-section 7.2.3. of the Specification.

7.2.3. Hot-dip Galvanising

Hot-dip galvanising shall be to BS EN ISO 1461, except that the minimum average zinc coating weight for the steel reinforcing elements specified in sub-section 7.2.2. above shall be 610g/m^2 (85 microns) for land-based structures or slopes and 1000g/m^2 (140 microns) for structures of slopes that are periodically submerged in water.

7.2.4. Joint Filler and Sealant

7.2.4.1. Joint filler shall be composed of durable, inert material resistant to atmospheric attack and shall comprise the following materials:

(i) For horizontal joint fillers, resin-bonded cork strip to ASTM D1752-84 Type II.

(ii) For vertical joint fillers, closed cell polyethylene foam strip or closed cell polyurethane foam strip approved by the S.O..

(iii) Proprietary joint fillers shall be purpose-made to size for the appropriate location shown on the Drawings.

(iv) The materials for filling, priming and sealing of joints should be obtained from a single supplier.

7.2.5. Fill Material

7.2.5.1. Fill material shall consist of naturally occurring or processed material which at the time of deposition is capable of being compacted in accordance with the specified requirements to form a stable mass of fill.

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7.2.5.2. Fill material shall not contain any of the following:

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

(ii) Peat, vegetation, timber, organic, soluble or perishable material.

(iii) Dangerous or toxic material or material susceptible to combustion, and

(iv) Metal, rubber, plastic or synthetic material.

7.2.5.3. The grading and index properties of the selected fill shall be in accordance with the requirement specified in **Table U8**

7.2.5.4. Selected fill for reinforced fill structures or slopes which contain hot-dip galvanised steel reinforcing elements shall comply with the electrical and chemical limits specified in **Table U9.**

7.2.5.5. Materials from excavation shall not be used as fill material for a reinforced fill structure of slope unless permitted by the S.O..

Fill materials shall meet any additional requirements given in the Drawings.

Table U8. Particle Size Distribution of Selected Fill

Requirement	Material Type	
	Type I	Type II
Maximum Size (mm)	150	150
% Passing 10mm BS Sieve Size	≥ 25	-
% Passing 600 microns BS Sieve Size	≥ 8	-
% Passing 63 microns BS Sieve Size	0 – 10	10 – 80
% Smaller than 2 microns	-	0 - 10
Coefficient of Uniformity	≥ 5	≥ 5
Liquid Limit (%)	Not applicable	≤ 45
Plasticity Index (%)	Not applicable	≤ 20

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Table U9. Allowable Electrical and Chemical Limits of Selected Fill and Granular Filter

Fill Property	Allowable Limits	
	Submerged	Non-Submerged
Resistivity (ohm-m)	≥ 30	≥ 10
Redox Potential (volts)	≥ 0.40 (granular fill) ≥ 0.43 (fine fill)	≥ 0.40 (granular fill) ≥ 0.43 (fine fill)
pH	5 – 10	5 – 10
Chloride Ion Content (% by weight)	≤0.01	≤ 0.02
Total Sulphate Content (% by weight)	≤ 0.10	≤ 0.20
Sulphate Ion Content (% by weight)	≤ 0.05	≤ 0.10
Total Sulphide Content (% by weight)	≤ 0.01	≤ 0.03
Note: Submerged structure means a structure that is periodically submerged in water but excluding marine condition and contaminated or saline water.		

7.2.6. Granular Filter

7.2.6.1. Granular filter material for reinforced fill structures or slopes which contain hot-dip galvanised steel reinforcing elements shall comply with the electrical and chemical limits specified in **Table U9.**

7.2.6.2. Granular filter material shall any additional given in the Drawings.

7.3. Submissions

7.3.1. Particulars of Reinforced Fill Structure and Slope

7.3.1.1. The Contractor shall submit to the S.O. a method statement for the construction of reinforced fill structures or slopes. The method statement shall contain proposal on:

(i) Details of construction plant.

(ii) Sequence of construction.

(iii) Programme of work.

(iv) Details of compaction method including the thickness of compacted fill layers and capacities of the earthmoving and compaction equipment.

(v) Methods of supporting the facing units during construction.

(vi) Details of all necessary temporary works for the construction of the reinforced fill structures or slopes.

(vii) Names and records of experience of the Contractor's supervisory staff to be employed on the works.

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(viii) Arrangements for stockpiling fill material.

(ix) Methods of controlling the moisture content of fill material.

(x) Methods of controlling surface water and groundwater.

(xi) Methods of protecting earthworks and earthworks materials from damage due to water and from weather conditions which may affect the earthworks or earthworks materials.

(xii) Methods of monitoring groundwater levels.

(xiii) Methods of monitoring the ground and structures for movements.

7.3.1.2. The particulars shall be submitted to the S.O. at least 6 weeks prior to commencement of construction.

7.3.2. Particulars of Facing Units

7.3.2.1. The following particulars of the proposed facing units shall be submitted to the S.O.:

(i) Manufacturer's literature on the proposed facing units.

(ii) Method of construction, including details of corner and facing connections.

(iii) A certificate showing the manufacturer's name, the date and place of manufacture and showing that the facing units comply with the requirements stated in the Contract and including the results of tests specified in the certificate or as specified by the S.O..

7.3.2.2. The particulars, including certificates, shall be submitted to the S.O. at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material delivered to the site and at least 14 days before the installation of the facing units starts.

7.3.3. Particulars of Reinforcing Elements and Connections

7.3.3.1. The following particulars of the hot-dip galvanised coatings to reinforcing elements and associated connection elements shall be submitted to the S.O..

(i) Name and location of the galvanising plant

(ii) A certificate from the manufacturer showing the date and place of application of the zinc coating and showing that the galvanisation conforming to the requirements stated in the Contract and including results of tests for:

(a) Weight of coating

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(b) Uniformity of coating

7.3.3.2. The particulars, including certificates, shall be submitted to the S.O. for each batch of galvanised reinforcing element delivered to the Site and at least 14 days before placing of the reinforcing element in the structure or slope starts.

7.3.4. Particulars of Joint Filler and Sealant

7.3.4.1. The following particulars of the proposed joint fillers and sealant shall be submitted to the S.O.:

(i) Manufacturer's literature on the material and the proposed method of installation.

(ii) A certificate for the manufacturer shows the date and place of application of the zinc coating and showing that the galvanisation conforming to the requirements stated in the Contract and including results of tests specified by the S.O..

7.3.4.2. The particulars, including certificates, shall be submitted to the S.O. at least 14 days before the first delivery of the material to the Site. Certificates shall be submitted for each batch of the material to the Site and at least 14 days before placing of the joint filler and sealant in the structure or slope starts.

7.3.5. Particulars of Fill Material

7.3.5.1. The following particulars of the proposed fill material shall be submitted to the S.O. for approval:

(i) A statement identifying each source of supply and showing that sufficient suitable materials are available for the works.

(ii) For material from borrow areas, a plan showing the location and extent of each proposed borrow area, and the location, depth and the test results of each sample obtained and each in-situ test carried out.

(iii) Certification from a laboratory approved by the S.O. which show that each material proposed for use complies with the requirements of the Contract and has been tested in accordance with the appropriate test methods given in this Specification.

7.3.5.2. On receipt of the above particulars, the S.O. may require the Contractor to carry out additional sampling and testing to demonstrate that the properties of the proposed sources of fill meet the requirements of the Contract.

7.3.5.3. The particulars, including certificates, shall be submitted to the S.O. at least 14 days before the first delivery of the material to the Site. Certificate shall be submitted for each batch of the

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material delivered to the Site and at least 14 days before the placement of the material in the structure or slope starts.

7.4. Handling, Delivery and Storage of Materials

7.4.1. Handling and Storage of Facing Units

Facing units shall be stored and handled in such a manner as to eliminate the possibility of any damage. They shall be stored flat and supported on firm blocking. The use of porous blocks to stack facing units shall be avoided.

7.4.2. Handling and Storage of Reinforcing Elements

7.4.2.1. Reinforcing elements shall not be subjected to rough handling, shock loading or dropping from a height.

7.4.2.2. Reinforcing elements shall be stored in such a manner to eliminate the possibility of any damage and shall be clearly labelled to identify items with different dimensions and properties.

7.4.2.3. Nylon, rope or padded slings shall be used for lifting galvanised reinforcing elements; bundles of reinforcement shall be lifted with a strong back or with multiple supports to prevent abrasion or excessive bending.

7.4.2.4. Polymeric reinforcing elements shall be properly stored and protected from precipitation, extended ultraviolet radiation, direct sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, temperatures in excess of 50°C, and any other environmental condition that may damage the physical property values.

7.4.3. Handling and Storage of Fill Material

7.4.3.1. Fill material shall not be handled or stored in a manner that will result in segregation, deterioration, erosion or instability of the material.

7.4.3.2. Different types of fill materials shall be kept separate from each other. Fill material shall not be contaminated and shall be maintained in a suitable condition for deposition and compaction.

7.5. Foundation Preparation

7.5.1. Unless otherwise specified by the S.O., all existing vegetation and all unsuitable foundation material shall be removed in those areas where the reinforcing element is to be placed.

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7.5.2. Surfaces on which reinforcing elements are to be placed shall be uniform, smooth and free of abrupt changes in slope, debris and irregularities that could damage the reinforcing elements.

7.5.3. During periods of heavy rainfall, the Contractor shall be responsible for protecting exposed surfaces of the foundation and the associated temporary cut slopes with heavy duty impermeable sheeting.

7.5.4. Surface water flowing over exposed surfaces of the foundation and the temporary cut slopes shall be intercepted and diverted away to a safe discharge point. All drainage works shall be kept free of debris to avoid blockage. Temporary conduits shall be provided to discharge water safely from partially completed surface drainage works.

7.5.5. During excavation for the foundation of a reinforced fill structure or slope, a method of working shall be adopted in which the minimum of bare soil is exposed at any time. The method of working shall be agreed with the S.O. before the commencement of work.

7.5.6. The Contractor shall remove all the soil and rock spoil spilled onto any sloping terrain during excavation for the foundation of a reinforced fill structure or slope prior to the commencement of the filling works.

7.6. Erection of Facing

7.6.1. Erection of Elemental Facing

7.6.1.1. Elemental facing units shall be placed in successive courses unless otherwise specified. The spacing, level and alignment of each unit shall be checked immediately after its placement and again at the completion of each course.

7.6.1.2. Adequate support for the facing units shall be provided at each stage of erection. The bottom course of facing units shall be shored to prevent movement during the placement and compaction of fill material.

7.6.1.3. As placed, all elemental facing units except those at the bottom course shall be inclined towards the fill to compensate for outward movement during or subsequent to compaction of the fill material. The degree of inclination shall be adjusted where necessary as placement and compaction of the fill material proceeds to ensure that the tolerances specified in sub-section 7.11. of this Specification are met.

7.6.2. Erection of Full Height Facing

7.6.2.1. Full height facings shall be properly placed and propped during construction. The level and alignment of each facing shall be checked immediately after its placement and again after the compaction of filling. The foundation for the props shall be adequate to support the propping loads.

7.6.2.2. The degree of inclination of the full height facing shall be adjusted to ensure that the tolerances specified in sub-section 7.11. of this Specification are met.

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7.6.3. Erection of Segmental Block Facing

7.6.3.1. Segmental block units shall be properly placed to ensure that all units are in contact. The level and alignment of the block shall be checked immediately after its placement and again at the completion of each course.

7.6.3.2. The top of each course of segmental blocks installed shall be cleaned before the next course of segmental blocks is placed.

7.6.3.3. Maximum stacked height of segmental block units, prior to backfill placement and compaction, shall not exceed two courses unless otherwise approved by the S.O..

7.7. Placement of Reinforcing Elements

7.7.1. Placement and Connection of Reinforcing Elements

7.7.1.1. The reinforcing elements shall be placed on the compacted fill material and connected to the facing units in accordance with the drawings. They shall be placed at right angles to the facing units or the place face of the slope unless otherwise shown on the Drawings. Bends in steel reinforcing elements shall be to a minimum radius of 300mm.

7.7.1.2. For reinforced fill slopes, in which the overfill and cut back technique is proposed to ensure proper compaction of the slope face, the construction method shall ensure that the reinforcing elements are exposed on the final slope face.

7.7.1.3. Polymeric reinforcing elements shall be pulled tight to eliminate waves and wrinkles and secured in place as necessary by staples, pins, sand bags, backfill or as directed by the S.O after placement.

7.7.1.4. After a layer of polymeric reinforcing element has been placed, the next succeeding layer of fill material shall be placed and compacted as soon as practicable to prevent potential damage or extended exposure to direct sunlight. No polymeric elements shall be left exposed for more than 8 hours after placement unless approved by the S.O..

7.7.1.5. Unless otherwise specified in the Drawings or as approved by the S.O., no splices or seams shall be made in the primary direction of tensile strength in the polymeric reinforcing elements. When splices are approved, they shall be made for the full width of the polymeric reinforcing elements by using a similar material with similar strength. Spices shall not be placed within 1.5m of the facing unit or slope face, with 1.5m below top of structure or slope, nor within 1.5m horizontally adjacent to another splice.

7.7.1.6. Unless otherwise specified, adjacent rolls of polymeric reinforcing elements in reinforced fill slopes shall be butted together to maintain 100% horizontal coverage. When used in a wrap-around facing system, adjacent rolls of polymeric

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reinforcing elements shall be overlapped with a minimum width of 150mm.

7.7.1.7. Reinforcing elements at corners and radii shall be placed in accordance with the Drawings.

7.7.2. Installation of Geogrid and Polymeric Materials for Reinforced Soil Slope

7.7.2.1. At each level of geogrid reinforcement, backfill shall be roughly leveled before placing the geogrids. Compaction shall be carried out to the requirements of the Specifications.

7.7.2.2. During backfill placement, trucks and heavy vehicles shall be kept back at least 2m from the face of the Geogrid Reinforced Slope.

7.7.2.3. The deposition, spreading, levelling and compaction of the fill shall be carried out generally in a direction parallel to the facing and shall be executed in stages to alternate with the placing and fixing of the reinforcing elements and the facing.

7.7.2.4. Care shall be taken to ensure that the reinforcing elements and facing are not damaged or displaced during deposition, spreading, levelling and compaction of the fill. The program of filling shall be arranged so that no machines or vehicles run on the reinforcing elements.

7.7.2.5. The fill within 2m of the face of the Geogrid Reinforced Slope shall be compacted using one of the following:

(i) Vibro tamper

(ii) Vibrating plate compacter having a mass not exceeding 1000kg, and

(iii) Vibrating roller having a mass per metre width of not more than 1300kg and a total mass of not more than 1000kg

7.7.2.6. The rear of the Geogrid Reinforcing Slope shall be adequately supported either by temporary shoring or by phasing the work in order to ensure the contemporaneous deposition of the retained fill material.

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7.8. Installation of Joint Filler and Sealant

7.8.1. Horizontal joint filler conforming to sub-section 7.2.4. of this Specification shall be placed on the cleaned top edge of each facing unit prior to the placing of the mating facing unit. No joint filler is required between the strip footing and the bottom course of the facing units.

7.8.2. Vertical joint filler conforming to sub-section 7.2.4. of this Specification shall be inserted only from the fill side on the structure.

7.8.3. Sealants shall be used to protect joint filler from the ingress of external materials. They shall not be used for joints which will be below the finished ground level.

7.9. Deposition and Compaction of Fill Material

7.9.1. Deposition and Compaction of Fill Material

7.9.1.1. Fill shall be placed and compacted in near horizontal layers of the thicknesses required to achieve the specified end product and shall, as far as practicable, be brought up at a uniform rate so that all parts of the Site reach finished formation level at the same time.

7.9.1.2. The fill material beyond 1.5m of the back face of the structure may be raised in thicker layers than that within the 1.5m zone provided that this is compatible with the arrangement of the reinforcing elements and the difference is compacted levels does not exceed 300mm.

7.9.1.3. The fill material shall be deposited, spread, levelled and compacted in layers of thickness appropriate to the compaction methods to be used and so that each reinforcing element can be fixed at the required level on top of the compacted fill material without any voids forming directly underneath the reinforcing element. Unless otherwise permitted by the S.O., layers of fill material shall be horizontal, except for any gradient required for drainage, and the thickness of each layer shall be uniform over the area to be filled.

7.9.1.4. The placement and compaction of fill material shall be carried out in a direction parallel to the face of the structure and shall be completed in stages to follow closely the erection of facing units and the placement of the reinforcing elements.

7.9.1.5. The fill material shall be compacted as soon as practicable after being deposited and in a manner appropriate to the location and to the material to be compacted. The in-situ dry density of the compacted fill material shall be at least 95% of the maximum dry density. Compaction shall continue until the whole layer of fill material has attained the minimum in-situ dry density specified above.

7.9.1.6. Cobbles, boulders, rock or waste fragments whose largest dimension is greater than two-thirds of the loose layer thickness shall not be incorporated into the fill.

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7.9.1.7. The Contractor shall ensure that the reinforcing elements and facing units are not damaged or displaced during placement and compaction of the fill material. Tracked machines or vehicles shall not be operated on top of reinforcing elements which are not covered by at least 150mm of fill material.

7.9.1.8. No fill shall be placed and left uncompacted at the end of a working day. Compacted fill shall be graded to falls to ensure free runoff of rainwater without ponding.

7.9.2. Moisture Content of Fill Material

7.9.2.1. The fill material shall be at optimum moisture content during compaction. The tolerance on the optimum moisture content shall be ± 3% provided that the fill material is capable of being compacted in accordance with the specified requirement to form a stable mass of fill. All necessary measures shall be taken to achieve and maintain the specified moisture content. The moisture content of the compacted surfaces shall be controlled to prevent cracking due to drying.

7.9.2.2. The Contractor shall take all necessary steps to ensure that the fill is placed at the moisture content necessary to achieve the specified level of compaction and shall, where necessary, add water to or dry the fill, in order to obtain this value. Where it is necessary to add water, this shall be done as a fine spray and in such a way that there is time for the water to be absorbed into the fill before being rolled by the compaction plant.

7.9.2.3. The Contractor shall examine the placed fill and remove any deteriorated material prior to recommencement of filling.

7.9.3. Compaction Plant

7.9.3.1. All vehicles and all construction equipment weighing more than 1000kg shall be kept at least 1.5m away from the face of the structure.

7.9.3.2. Compaction plant and compaction method shall be selected having regard to proximity of existing trenches, excavations, retaining walls or other structures and all work shall be performed in such a way as to ensure that their existing stability is not impaired. In particular, great care should be taken to limit the compactive effort close to reinforced fill facing panels to prevent damage to connections or produce displacement of the facing.

7.9.3.3. Unless otherwise permitted by the S.O., the fill material within 1.5m of the face of reinforced fill structures or slopes supported by facings shall be compacted using:

(i) Vibro tamper.

(ii) Vibrating plate compactor having a mass not exceeding 1000kg, or

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(iii) Vibrating roller having a mass per metre width of not more than 1300kg and a total mass of not more than 1000kg.

7.9.3.4. In the case of reinforced fill slopes, compaction plant shall be restricted to that which does not cause distortion and settlement of the edge of the slope. No sheepsfoot, grid rollers or other type of equipment employing a foot shall be used.

7.9.4. Compaction Adjacent to Structures

During construction, the fill material retained at the rear of the reinforced fill block, defined as the position coinciding with the ends of the reinforcing elements, furthest away from the facing units, shall be maintained at the same level as the adjoining structure. Where the retained material is an existing earthwork or natural slope which requires temporary support by shoring, the shoring shall be removed progressively as the selected fill or filter material is compacted. The shoring shall be removed in such a manner to ensure that the stability of the adjacent ground is maintained, the compacted fill material is not disturbed, and the formation of voids is prevented.

7.10. Damage to Components

7.10.1. Damage to Components

7.10.1.1. In the event of any facing units, reinforcing elements, joint filler or sealant sustaining damage during erection or installation, it shall be set aside until it has been inspected by the S.O., who shall decide whether the Contractor can use it and if so under what conditions.

7.10.1.2. The cost of any repair and the cost of replacing rejected components shall be borne entirely by the Contractor.

7.10.1.3. Protection of Completed Geogrid Reinforced Slopes from Erosion

The Contractor, where instructed by the S.O., shall carry out Hydraulic Mulch Grass Seeding in the erodable area before Hydraulic Mulch Grass works commence in other areas.

7.11. Tolerances

7.11.1. Reinforced fill structures constructed using elemental facing units, full-height facings, cast-in-place facings and segmental facing shall be within the tolerances stated in **Table U10** for the specified lines and levels.

7.11.2. The location of referencing elements shall be within ± 50mm of the specified lines and levels.

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Table U10. Tolerances of Reinforced Fill Structure

Designation	Tolerances
Location of place of structure	± 50mm
Overall height	± 50mm
Verticality	± 5mm per metre height
Bulging (vertical) and bowing (horizontal)	± 20mm over 4.5m straight edge
Steps in joints	± 10mm
Crest alignment	± 15mm from reference
Rotation from wall batter	± 2^{o}

7.12. Testing: Reinforcing Elements – General Requirements

7.12.1. General

7.12.1.1. Prior to the procurement of materials, the contractor shall provide a sample and the Manufacturer's Independent Test Report (ITR), showing full compliance of the proposed geogrid to all the above-specified property values corresponding to their respective test methods, for the approval of the S.O..

7.12.1.2. All tests shall be carried out in accordance with the codes of Practices and Standards as provided within this specification, unless otherwise approved by the S.O.. The independent test report and tests shall be prepared and carried out at reputable institutions or accredited independent laboratories approved by the S.O..

7.12.1.3. Routine sample testing, when required and specified, shall be carried out at factory or at independent laboratory witnessed by the S.O.'s representative. Test certificates from reputable or accredited laboratories approved by the S.O., showing the material's compliance to the specification, shall be submitted to the S.O. for verification and approval.

7.12.2. Batch: Reinforcing Elements

A batch of reinforcing elements or reinforcement connections is any quantity of reinforcing elements or reinforcing connections of the same type, size and grade, manufactured by the same plant, covered by the same testing certificates and delivered to the Site at any one time.

7.12.3. Samples: Reinforcing Elements

7.12.3.1. Samples of reinforcing elements or reinforcement connections shall be provided from each batch of the material delivered to the Site and at least 14 days before installation of the reinforcing elements or reinforcement connections starts.

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7.12.3.2. For strip reinforcing elements, either 3 samples from each batch of the reinforcing elements or samples taken at the rate of 1 sample per 100m^2 of area of facing shall be provided for testing, whichever is the larger.

7.12.3.3. For grid of sheet reinforcing elements, either 0.5m^2 of sample from each batch of the reinforcing element or samples taken at the rate of 0.5m^2 per 100m^2 of area of facing shall be provided for testing, whichever is the larger.

7.12.3.4. For reinforcement connections, either 3 samples from each batch of the reinforcing element or samples taken at the rate of 1 sample per 100m^2 of area of facing shall be provided for testing, whichever is the larger.

7.12.4. Testing: Reinforcing Elements

7.12.4.1. Metallic reinforcing elements and the associated connections with hot-dip galvanising for reinforced fill structures shall be tested for the following:

(i) Tensile strength

(ii) Weight and uniformity of galvanised coating

7.12.4.2. Polymeric reinforcing elements for reinforced fill structures shall be tested for the following:

(i) Tensile strength

(ii) Elongation

(iii) Weight

7.12.5. Non-Compliance: Reinforcing Elements

If the result of any test of a reinforcing element does not comply with the specified requirements for the property, additional samples shall be provided from the same batch and additional tests for the property shall be carried out. The number of additional samples shall be in accordance with sub-section 7.12.3. of the Specification.

7.13. Testing: Reinforcing Element – Tensile Test

7.13.1. The tensile strength of metallic reinforcing elements and reinforcement connections shall be determined in accordance with BS EN 10002-1: 2001.

7.13.2. The tensile strength of polymeric reinforcing elements shall be determined in accordance with BS EN ISO 10319: 1996. The tensile strength of polymeric reinforcement connections shall be determined in accordance with BS EN ISO 10321: 1996.

7.14. Testing: Fill Material – General Requirements

7.14.1. Samples: Fill Material

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7.14.1.1. The maximum dry density and optimum moisture content tests shall be carried out for each source of fill material when it is first used and thereafter at the same time as every set of in-situ dry density and moisture content tests where required by the S.O.. Samples of fill material to be tested shall be delivered to the S.O. at least 48 hours, or such shorter period as agreed by the S.O., before deposition of the fill material commences. The Contractor shall inform the S.O. of the exact location in which the fill material from which each sample is taken is to be deposited.

7.14.1.2. The location and frequency of in-situ dry density and moisture content tests shall be as required by the S.O. but shall not be less than that given in this sub-section. Testing shall be carried out for each layer of compacted fill material in the reinforced fill structure, in which there shall be a minimum of one test on the filter material and two tests on the fill material and, where the plan area of the structure exceeds 800m^2, one additional test on the filter material and two additional tests on the fill material shall be carried out for each additional 800m^2 or part thereof. Samples of the fill material to be tested for moisture content shall be taken during deposition and compaction of fill material and shall be delivered to the S.O. not more than 1 hour after the fill material has been deposited in its final position.

7.14.1.3. The location and frequency of all other tests specified in sub-section 7.14.2. or sub-section 7.14.3. of this Specification shall be as required by the S.O. but shall not be less than that given in this sub-section. Testing shall be carried out for the top and bottom compacted layer of fill in reinforced fill structures which are up to 5m high, and also for the middle-compacted layer in reinforced fill structures higher than 5m. In each of these layers, a minimum of one sample of filter material and two samples of selected fill material shall be tested; for structure with plan area exceeding 800m^2, on additional sample of filter material and two additional samples of selected fill material shall be tested for each additional 800m^2 or part thereof.

7.14.1.4. Sampling and testing shall be in positions specified by the S.O..

7.14.2. Testing: Fill Material for Reinforced Fill Structures or Slopes with Metallic Components

Fill material for reinforced fill structures or slopes with metallic components shall be tested for the following:

(i) Compaction tests, comprising the determination of maximum dry density, optimum moisture content, in-situ dry density and moisture content.

(ii) Particle size distribution.

(iii) Liquid limit and plasticity index of the fill material

(iv) Coefficient of uniformity

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(v) Resistivity

(vi) Redox potential

(vii) Ph

(viii) Chloride ion content

(ix) Total sulphate content

(x) Sulphate ion content

(xi) Total sulphide content

(xii) Any other tests as specified by the S.O..

7.14.3. Testing: Fill Material for Reinforced Fill Structure or Slope without Metallic Components

Fill material for reinforced fill structures or slopes without metallic components shall be tested for the following:

(i) Compaction tests, comprising the determination of maximum dry density, optimum moisture content, in-situ dry density and moisture content

(ii) Particle size distribution

(iii) Liquid limit and plasticity index for the fill material

(iv) Coefficient of uniformity

(v) Any other tests as specified by the S.O..

7.14.4. Non-Compliance: Fill Material

If the result of any tests for fill material does not comply with the specified requirements for the property, additional samples shall be provided from the same batch and additional tests for the property shall be carried out. The number of additional samples shall be in accordance with subsection 7.14.1. of this Specification.

7.15. Testing: Fill Material - Resistivity

7.15.1. Each sample of fill material as stated in sub-section 7.14.1. of this Specification shall be tested to determine resistivity.

7.15.2. The method of testing shall be in accordance with the method as specified in ASTM G187-05: Standard Test Method for Measurement of Soil Resistivity using the Two-Electrode Soil Box Method.

7.16. Testing: Fill Material – Redox Potential

7.16.1. Each sample of fill material as stated in sub-section 7.14.1. of this Specification shall be tested to determine redox potential.

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7.16.2. The method of testing shall be in accordance with the method as specified in ASTM G200-09: Standard Test Method of Oxidation-Reduction Potential of Soil.

7.17. Testing: Fill Material – Total Sulphide Content

Total sulphide content of the fill material shall be determined in accordance with APHA: Part 427: 1985.

7.18. Testing: Fill Material – Shear Strength

The shear strength of the fill material shall be determined using triaxial apparatus or shear box apparatus in accordance with BS 1377: 1990. For shear strength test using shear box apparatus, the test specimen shall be sheared under drained conditions under a normal stress equal to the theoretical maximum vertical earth pressure in the reinforced fill structures or slopes.

7.19. Testing: Fill – Reinforcement Interaction – General Requirement

7.19.1. Samples: Fill – Reinforcement Interaction

Each sample of reinforcing element tested in accordance with sub-section 7.12.3. of this Specification shall also be tested for fill – reinforcing element interaction. Samples for testing shall be delivered to the Site at least 14 days before installation of the reinforcing element in the structure or slope starts.

7.19.2. Testing: Fill – Reinforcement Interaction

Reinforcing elements shall be tested for the following:

(i) Pull out resistance

(ii) Direct sliding resistance

The method of testing shall be in accordance with the method stated in sub-section 7.20. and 7.21.1. of this Specification.

7.19.3. Non-Compliance: Fill–Renforcement Interaction

If the result of any tests for fill – reinforcement interaction does not comply with the specified requirements for the property, additional samples shall be provided from the same batch and additional tests for the property shall be carried out. The number of additional samples shall be in accordance with sub-section 7.14.1. of this Specification.

7.20. Testing: Coefficient of Friction between Fill Material and Reinforcement - Pullout

The pullout resistance of reinforcing elements shall be determined in accordance with BS EN ISO 10319: 1996.

7.21. Testing: Coefficient of Friction between Fill Material and Reinforcement – Direct Sliding

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The coefficient of friction between the fill material and the reinforcing elements shall be determined by the direct shear test in accordance with BS1377:1990 with the following modification:

7.21.1. The weight of fill material required to prepare a compacted test specimen 300mm x 300mm x 75mm shall be calculated.

7.21.2. For strip reinforcing elements, the strips shall be cut to tightly fit the interior plan shape of the lower half of the shear box. Ribbed strips shall be cut so that the ribs can be placed as far away from the edge of the box as possible. For plane strips, the top surface and for ribbed strips, shall be at least 1mm and not more than 3mm below the top edge of the lower half of the shear box. The reinforcing elements shall be aligned so that shearing can occur in a direction parallel to their longitudinal axes. The strips shall then be placed and secured in the lower shear box by filling the lower shear box with plaster of Paris so that the strips remain fixed at all stages of the test.

7.21.3. For grid or sheet reinforcing elements, the fill material shall be compacted into the lower shear box in accordance with BS1399:1990, except that the surface of the second compacted layer shall be between 1mm and 2mm below the top edge of the lower shear box. The grid or sheet shall then be cut and fitted to match the width of the shear box and to allow it to be secured below the top edge of the lower shear box. The reinforcing elements shall be aligned so that shearing can occur in a direction parallel to their longitudinal axes.

7.21.4. The fill material shall be placed over the reinforcing element and compacted in two equal layers until about 20mm of the compacted fill projects above the top edge of the upper box, if vibratory compaction is used; or in two equal layers until the top of the compacted surface is approximately 20mm below the top of the shear box, if static compaction is used.

7.21.5. Shearing shall be carried out until the horizontal displacement is twice the displacement recorded at peak shear stress or until ant rib comes into contact with the edge of the shear box, whichever occurs first.

7.21.6. The result of the test shall be taken as the maximum ratio between the shear stress and the normal stress.

8. Tieback Works

8.1. General

This chapter contains recommendations for the specification of permanent tieback works. Since some of the tieback systems or corrosion protection methods are patented, and many contractors have developed unique installation methods, it is virtually impossible for the designer to be familiar with all the various tieback systems which are used. Therefore, the designer needs to prepare a specification that will establish a quality level without eliminating suitable proprietary systems or methods. The specifications should enable qualified contractors to use their experience gained on previous jobs.

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8.2. Performance Specification

8.2.1. A performance specification which establishes a quality level and describes the desired end-results enables the designer and the contractor to use their experience and expertise. The designer establishes those things which affect his design, and he specifies a tieback testing procedure and monitoring requirements to verify performance. The installation methods and the development of the tieback capacity should be the responsibility of the contractor. This enables the contractor to provide his most economical tieback, and still satisfy the requirements of the design. The designer and the contractor will share the responsibility for the work.

8.2.2. The designer is required to:

(i) Provide a detailed geotechnical site investigation.

(ii) Determine the design load.

(iii) Specify a testing procedure and acceptance criterion.

(iv) Estimate the settlement of adjacent structures and establish permissible deformations.

(v) Specify the tieback clearance around utilities.

(vi) Provide installation tolerances.

(vii) Rate the risk associated with the work, and establish the safety factors.

(viii) Determine the un-bonded length, and minimum total length.

(ix) Determine the lock-off load.

(x) Determine the monitoring requirements.

(xi) Describe the level of corrosion protection required and evaluate the contractor's proposed corrosion protection system.

8.2.3. The contractor is required to:

(i) Design the tendon.

(ii) Select the installation method.

(iii) Select the anchor length.

(iv) Propose the corrosion protection system.

(v) Be responsible for the contract compliance of the materials used.

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(vi) Guarantee the tieback capacity.

(vii) Obtain the required un-bonded length.

(viii) Provide the required records.

8.3. Prequalification

The designer may require the prequalification of the tieback contractor. The prequalification may be based on experience, or a list of acceptable contractors may be included in the specification. An alternate type of prequalification should be tried and evaluated for permanent tieback work. The specification would require the submission and approval of the tieback system design, and the corrosion protection method prior to bid. The submission must be detailed enough for the designer to determine whether or not his design is satisfied. This method would enable the contractor to know if his proprietary techniques would be acceptable, and to provide the most economical installation. Preparation and review of the submittal would not require a substantial effort, and this contracting practice would encourage alternate tieback types, continued tieback development, and most economical tieback.

8.4. Permanent Tieback Specification

8.4.1. Scope of the Work

This section of the specification describes the materials, labor and equipment required for the installation and monitoring of the permanent tiebacks shown on the contract drawings.

8.4.2. Tieback Capacity

The Contractor shall be responsible for obtaining the desired tieback capacity in accordance with the tieback testing section of this specification. (The engineer can use one of the following alternatives):

8.4.2.1. Alternative A: The contract drawings contain a loading diagram which the contractor shall use to determine the number and capacity of the tiebacks. The anchor zones of the tiebacks shall be at least 1.5m apart.

8.4.2.2. Alternative B: The contract drawing contains tieback loadings per linear foot of wall. The contractor shall use these loadings to determine the number and capacity of the tiebacks. The anchor zones of the tiebacks shall be at least 1.5m apart.

8.4.2.3. Alternative C: The contract drawings indicate the location and capacity of tiebacks.

8.4.3. Minimum Un-bonded Length and Tieback Angle

Each tieback shall have a minimum un-bonded length of 4.5m. The contract drawings shall indicate the un-bonded length required for each tier of tiebacks. The tieback shall be installed at an angle varying between 10° and 30° downward from the horizontal.

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8.4.4. Total Tieback Length and Minimum Anchor Length

The minimum total tieback lengths shall be indicated on the contract drawing. In no case shall the anchor length be less than 3m. The tieback must not extend beyond the easement shown on the contract drawing.

8.4.5. Prequalification

Twenty (20) working days prior to the bid date, the tieback contractor shall submit a proposal describing the tieback system he intends to provide to the S.O. for review and approval. The submission shall include:

8.4.5.1. Qualifications if required.

8.4.5.2. A description of the tieback installation includes drilling, grouting and stressing information.

8.4.5.3. Estimated tieback capacity.

8.4.5.4. Tendon type and capacity.

8.4.5.5. Anchorage type.

8.4.5.6. Corrosion protection details-shop drawings required.

8.4.5.7. Exceptions to the specification and reasons for exceptions.

8.4.5.8. The S.O. will review the submission and give written comments to the prospective contractors within five (5) working days after receipt of the submission. Within five (5) working days, the contractor can resubmit a revised proposal. The S.O. will notify the contractor by writing within five (5) working days before bid date whether or not his tieback system and corrosion protection meets the requirements of the specification.

8.4.6. Materials

8.4.6.1. Tieback tendons shall be fabricated from single or multiple elements of the following:

(i) Steel bars conforming to ASTM Designation A 722, "Uncoated High-Strength Steel Bars for Prestressed Concrete"

(ii) Seven-wire strand conforming to ASTM Designation A 416, "Uncoated Seven Wire Stress-Relieved Strand for Prestressed Concrete"

(iii) Wires conforming to ASTM Designation A 421, "Uncoated Stress-Relieved Wire for Prestressed Concrete"

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(iv) Compact seven-wire strands conforming to ASTM Designation A 779-80, "Uncoated Seven-Wire Compacted, Stress-Relieved Steel Strand for Prestressed Concrete"

8.4.6.2. Anchorages shall be capable of developing 95% of the guaranteed minimum ultimate tensile strength of the prestressing steel. (The S.O. shall indicate if the anchor head must be restressable and/or capable of load adjustment).

8.4.6.3. The bearing plate shall be fabricated from mild steel and it shall be capable of developing 95% of the guaranteed minimum ultimate tensile strength of the pre-stressing steel. Pre-stressing steel couplers shall be capable of developing 100% of the ultimate strength of the prestressing steel.

8.4.6.4. Centralisers shall be fabricated from material which is nondetrimental to the prestressing steel. (Steel or plastic is commonly used. Wood should not be used.) The centralisers shall position the tendon in the drill hole so a minimum of 0.5 inch (12.7cm) of grout cover is provided. (Pressure-injected tiebacks do not require centralisers)

8.4.6.5. Spacers shall be used to separate elements of multielement tendons. They shall be fabricated from material which is nondetrimental to the prestressing steel. A combination centraliser spacer can be used.

8.4.6.6. Type I, II, or III Portland cement conforming to ASTM C-150 specifications shall be used for grout. (If the soluble sulfate content of the soil or the groundwater is greater than 2,000mg/kg, then Type V cement should be used.) (If the soil or groundwater pH is less than 4.5 or nearby buried concrete structures have experienced chemical attack, then Portland cement grout should not be used. Acid resistant cements may be used in acidic conditions.) Cement should be fresh and should not contain any lumps or other indications of hydration.

8.4.6.7. Water for mixing grout should be potable.

8.4.6.8. Grout additives should be avoided. Accelerators should not be used. Expansive admixtures should only be used for secondary grouting, and filling trumpets and anchorage covers. Admixtures which control bleed and retard set may be used. Additives shall be mixed and placed in accordance with the manufacturer's recommendations.

8.4.6.9. The sheath or bond breaker shall be either a steel, PVC, polyethylene, or polypropylene pipe or tube. The sheath may surround individual tendon elements or the entire tendon. The material shall be capable of withstanding damage during shipping, handling, and installation. The material is subject to the approval of the S.O..

8.4.6.10. Grease injected under the sheath shall be formulated to provide lubrication and inhibit corrosion. The chlorides, nitrates,

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and sulfides present in the grease shall not exceed the following limits:

(i) Chlorides 10ppm

(ii) Nitrates 10ppm

(iii) Sulfides 10ppm

8.4.6.11. The contract documents should indicate if simple or encapsulation corrosion protection is required. A simple protected tieback tendon shall be provided. Details of the protection system shall be submitted to the S.O. for review and approval. The contract drawings shall show details of a simple corrosion protected tieback. The ends of the grease filled sheath shall be sealed with tape, heat shrinkable tubes, or other means subject to the approval of the S.O.. A plastic trumpet shall be used to make the transition from the bearing plate to the corrosion protection over the unbonded length. A tight-fitting seal shall be provided at the end of the trumpet. Insulating bearing strips shall be provided under the bearing plate. The bearing strips material must:

(i) Be an electrical insulator

(ii) Be resistant to attack from cement, grease or aggressive environments

(iii) Be non-detrimental to the prestressing steel

(iv) Have compressive strengths greater than concrete

(v) Not be susceptible to significant creep deformations

8.4.6.12. Manufacturer's literature describing the bearing material shall be submitted to the S.O. for review and approval.

8.4.6.13. The insulation over the anchorage and bearing plate shall be fabricated from a heat shrinkable cap with an elastic adhesive, a mouldable sealant, or other suitable material. Manufacturer's literature describing the insulation shall be submitted to the S.O. for review and approval. The anchorage insulation must be:

(i) An electrical insulator

(ii) Resistant to attack from cement, grease, or aggressive environments

(iii) Nondetrimental to the prestressing steel

(iv) Capable of withstanding atmospheric exposure and ultraviolet light if the-anchor head is intended to remain exposed

8.4.6.14. An encapsulated tieback tendon is required. Details of the proposed encapsulated protection system shall be submitted to

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the S.O. for review and approval. The contract drawings shall show details of encapsulated tendon. The anchor length shall be encapsulated in a corrugated plastic or deformed metal tube. The capsule must be:

(i) Capable of transferring stresses from the encapsulation grout to the anchor grout

(ii) Accommodate movement during testing, and after lock-off

(iii) Resistant to chemical attack from aggressive environments, grout, or grease

(iv) Fabricated from materials nondetrimental to the tendon

(v) Capable of withstanding abrasion, impact, and bending during handling and installation

(vi) Leak proof

8.4.6.15. The tendon shall be centralized inside the capsule. Cement grout shall be used to secure the tendon inside the capsule. A leak tight transition shall be provided between the anchor length capsule and the unbonded length capsule. A heat shrinkable sleeve, or other suitable splices, subject to the approval of the S.O., shall be used. A smooth plastic or metal tube can be used over the unbonded portion of the tendon. If the tendon is greased and sheathed within the smooth portion of the capsule, then grout should be used to fill the annular space between the tendon and the plastic or metal tube. If the tendon is not sheathed, grease shall be used to fill the annular space between the smooth tube and the steel. The smooth tube must:

(i) Accommodate movement during testing and after lock-off

(ii) Resistant to chemical attack from aggressive environments, grout or grease

(iii) Fabricated from materials non detrimental to the tendon

(iv) Capable of withstanding abrasion, impact and bending during handling and installation

(v) Leak proof

8.4.6.16. A steel or plastic trumpet shall be used to make the transition from the bearing plate to the protection over the unbonded length. A tight-fitting seal shall be provided at the end of the trumpet. The anchorage shall be encased in, concrete if possible. Exposed anchorages shall be covered with grease or grout filled cover. The contractor shall ensure that the grease or grout fully covers the anchor head.

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(i) Tendon Fabrication

(a) Prestressing steel shall be protected from dirt, rust, or deleterious substances. A light coating of rust on the steel will not affect its function. Heavy corrosion or pitting shall be cause for tendon rejection. If there is a question about the extent of the corrosion, the steel can be tested to determine if it still meets the appropriate ASTM specification.

(b) Tendons can be either shop or field fabricated.

(c) Tendons shall be stored and handled in such a manner as to avoid damage or corrosion.

(ii) Installation

(a) Core drilling, rotary drilling, or percussion drilling can be used to drill rock foundations. Auger drilling, rotary drilling, or percussion driven casing can be used for soil tiebacks. The drill hole shall be located within 76mm of the desired location.

(b) The engineer may specify water-tightness test for rock tiebacks. The test is not necessary for every tieback. Cavernous limestone formations, open jointed or fractured rock, and formations where water loss or gain was observed during exploratory drilling should be checked for water-tightness. The engineer should determine the number of tests to be performed. If the need for water-tightness testing is uncertain, then the initial drill holes need to be tested. If it is certain that the formation is open, then water-tightness testing may be required for each tieback. Pressure grouting the anchor zone using the casing or a packer to seal the hole can be used in lieu of water-tightness test. If pressure grouting is used in rock, the engineer should specify a minimum refusal pressure.

(c) After drilling the permanent rock tieback hole to the desired depth, water-tightness test shall be performed to determine the tightness of the drill hole. If the unbonded soil, a packer or casing shall be used to isolate the anchor length so it can be tested. The hole shall be filled with water and subjected to a pressure of 34.5kPa in excess of the hydrostatic head measured at the top of the drill hole. If the leakage rate from the drill hole exceeds 19/ in a 10 minute period, then the hole should be consolidated grouted, re-drilled or water flushed, and retested. If the second water-tightness test fails, the process should be repeated. The water level in adjacent drill holes should be observed during the test.

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(d) The water cement ratio of the consolidation grout may be adjusted as required to seal the hole.

(e) If flowing water is observed in the drill hole or artesian water flows out of the hole, then the consolidation grout should be pressurized.

(f) The contractor shall submit for review and approval a description of the water-tightness test procedures and equipment.

(iii) The anchor grout shall have a water cement ratio between 0.35 and 0.50. The grouting equipment should include a mixer capable of producing a grout free of lumps and undispersed cement. A positive displacement grout pump shall be used. The pump shall be equipped with a pressure gauge to monitor grout pressures. The grouting equipment shall be sized to enable the tieback to be grouted in one continuous operation. Neat cement grouts should be screened to remove lumps. The maximum size of the screen openings shall be 6.4mm. Mixing and storage times should not cause excessive temperature build in the grout. The mixer should be capable of continuously agitating the grout.

(a) The anchor grout shall be injected from the lowest point of the tieback. The grout may be placed using grout tubes, casing, or drill rods. The grout can be placed before or after insertion of the tendon. The quantity of the grout and the grout pressures shall be recorded. The grout pressures and grout take shall be controlled to prevent excessive heave in cohesive soils or fractured rock.

(b) The tieback shall remain undisturbed for a minimum of 3 days or until the grout has cured.

8.4.6.17. Testing

The S.O. should select the appropriate tests and specify the number of each type to be performed.

8.4.6.18. Monitoring

Permanent load cells and extensometers shall be provided where indicated on the contract drawings. The contractor shall read the instrumentation biweekly during construction. Upon completion of construction, the contractor shall turn over to the S.O. the readout equipment required to continue monitoring. The S.O. shall monitor the tiebacks for additional year.

8.4.6.19. Records

The contractor shall provide the S.O. with the following records:

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(i) Drawings showing the location of the tiebacks, total tieback length, anchor length and unbonded length

(ii) Steel and grout certifications and/or mill reports

(iii) Grouting records indicating the cement type, quantity injected and the grout pressures

(iv) Tieback test results

(v) Monitoring results

9. Gabions

9.1. Description

This work shall consist of the construction of miscellaneous erosion protection and retaining structures to be composed of stone filled wire mesh gabions. The work shall be carried out all in accordance with this Specification and as shown on the Drawings and/or as approved by the S.O..

9.2. Materials

9.2.1. Wire Mesh Gabions

9.2.1.1. Gabions shall be rectangular baskets of the required dimensions as shown on the Drawings or ordered by the S.O. unless otherwise specified, they shall be of the following standard dimensions:

(i) Width – 1.2m

(ii) Length - 1, 2 or 3m

(iii) Height - 0.5 or 0.8m

9.2.1.2. Gabions longer than 1m shall be divided into compartments of equal length not exceeding 1m by wire mesh diaphragms securely tied along all edges. Each gabion or compartment of a gabion shall be provided with at least 4 cross-connecting wires if its height is 0.5m or less, and with at least 8 cross-connecting wires if its height is in the range 0.5m to 1m.

9.2.1.3. Gabions shall be fabricated from steel wire manufactured in accordance with BS 1052 and galvanised in accordance with MS 407, or such similar standards as S.O. shall approve. The galvanised wire sizes used shall be in accordance with **Table U11.**

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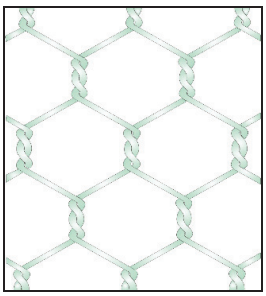
Table U11. Galvanised Wire Sizes for Gabions

Type of Wire	Minimum Diameter (mm)
Selvedge (perimeter) wire	3.50
Mesh wire	2.70
Tying and connecting wire	2.20

9.2.1.4. Gabions mesh shall be double twisted and shall have a uniform hexagonal pattern with openings of 100mm x 120mm or less. The mesh shall be securely tied to selvedge wires to form rectangular panels which shall be securely wired together to form the completed gabion baskets. The ties and connections for each gabion basket shall comprise not less than 8% of its total weight, and the fabrication shall be all to the satisfaction of the S.O..

Double-twist mesh is demonstrated in **Figure U/1**:

Figure U/1. Double-Twist Mesh



9.2.1.5. The tightness of the twisted joints shall be such that a force of not less than 1.7kN is required when pulling on one wire to separate it from the other wire, provided each wire is prevented from turning under the applied forces, and the wire is all in the same plane.

9.2.2. Zinc Coating

9.2.2.1. All wire used in the fabrication of the gabions and in the wiring operations during construction shall be heavily galvanised and exceed MS 407, or such similar standards as the S.O. shall approve. The minimum mass of the zinc coating shall be according to the figures shown in the **Table U12**.

9.2.2.2. The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six times around a four-wire diameter size mandrel it shall not flake or crack to such an extent that any zinc can be removed.

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Table U12. Minimum Mass of Zinc Coating for Gabions

Diameter of Wire (mm)	**Weight of Coating** (g/m^2)
2.20	240
2.70	260
3.50	275

9.2.3. Polyvinyl Chloride Coating

When specified on the Drawings, all wire used in the fabrication of gabions and in the wiring operation during construction shall, after galvanising, have extruded on to it a coating of polyvinyl chloride (PVC). The PVC coating, not inclusive of galvanising, shall nowhere be less than 0.55mm in thickness.

9.2.4. Geotextile

Non-woven geotextile, as specified in the contract drawings and approved by the S.O., shall be placed vertically at the back of each gabion box, and extend backwards into the fill at least 0.5m parallel to the mesh of homogenous lower panel and also 0.5m below the panel directly above the unit, to prevent migration of fines

9.2.5. Stone

Stone fill for gabions shall be clean rough quarry stone, or pit or river cobbles, or a mixture of any of these materials, and shall be essentially free from dust, clay, vegetative matter and other deleterious materials. Individual pieces of stone shall have least dimensions not less than 20mm larger than the gabion mesh openings and greatest dimensions not more than 250mm. The stone shall be hard, tough, durable and dense, resistant to the action of air and water, and suitable in all aspects for the purpose intended. The material shall be approved by the S.O..

9.3. Construction Methods

9.3.1. Prior to placing gabions, the surface on and against, which they are to be constructed shall have been prepared and finished in accordance with the relevant provisions of the appropriate Sections of this Specification. Notwithstanding any earlier approval of these finished surfaces, any damage to or deterioration of them shall be made good to the satisfaction of the S.O. before gabions are placed.

9.3.2. Each gabion basket shall be put in place in its turn, completely fabricated except for the fastening down of the lid, stretched to the correct shape and dimensions, and fastened securely to all contiguous baskets along each edge with tying wire. The basket shall then be tightly packed with approved stone by hand in such a manner that voids are kept to a practicable minimum and are uniformly distributed in the stone mass. Finally, the lid of the basket shall be securely fastened down with tying wire along all hitherto unfastened edges, all to the satisfaction of the

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S.O.. In no case shall the weight of the finished gabion be less than 1300kg/m^3.

9.3.3. As a gabion structure is built up, backfilling against finished gabions shall be carried out as necessary for proper progressive construction, all in accordance with the relevant provisions of the appropriate Sections of this Specification. Unless otherwise specified, vertical joints between gabions shall be staggered in gabion structures in a pattern similar to the joints in running bond brickwork.

10. Gabion Reinforced Earth System

10.1. Materials Specification

10.1.1. Introduction

10.1.1.1. The specification below applies to Gabion Reinforced Earth System units and to the materials from which these are manufactured.

10.1.1.2. For simplicity the word “GRES” is used.

10.1.2. Definitions

10.1.2.1. GRES is defined as PVC coated heavily galvanized steel wire mesh box-shaped basket with a section of the mesh extending into the soil to act as soil reinforcement into the backfill soil. The basket is filled on site with clean-hard stones.

10.1.2.2. The selvedges of the GRES are the thicker perimeter and edge wires to which the wire mesh is securely tied to withstand sudden or gradual stress from any direction.

10.1.2.3. The diaphragms are the internal wire mesh partitions which divide the GRES box into approximately equal sized cells.

10.1.2.4. Lacing and bracing wire is the wire used to assemble and join the GRES units.

10.1.2.5. Connecting wires are the internal wires used to prevent the GRES from bulging during filling.

10.1.3. General Description

10.1.3.1. GRES shall be made from flexible woven wire Heavily Galvanized and PVC Coated 80mm type mesh boxes with integral panels of dimensions as specified in the Contract drawings or an approved equivalent.

10.1.3.2. All material supplied must be accompanied by a manufacturing certificate from the factory for quality control and quality management purposes. The material shall come from an ISO 9001 certified factory, and every batch supplied shall be accompanied by a manufacturing certificate from the approved supplier.

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10.1.3.3. The front face box and the soil reinforcement tail shall be made from one continuous mesh panel.

10.1.3.4. For GRES, the mesh twists are oriented vertically on the gabion face and perpendicular to the front face in the reinforcement panel.

10.1.4. Steel Wire

10.1.4.1. General

All steel wire used in the fabrication of the GRES, and also in the wiring operations during construction, shall be to BS 1052, having a tensile strength of not less than 380N/mm^2 and not exceed 550N/mm^2.

10.1.4.2. Wire Diameter

Wire diameters and relevant tolerances shall be in accordance with the **Table U13**:

Table U13. Wire Diameter and Tolerance

Wire Diameter (mm)	Wire use	Tolerance (mm)
2.20	Lacing Wire	± 0.06
2.70	Body Wire	± 0.08
3.40	Selvedge Wire	± 0.10

10.1.4.3. Zinc Coating

(i) All wire used in the fabrication of the GRES and in the wiring operations during construction shall be heavily galvanized and exceed MS 407, or such similar standards as the S.O. shall approve, the minimum mass of the zinc coating shall be according to the figures shown in the **Table U14**:

Table U14. Minimum Mass of Zink Coating of Wire

Diameter of Wire (mm)	Weight of Coating (g/m^2)
2.20	240
2.70	260
3.40	275

(ii) The adhesion of the zinc coating to the wire shall be such that when the wire is wrapped six times around a

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four wire diameter size mandrel it shall not flake or crack to such an extent that any zinc can be removed.

10.1.4.4. PVC Coating

(i) All wire used in the fabrication of GRES and in the wiring operations during construction shall have extruded onto it (after coating it with zinc in accordance with the foregoing specification) a coating of Poly Vinyl Chloride, otherwise referred to as “PVC”, or other plastic material having superior characteristics than PVC as otherwise approved.

(ii) The coating shall be 0.50mm average thickness with a tolerance of ± 0.05mm, and nowhere shall be less than 0.40mm thickness.

(iii) The PVC shall be grey in colour.

(iv) It shall be capable of resisting deleterious effects of natural weather exposure, immersion in salt water and not show any material difference in its initial characteristics which are:

(a) Specific Gravity
Shall be 1.30 to 1.35 in accordance with ASTM D 792-91

(b) Durometer Hardness
Shall be 50 to 60 shore D, in accordance with ASTM D 2240-91 (ISO 868-1985)

(c) Volatile Loss
At 105 °C for 24 hours - Shall not be greater than 5% in accordance with ASTM D 2287-92 E2. Residual Ashes shall be less than 2% according to ASTM D2124-62T

(d) Tensile Strength
Shall not be less than 210kg/cm^2 in accordance with ASTM D 412-92

(e) Elongation
Shall not be less than 200% and not greater than 280% in accordance with ASTM D 412-92

(f) Modulus of Elasticity at 100% of Elongation
Shall not be less than 190kg/cm^2 in accordance with ASTM D 412-87

(g) Resistance of Abrasion
The loss in volume shall be less than 0.30cm^3 in accordance with ASTM D 1242-56

(h) Creeping Corrosion
Maximum penetration of corrosion of the wire core from a square cut end shall not be greater than

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25mm when the specimen has been immersed for 2000 hours in a 50% solution of HCL (Hydrochloric Acid 12 BE).

10.1.4.5. Testing for deterioration shall be as described below. Variation of the initial characteristics may be allowed, as specified hereunder, when the specimen is submitted to the following tests:

(i) Salt Spray

(a) According to ASTM B 117-90

(b) Period of test = 1500 hours

(ii) Exposure to Ultraviolet Light

(a) According to ASTM D 1499-92 and ASTM G 23(93) apparatus type E.

(b) Period of test = 2000 hours at 63°C

(iii) Exposure at High Temperature

(a) According to ASTM D 1203-89, (ISO 176-1976) and ASTM D 2287-(92) E2.

(b) Period of test = 240 hours at 105°C.

(iv) Brittleness temperature: cold bend less than -30°C test method BS2782-104A; cold flex less than +15°C in accordance with BS2782-151A (84).

10.1.4.6. After the above tests have been performed, the PVC coating shall exhibit the following properties:

(i) Appearance
The vinyl coating shall not crack, blister or split and shall not show any marked change in colour

(ii) Specific Gravity
Shall not show change higher than 6% of its initial value

(iii) Durometer Hardness
Shall not show change higher than 10% of its initial value

(iv) Tensile Strength
Shall not show change higher than 25% of its initial value

(v) Elongation
Shall not show change higher than 25% of its initial value

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(vi) Resistance to Abrasion
Shall not show change higher than 10% of its initial value

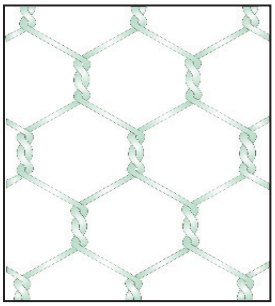
(vii) Brittleness Temperatures
Cold-bend not exceeding -20°C; cold-flex not exceeding +18°C

10.1.5. Wire Mesh

10.1.5.1. Wire mesh shall be mechanically pre-fabricated to become a uniform hexagonal woven mesh wherein the joints are formed by twisting each pair of wires through three half-turns (commonly known as double twist), in such a manner that unraveling is prevented.

10.1.5.2. Double-twist mesh is demonstrated in **Figure U/2**:

Figure U/2. Double-Twist Mesh

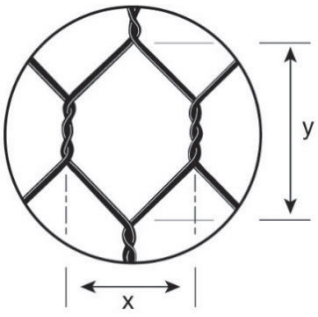


10.1.5.3. The tightness of the twisted joints shall be such that a force of not less than 1.7kN is required when pulling on one wire to separate it from the other wire, provided each wire is prevented from turning under the applied forces, and the wire is all in the same plane.

10.1.5.4. The mesh tensile strength, in soil, is to be equal to or greater than 47kN/m. All wire used in GRES units shall be PVC coated.

10.1.5.5. Certain other wire diameters may be utilised if specified by the S.O.. The wire mesh dimensional layout is as per **Figure U/3**:

Figure U/3. Wire Mesh Dimensional Layout



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Mesh Type	X (mm)	Y (mm)	Tolerance (%)
80	82	122	± 5

10.1.6. Selvedges

10.1.6.1. The cut edges of all mesh used in the construction of GRES, except the bottom edges of diaphragms and the end of the soil reinforcing tail shall be tightly selvedged with a wire having a diameter of at least 3.40mm.

10.1.6.2. The side selvedge of all and any mesh panels shall be woven integrally with the main mesh as described in the above sub-section 10.1.5. with a selvedge wire of at least 3.40mm in diameter.

10.1.6.3. Where the selvedge is not woven integrally with the mesh but has to be fastened to the cut ends of the mesh, it must be attached by mechanically binding the cut ends of the mesh two and half turns around the selvedge wire or by other approved method, provided that the force of not less than 8.5kN applied in the same plane as the mesh, at a point on the selvedge of a mesh sample one metre long, is required to separate it from the mesh.

10.1.7. Diaphragms and End Panels

10.1.7.1. The rear/side panels shall be selvedged on the top, bottom and vertical sides as described in sub-section 10.1.6. The diaphragms shall be selvedged on the top and vertical sides.

10.1.7.2. The rear and side panels of the box gabion section of the GRES unit shall be formed by a continuous panel connected to the main panel, along the bottom of the rear panel, either by a spiral wire through the mesh openings or by being mechanically placed with four connecting rings.

10.1.8. Lacing and Bracing Wire

10.1.8.1. Sufficient lacing and bracing wire must be supplied with the gabion cages to perform all the wiring operations to be carried out in the construction of the GRES work.

10.1.8.2. The lacing and bracing wire shall be made from Heavily Galvanized Wire, coated with PVC and have a core diameter of 2.20mm.

10.1.9. Unit Sizes

10.1.9.1. GRES shall be mechanically pre-fabricated in such a manner that the sides, ends and diaphragms can be assembled at the construction site into rectangular baskets of the standard sizes indicated in **Table U15** or as specified and shown in the contract drawings.

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10.1.9.2. All GRES dimensions shall be within a tolerance limit of 5% of the required size.

Table U15. Standard Size of GRES

Mesh type	80mm
Width (W)	2m
Length (L1)	1m
Length (L2)	To suit design
Depth (D)	0.5m and 1m
Diaphragm	Every 1m

10.1.10. Stone Fill for Facing Box

10.1.10.1. The material used for GRES facing box fill shall be clean, dense hard and durable stone, rounded and angular shape.

10.1.10.2. No rock shall exceed 250mm and at least 85% by weight of the stone shall have a size equal to or larger than 100mm. No rock shall pass through the mesh.

10.1.11. Structural Embankment

10.1.11.1. The embankment forming the reinforced soil structure should be constructed with material having the soil properties as specified in the design and approved by the S.O..

10.1.11.2. Ideally, the backfill shall be granular, free draining and have the following specification, unless otherwise approved by the S.O.:

(i) Not more than 15% by mass of total material to be finer than 75 micron sieve opening

(ii) At least 90% by mass of total material to be finer than the 100mm sieve opening, and

(iii) Maximum particle size to be limited to 125mm

10.1.11.3. Cohesive frictional fill is permitted provided it is in accordance with the design and internal drainage system is included.

10.1.11.4. The soil should not exhibit any deterioration in these characteristics with time.

10.2. Assembly and Erection Specification for Gabion Reinforced Earth System

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10.2.1. Scope

10.2.1.1. This part of the specification details the requirements from the assembly stage through to the final wiring of the completed GRES units.

10.2.1.2. The contractor shall provide to the S.O., for his approval, full details and specifications of the GRES he proposes to use in this contract. Only those products approved by the S.O. shall be allowed to be incorporated in the works.

10.2.2. Preparation

10.2.2.1. The site shall be surveyed, cleared, trimmed level and the ground compacted accordingly.

10.2.2.2. Prior to assembly, the GRES units shall be opened out flat on the ground and stretched to remove all kinks and bends.

10.2.2.3. The GRES units shall be assembled individually by raising the front panel (with lid), the hinged rear panel, and the two ends vertical ensuring that all creases are in the correct position and that tops of all four sides are even. The diaphragm panel should be located in a vertical plane centrally within the facing box.

10.2.2.4. The four corner edges of the facing box shall be laced first followed by the edges of the internal diaphragm to the sides.

10.2.2.5. In all cases, lacing shall commence by twisting the end of the lacing wire tightly around the selvedge/s. It shall then pass round the two edges being joined using alternate single and double loops at 100mm intervals and be securely tied off at the bottom. The ends of all lacing wires shall be turned to the inside of the box on completion of each lacing operation. Each loop shall be pulled tight to prevent the joint opening during filling.

10.2.3. Erection

10.2.3.1. Only assembled boxes, or groups of boxes, shall be positioned in the structure. The side, or end, from which work is to proceed, shall be secured either to the completed work, or by rods or stakes driven into the ground at the corner. These stakes must be secure and be high enough to reach at least to the top of the gabion box.

10.2.3.2. Further gabion boxes shall be positioned in the structure as required, each being securely laced to the preceding one along all common corners and diaphragms using the lacing technique described above.

10.2.3.3. Adjacent panels shall be laced longitudinally to provide a homogeneous reinforcement layer.

10.2.3.4. All lacing wire shall be PVC coated.

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10.2.4. Geotextile

Non-woven geotextile, as specified in the contract drawings and approved by the S.O., shall be placed vertically at the back of each gabion box section of the GRES units, and extend backwards into the fill at least 0.5m parallel to the mesh of homogeonous lower panel and also 0.5m below the panel directly above the unit, to prevent migration of fines.

10.2.5. Stretching

10.2.5.1. Final stretching of the gabion boxes shall be carried out using a pull-lift of at least one tonne capacity, firmly secured to the free end of the assembled gabion boxes.

10.2.5.2. Whilst under tension, the gabion box section of the GRES units shall be securely laced along all edges (top, bottom and sides) and at diaphragm points, to all adjacent boxes.

10.2.6. Filling

10.2.6.1. Filling shall be carried out whilst gabion boxes are under tension.

10.2.6.2. The front face and all other faces which will be exposed in the completed structure shall be “hand packed” with the stones placed so as to produce a neat face free from excessive bulges, depressions and voids.

10.2.6.3. Internal bracing wires shall be provided on the exposed faces at the rate of 4/m^3 at 330mm centres to prevent distortion of the units during filling and in the completed structure. These bracing wires shall be wrapped around two of the mesh wires and extend from front to back. Additional bracing wires shall be provided on exposed ends at a rate of 4/m^2 of face.

10.2.6.4. Mechanical filling equipment may be used with the approval of the S.O., provided adequate precautions are taken to protect the PVC coating from abrasion during filling operations.

10.2.6.5. Tension on the gabion boxes shall be released only when fully laced and sufficiently full to prevent the mesh from slackening.

10.2.6.6. All gabions shall be overfilled by 25mm using flat stone to allow for minor settlement and to provide a level surface for subsequent layers.

10.2.7. Structural Embankment Material

Select backfill shall be placed between each subsequent mesh panel layer to the full extent of the mesh reinforcement at each level as specified in sub-section 10.1.11..

10.2.8. Compaction of Backfill

10.2.8.1. The select backfill shall be compacted in lifts not exceeding 250-300mm to 90% of maximum density as determined by Test

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12 of BS1377, unless otherwise specified on the drawings or specified by the S.O..

10.2.8.2. Care shall be taken to ensure heavy compaction equipment does not come into contact with the mesh panels or within 1.0m of the front face. Tracked construction equipment shall not be operated directly upon the mesh reinforcement. A minimum fill thickness of 150mm is required prior to operation of tracked vehicles over the mesh.

10.2.8.3. During construction, the surface of fill should be kept horizontal. A slight sloping surface shall be maintained to facilitate drainage of surface water run-off.

10.2.8.4. Compaction adjacent to the front edge should be done using hand operated rollers or plate compactors.

11. Hydroseeding

11.1. Where hydroseeding is required for slope protection, it shall be carried out as specified under SECTION W: HYDROSEEDING.

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1. Description

This work shall consist of numerous ground improvement technique and instrumentation in regards with general requirement, method of installation and relevant testing to be implemented during construction.

2. Removal and Replacement

2.1. General

This Section shall be read together with SECTION B: EXCAVATION AND EARTHWORKS. Removal and replacement shall be used for ground improvement purposes to increase the bearing capacity of the ground. The work involves removal of unsuitable material and soft soil layer, hence replaced with suitable material as shown in the Drawing. Unsuitable material and suitable material are as defined in SECTION B: EXCAVATION AND EARTHWORKS.

2.2. Determination of Depth of Removal

2.2.1. The depth of removal shall be as shown on the Drawing or as determined by trial pits or JKR/Mackintosh Probe test as approved by the S.O.. The trial pits or probe test shall be carried out at locations as indicated in the Drawing or as instructed by the S.O..

2.2.2. The apparatus used shall be the standard JKR probes or Mackintosh probes. Procedure of works and details of the JKR probes and Mackintosh probes are as per *Standard Specification for Roadworks* "SECTION 17: SITE INVESTIGATION".

2.3. Materials for Replacement

2.3.1. Where geotextile is specified, it shall be laid as shown in the Drawing before commencement of filling works. The specification of geotextile shall be in accordance to sub-section 4.4..

2.3.2. Unless otherwise indicated in the Drawing, suitable materials for fill and method of compaction shall conform to SECTION B: EXCAVATION AND EARTHWORKS.

2.3.3. For replacement of excavated material under standing water, the fill material shall be granular material conforming to SECTION B: EXCAVATION AND EARTHWORKS.

3. Surcharge

3.1. General

3.1.1. The execution of surcharging works shall be in accordance with this Specification and details as shown in the Drawing.

3.1.2. The scope of works shall cover the following:

3.1.2.1. Spread, level and compact surcharging material in accordance with SECTION B: EXCAVATION AND EARTHWORKS and details as shown in the Drawing.

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3.1.2.2. Install geotechnical instrumentation to monitor and validate the performance of the works.

3.1.2.3. Removal and disposal of excess material on completion of specified surcharge period or as shown in Drawing or when directed by the S.O..

3.1.2.4. Removal and disposal of excess material of the embankment to the line, level and grade in accordance to details as shown in the Drawing to complete the works.

3.1.3. The Contractor shall be responsible for the provision of surcharge material and the removal and disposal of excess material on completion of the specified surcharge period or when directed by the S.O..

3.2. Materials

3.2.1. Materials for use in surcharging shall be suitable material conforming to *Standard Specification for Building Works* SECTION B: EXCAVATION AND EARTHWORKS.

3.2.2. The filling material shall be laid in layer and compacted as per SECTION B: EXCAVATION AND EARTHWORKS.

3.3. Surcharge Load and Surcharge Period

The surcharge load shall be applied throughout the surcharge period. The surcharge period specified in the Drawing is subjected to validation from field monitoring results, which may be shortened or lengthened at the discretion of the S.O. based on interpretation of field monitoring results.

3.4. Stability of Embankment

3.4.1. The height of the embankment including the surcharge shall at no time exceed the specified height in the Drawing. The placement of the surcharge materials shall be in uniform layers and care shall be given to ensure stability of the embankment. The Contractor shall check at all times the rate of placement and adjust accordingly in order to avoid instability. Stockpiling of excess earth, machineries or any other materials shall not be permitted on the embankment.

3.4.2. Where counterweight berm is designed to enhance the stability of the embankment including the surcharge, the counterweight berm shall be constructed first prior to placement of surcharge material.

3.4.3. The width, height and slope gradient of the counterweight berms shall be constructed in accordance to details shown in the Drawing. Any remedial works arising from non-compliance of the requirements of this section which leads to embankment failure shall be borne by the Contractor at his own cost and time.

3.5. Drainage Blanket

3.5.1. The drainage blanket layer shall consist of clean sand with less than 10% of fine content passing the 75μm sieve having grading within the respective limits specified in SECTION B: EXCAVATION AND EARTHWORKS, **TABLE B1**.

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3.5.2. The drainage material for depositing in water shall be deposited without the associated use of a compaction plant.

3.5.3. The drainage blanket shall be built up evenly in horizontal layers, each not more than 300mm thick up to the design thickness as specified in the Drawing. Filling shall commence from the lowest level, and each layer shall cover the full area of the intended total fill area at that level before deposition of the subsequent layer commences.

3.5.4. The drainage system shall be regularly maintained throughout the surcharge period to ensure smooth dissipation of water. The outlets of water at the brinks of drainage blanket shall be cleared of any obstruction at all times by way of regular maintenance.

3.6. Instrumentation

3.6.1. Surcharge monitoring shall be carried out to monitor stability, settlement, deflection and pore water pressure of the embankment due to Surcharging. The types and numbers of instruments and frequency of monitoring shall be in accordance to the Drawing or as specified by the S.O.. Specification for Instrumentation shall be in accordance with sub-section 10..

3.6.2. The monitoring results shall be submitted to the S.O. according to the agreed frequency and shall form part of the surcharge control measures. Evaluation and amendments to the surcharging design may be carried out from time to time by the S.O. based on interpretations of the monitoring results.

3.6.3. The Contractor shall be responsible for and shall follow the instructions of the manufacturer in the installation, calibration and testing of all measuring instruments and equipment.

3.7. Removal of Surcharge Materials

3.7.1. Removal of surcharge materials shall only be carried out as instructed by the S.O. upon completion of the specified surcharge period and validated with field monitoring results.

3.7.2. There shall be no unauthorized removal of surcharge materials before the completion of the specified surcharge period and any remedial works arising from such unauthorized removal of surcharge shall be borne by the Contractor at his own cost and time.

3.8. Use of Surcharging in Conjunction with Other Ground Improvement Methods

When surcharging is used in conjunction with other ground improvement methods such as prefabricated vertical drains, the works shall conform to the requirements of the associated ground improvement works.

4. Geosynthetics

4.1. General

4.1.1. Unless otherwise specified elsewhere in the specification or on the Drawing, geosynthetics for use in ground treatment shall conform to requirement as specified herein.

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4.1.2. Geosynthetics used shall be manufactured by manufacturer that is ISO 9001 certified.

4.1.3. Geosynthetics shall be durable and resistant to naturally occurring chemical, fungi and bacteria when in contact with soils or materials to be treated. In addition, geosynthetics used shall be resistant against rotting, mildew, insects, salts, alkali, solvent and other constituents of the ground water.

4.1.4. The contractor shall be responsible for the true and proper setting-out of the areas to which the geosynthetics are to be placed and provide all necessary resources and equipment related to supply and laying of geosynthetics to the correct level and dimension as shown in the Drawing or as instructed by the S.O..

4.2. Packaging, Transportation and Storage

4.2.1. Geosynthetics shall be wrapped in heavy paper or similar heavy-duty protection covering for transportation and storage. If no covered area is available, geosynthetics shall be stored on raised platform and covered with a waterproof canvas. Geosynthetics shall be protected from sunlight, moisture, mud, dirt, dust, debris and other detrimental substances during transportation and storage.

4.2.2. Each roll of geosynthetics delivered to site shall be clearly labelled with the following:

4.2.2.1. Product brand name

4.2.2.2. Product type

4.2.2.3. Product grade

4.2.2.4. Date of manufacture or submission of mill certificate

4.2.2.5. Roll width and length

4.2.2.6. Batch serial number

4.2.3. The Contractor is solely responsible for the good condition of the geosynthetics stored at the worksite and in the event of damages or deterioration of the geosynthetics due to improper storage, the Contractor shall be liable to replace the affected materials at his own cost when directed by the S.O..

4.2.4. All materials which are damaged during transportation, handling or storage and do not meet the minimum requirements of the specification shall be rejected by the S.O. and shall be immediately taken off the site. No payment of any kind shall be made on the rejected product.

4.3. Quality Control and Testing

4.3.1. Submission of Material Test Report (MTR)

4.3.1.1. The contractor shall obtain the S.O.'s approval prior to supplying the geosynthetics to the site. Prior to the procurement of materials, the Contractor shall provide a sample and Material Test Report (MTR) not more than two (2) years old from the *ISO/IEC 17025* accredited laboratory with the scope of

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accreditation referring to geosynthetics, showing full compliance of the proposed geosynthetics to all the specified property values corresponding to their respective test methods for the approval of the S.O.. The *ISO/IEC 17025* accredited laboratory shall be internationally recognized accredited laboratory or higher learning institutions research laboratory.

4.3.1.2. The Contractor shall also submit technical data and samples to verify the physical, mechanical and hydraulic properties of the geosynthetics to be used for S.O.'s approval.

4.3.1.3. All tests shall be carried out in accordance with the Codes of Practices and Test Standards provided within this Specification. All cost associated with the tests and preparation of report shall be borne solely by the Contractor.

4.3.2. Routine Sample Testing

4.3.2.1. Routine sample testing shall be carried out at factory or at an accredited laboratory witnessed by the S.O.'s representative. The Contractor shall submit test report after each routine test showing compliance of the Specification.

4.3.2.2. Prior to installation and at the discretion of the S.O., test samples shall be carried out at the frequency specified in **Table V1** and **Table V2**. Control testing shall be carried out for each batch of geosynthetics in accordance with the provisions of **Table V1** and **Table V2**.

4.3.2.3. Individual sample shall not be less than two (2) meters in length for non-woven geotextile and one (1) meter in length for high strength woven geotextile and geogrid, times the full width of the geosynthetics. Samples submitted for tests shall indicate the linear meters of the geosynthetics and manufacturer's identifications represented by the sample.

4.3.2.4. Should any individual sample selected at random fail to meet the Specification, then that roll shall be rejected, and two additional samples shall be taken at random from two other rolls representing the same batch. If either of these two additional samples fails to comply with the Specification, then the entire batch of geotextile represented by the samples shall be rejected.

4.4. Geotextile

4.4.1. General

Geotextile shall be made of new synthetic polymeric fabric that are stable or stabilized against ultra violet (UV) radiation such that three months exposure to sunlight shall not reduce its specified strength to less than 70%.

4.4.2. Installation

4.4.2.1. Prior to the laying of geotextile, site clearance shall be carried out in accordance with the Specification and Drawing or as directed by the S.O.. All voids shall be filled with suitable material and the area cleared of large stones and exposed tree

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root systems or other such like protrusions. Geotextile fabric shall be installed to the shape and requirements as specified herein and in the Drawing.

4.4.2.2. Geotextile shall be placed just in advance of placement of the specified overlying fill material. Geotextiles laid shall be covered by the fill as soon as possible within seven (7) days of being placed. The counting of this foresaid seven (7) days shall commence immediately upon the geotextile being exposed from its protective wrapping. Installation proposals and trials as deemed required shall be carried out for approval by the S.O. prior to the acceptance of the placement method for the main works.

4.4.2.3. The geotextile shall be unrolled smoothly on the prepared ground. In general, high strength woven geotextile shall be placed transversely, across the direction of the road, or otherwise as approved by the S.O.. The geotextile shall be laid flat on the underlying surface with no wrinkles or folds and shall extend far enough over the edges of the embankment for a wrap-around as shown in the Drawing.

4.4.2.4. Adjacent geotextile rolls shall be overlapped or sewn in accordance with this Specification. Overlapping of geotextile without sewn connections shall only be allowed with the approval of the S.O.. On curves and corners, geotextile may be folded or cut to conform to the direction as approved by the S.O.. The seaming of geotextile is as described in sub-section 4.4.3..

4.4.2.5. The specified overlying fill material properties and method of compaction on the non-woven geotextile fabric shall be in accordance with SECTION B: EXCAVATION AND EARTHWORKS. Fill materials shall be deposited in layers in accordance with SECTION B: EXCAVATION AND EARTHWORKS and shall be spread simultaneously with the dumping in a manner to prevent any localized distress or failure of the ground.

4.4.2.6. No traffic shall travel directly on the non-woven geotextile and there shall be no sudden stops, starts or turns on the fill materials by the construction equipment or other such actions which may cause damage to the geotextile.

4.4.2.7. In water logged or swampy areas, the non-woven geotextiles shall be sunk after jointing by ballasting with sufficient sandbags. To control the location of the mattress, buoys shall be fixed with ropes on the edges of the non-woven geotextile or using other method as approved by the S.O.. The mattress shall be ballasted as soon as possible after positioning.

4.4.2.8. The contractor shall submit a detailed method statement on installation of the non-woven geotextile to the S.O. for approval prior to commencing installation works.

4.4.3. Jointing of Geotextile

4.4.3.1. In general, the joints are allowed for both machine direction (MD) and cross direction (CD) of the non-woven or woven

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geotextile used in separation and filtration application. Jointing of reinforcement geosynthethics such as high strength woven geotextile, geogrid, etc. is only allowed in the CD for reinforced soil structures (reinforced soil wall/soil slope and mechanically stabilized embankment).

4.4.3.2. Methods of Jointing

(i) There are two common methods to connect the geotextile, which are by overlapping or seaming. The decision to use an overlap or seam shall be based on the following: -

a) The weakness of the foundation soil upon which the geotextile is directly placed with respect to the potential for mud waving during the backfill operation;

b) the material and labour costs of deploying individual geotextile panels with extra material required for the overlap versus the material and labour costs of seaming and installing large, fabricated panels; and

c) The feasibility of deploying individual geotextile panels in poor access and/or adverse climatic conditions.

(ii) **Table V3** provides a guide in determining overlap requirements for separation/stabilization applications based on sub grade strength. When the sub grade soils upon which the geotextile is directly placed provides shear strength less than CBR = 0.5, the adjacent geotextile panels shall be seamed.

4.4.3.3. Sewn Seams

(i) The geotextile may be jointed using an approved handheld sewing machine by sewing a double thread ‘lock stitch’ with 'prayer' or ‘J’ or ‘butterfly’ seam (minimum lap of 50mm) as shown in **Figure V1**. Typically, polyester thread is used for seaming geotextiles. Minimum required density of stitches during sewing of the geotextile is 3 stitches per 25mm. The thread shall have a breaking load of not less than 200N.

(ii) The expected seam strength shall be more than 70% of the original strength of the non-woven geotextile. For high strength woven geotextiles, the expected seam strength shall be more than 30% of the original strength. Samples of such sewn seam assembly shall be tested in accordance with *ISO 10321* or *ASTM D4884* as requested by the S.O..

4.4.4. Non-Woven Geotextile

4.4.4.1. Non-woven geotextile described in this specification shall be for separation and filtration application of the ground treatment.

4.4.4.2. Unless otherwise approved by the S.O., non-woven geotextile shall be needle punched fibres of polypropylene or polyester supplied by an approved manufacturer.

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4.4.4.3. The physical, mechanical and hydraulic properties of non-woven geotextile shall meet the minimum requirement as given in **Table V4**. Minimum roll width shall be 4.0 meters.

4.4.4.4. In addition to requirement given in sub-section 4.3., the Contractor shall furnish test certificate from accredited laboratory that includes the following:

(i) Wide width tensile strength

(ii) Elongation

(iii) CBR Puncture Resistance

(iv) Permeability

(v) Effective Opening Size, O_{90} or Apparent Opening Size, O_{95}

4.4.5. High Strength Woven Geotextile

4.4.5.1. High strength woven geotextile described in this specification shall be for basal reinforcement application of the ground treatment.

4.4.5.2. Unless otherwise approved by the S.O., high strength woven geotextile shall comprise of woven yarns of high tenacity polyester filaments with properties that meet the requirement as given in **Table V5**. The edges of fabric shall be selvedge or otherwise finished in such a way to prevent the outer yarn from unravelling.

4.4.5.3. High strength woven geotextile shall be free of any flaws that may have an adverse effect on its physical and mechanical properties. Minimum roll width shall be 5.0 meters.

4.5. Geogrid

4.5.1. General

4.5.1.1. Unless otherwise specified elsewhere in the specification or in the Drawing, geogrid for use as geotechnical reinforcement and in ground treatment shall conform to the requirements as specified herein.

4.5.1.2. Geogrid shall be made of high tenacity polyester coated with PVC that meets the requirements as given **Table V6**. The geogrid shall be formed from cross-laid strips (geo-linear elements) bonded at the cross-over points. The geo-linear elements shall consist of continuous high tenacity polyester fibres coated with PVC.

4.5.1.3. Bonding at the cross-over points shall be such that the properties as required by the Contract are not affected. The strength of the bond shall be such as to ensure the function of the geogrid is achieved.

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4.5.1.4. The polyester fibres shall be:

(i) Coated with PVC to completely prevent ingress of moisture;

(ii) All free ends shall be sealed to completely prevent ingress of moisture;

4.5.1.5. The weft (referring to CD) elements shall be the same quality material as the warp (referring to MD) elements.

4.5.2. Durability of Geogrid

4.5.2.1. Durability of the geogrid shall be such that a design life of 120 years is achieved. The geogrid shall not deteriorate from exposure to sunlight and due to chemical action or biodegradation when buried in wet soil.

4.5.2.2. Information relating to the durability of the geogrid shall be submitted as required by the S.O. for his approval.

4.5.3. Method of Installation

4.5.3.1. Installation of geogrid shall be carried out by qualified and experienced workers under the supervision of a competent person. The geogrid shall be installed in compliance to Manufacturer's instructions utilizing approved plants/equipment. The fill to the lines and levels shall be well-graded granular, dry cohesive soils or other engineered fill as shown in the Drawing.

4.5.3.2. All works related to earthwork shall be referred to SECTION B: EXCAVATION AND EARTHWORKS.

4.5.3.3. Installation of Geogrid for Reinforced Slope

(i) At each level of geogrid reinforcement, backfill shall be roughly levelled before placing the geogrid. Compaction shall be carried out to the requirements of the Specifications. During backfill placement, trucks and heavy vehicles shall be kept back at least 1.0 meter from the face of the Geogrid Reinforced Slope.

(ii) The deposition, spreading, levelling and compaction of the fill shall be carried out generally in a direction parallel to the facing and shall be executed in stages to alternate with the placing and fixing of the reinforcing elements and the facing. The geogrid shall be laid whereby machine direction (MD) is in a direction perpendicular to the face of reinforced wall or slope. The overlapping width of adjacent panels of geogrid shall be minimum 150mm.

(iii) Care shall be taken to ensure that the reinforcing elements and facing are not damaged or displaced during deposition, spreading, levelling and compaction of the fill. The program of filling shall be arranged so that no machines or vehicles run on the reinforcing elements.

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(iv) The fill within 1.0 meter of the face of the Geogrid Reinforced Slope shall be compacted using one of the following:

a) Vibro tamper

b) Vibrating plate compacter having a mass not exceeding 1000kg

c) Vibrating roller having a mass per metre width of not more than 1300kg and a total mass of not more than 1000kg

(v) The rear of the Geogrid Reinforcing Slope shall be adequately supported either by temporary shoring or by phasing the work to ensure the contemporaneous deposition of the retained fill material.

4.5.3.4. Protection of Completed Geogrid Reinforced Slopes from Erosion

The Contractor, as specified in the Drawing or where instructed by the S.O., shall carry out adequate erosion protection measures such as vegetation, etc.

4.5.3.5. Drainage

The Contractor, as specified in the Drawing or where instructed by the S.O., shall carry out adequate water discharge method such as horizontal drain, cascade drain, etc to ensure the drainage of impounding water on the slope and the surface runoff.

5. Prefabricated Vertical Drains (PVD)

5.1. General

5.1.1. This specification covers the technical requirements for the supply and installation of Prefabricated Vertical Drains (PVD) as described herein. All materials used shall meet the requirements of this specification and all works shall be executed in accordance with the details shown in the Drawing and the procedures described herein.

5.1.2. The Contractor shall provide all necessary resources including materials, skilled workers, and plant/equipment to execute and complete the works related to supply and installation of PVD as shown in the Drawing.

5.1.3. All materials and workmanship shall be in accordance with the appropriate British Standards current at the time of tender, including those listed in this Specification, except where the requirements of British Standards conflict with this Specification, the latter shall take precedence unless otherwise approved by the S.O..

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5.1.4. The Contractor shall be responsible for the true and proper setting-out of the areas to which the PVD is to be placed and for the correctness of the lines, widths and levels.

5.2. Soil Investigation Report

A soil investigation report shall be made available at the S.O.'s office for the Contractor's information. The report is intended solely as a preliminary guide and neither the completeness nor the accuracy of the information provided is guaranteed. No responsibility is assumed by the S.O. for any opinion or conclusion given in the soil report. The Contractor shall study the given soil report and make his own interpretation of the information provided and to make due allowance for the effect of site conditions on his construction operations.

5.2.1. Pre-Treatment Soil Investigation

Cone Penetration Test (CPT) may be carried out to verify the thickness of sub-soil to be treated using PVD. CPT may be carried out if necessary. The CPT results shall be submitted to the S.O. for design verification purpose prior to the commencement of work.

5.3. Transportation and Storage

5.3.1. The PVD materials shall be labelled or tagged for sample identification and other quality control purposes. Each pallet shall be identified by the manufacturer's name, lot number, individual roll number, roll length, date of manufacture or mill certificate, manufacturer and product identification of the jacket and core.

5.3.2. During transportation and storage, the PVD shall be wrapped in heavy paper, burlap or similar heavy-duty protection covering. The PVD shall be protected from sunlight, mud, dirt, dust, debris and other detrimental substances during transport and on-site storage.

5.3.3. The Contractor shall ensure that the PVD is in good condition and properly stored in a covered area at the worksite. If no covered area is available, the PVD may be stored on raised platform and covered with a waterproof canvas. In the event of damage or deterioration of the PVD due to improper storage, the Contractor shall be liable to replace the affected materials at his own cost.

5.4. Materials

5.4.1. Prefabricated Vertical Drains (PVD)

5.4.1.1. General Requirements

(i) Prefabricated Vertical Drains (PVD) shall be from an approved manufacturer and consist of a polymer core enclosed within an external non-woven filter jacket and shall comply with the requirements as indicated in **Table V7**. The PVD shall be produced by factory with *ISO 9001* certification. The manufacturing process as well as the relevant tests required shall be accredited. The filter jacket shall be capable of resisting all bending,

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puncturing and tensioning subjected during installation and design life of the drain.

(ii) The core shall be made of continuous plastic material fabricated to facilitate drainage along the axis of the vertical drain.

(iii) The prefabricated vertical drain shall be resistant against rotting, mildew, bacterial action, insect, salts, acids, alkalis, solvent and other constituents in ground water.

5.4.1.2. Quality Control and Testing

(i) Submission of Material Test Report (MTR)

This section shall be in accordance with sub-section 4.3.1..

(ii) Routine Sample Testing

a) This section shall be in accordance with sub-section 4.3.2..

b) Prior to installation and at the discretion of the S.O., individual test sample shall be cut off from at least one roll selected at random to represent each batch or the first 100,000 meters, whichever is lesser. Individual sample shall be not less than 15 meters in length. Samples submitted for tests shall indicate the linear meters of drain and manufacturer's identifications represented by the sample.

5.4.2. Geotextile

This section shall be in accordance with sub-section 4.4..

5.4.3. Drainage Blanket

This section shall be in accordance with sub-section 3.5..

5.5. Installation

Proper method statement for installation shall be prepared and submitted to the S.O. for approval before commencement of works. The method statement shall include the use of all necessary resources such as materials, manpower, machineries and equipments. Also, to include is the sequence of works with diagrammatical illustrations where necessary, workmanship requirements as well as the construction quality controls.

5.5.1. Procedure

The equipment used for the installation of the PVD shall have adequate capacity to install the PVD to the required depth at one go without the need for any withdrawal and re-insertion. The Contractor shall be responsible to ensure that the working platform is stable and safe without risks to workers and nearby buildings or structures.

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5.5.2. Geotextile

The installation of geotextile section shall be carried out in accordance with sub-section 4.4..

5.5.3. Drainage Blanket

This section shall be in accordance with sub-section 3.5..

5.5.4. Prefabricated Vertical Drain (PVD)

5.5.4.1. Equipment

(i) PVD shall be installed with approved equipment of a type which will cause minimum disturbance to the sub-soil during the installation and maintain the mandrel in a vertical position.

(ii) PVD shall be inserted into the soil using a mandrel or sleeve. The mandrel or sleeve shall protect the drain material from tears, cuts and abrasion during installation and shall be retracted after each drain is installed.

(iii) The size and shape of the mandrel or sleeve shall be as close as possible to the size and shape of the drains to minimize disturbance to the soil. The length of the mandrel shall be not less than the maximum length of the drain. The mandrel shall be capable of making a clean puncture through any geotextile if necessary.

(iv) The mandrel or sleeve shall be provided with an anchor plate or similar arrangement at the bottom to prevent the soil from entering the bottom of the mandrel during the installation of the drain and to anchor the drain tip at the required depth at the time of mandrel withdrawal.

(v) The installation equipment of PVD shall come with a data log that shows the details of each PVD installed which includes, among others, the tag number and depth depending on what is required by the S.O.. The data log shall be converted into a file that is accessible and readable to the S.O..

5.5.4.2. Method Statement

(i) Fourteen (14) working days before the commencement of PVD installation, the Contractor shall submit full details of the materials, equipment, sequence and method proposed for PVD installation to the S.O. for review and approval. Approval by the S.O. of installation sequence and methods shall not relieve the Contractor of his responsibility to install drains in accordance with the Drawing and specifications.

(ii) Approval by the S.O. of the method or equipment used to install the drains shall not constitute, necessarily,

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acceptance of the method for the remainder of the project. If, at any time, the S.O. considers that the method of installation does not produce satisfactory quality and productivity as expected, the Contractor shall alter his method and/or equipment as necessary to comply with these specifications.

5.5.4.3. Setting Out

The intended positions of PVD shall be marked, numbered and pegged by the Contractor using a baseline and benchmark indicated by the S.O.. The Contractor shall take all reasonable precautions to preserve the pegs and is responsible for any necessary re-pegging.

5.5.4.4. Depth and Positioning

PVD shall be installed from the working surface to the depth shown in the Drawing, or to such depth as directed by the S.O.. The Contractor shall furnish to the S.O. on the next working day a summary of the PVD installed that day. The summary shall include the PVD type, location and length of PVD installed at each location.

5.5.4.5. Verticality

Equipment for installation PVD shall be plumbed prior to installing each PVD and shall not deviate from the vertical more than 1 in 50 during installing of any PVD.

5.5.4.6. Tolerances

The positions of installed PVD shall not vary by more than 150mm from the positions indicated in the Drawing. PVD installed which deviated more than 150mm from design plan positions or are damaged or improperly installed shall be rejected and abandoned in place and replaced accordingly.

5.5.4.7. Installation

(i) PVD shall be installed using a continuous push using static weight or vibration. Installation techniques using driving will not be permitted.

(ii) The installation shall be performed, without any damage to the PVD during advancement or retraction of the mandrel. In no case will alternate raising or lowering of the mandrel during advancement be permitted. Raising of the mandrel will only be permitted after completion of an installation.

(iii) The completed PVD shall be cut off neatly 150mm above the working grade, or as otherwise specified in the contract Drawing.

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5.5.4.8. Instrumentation Damage

The Contractor shall observe precautions necessary for protection of any field instrumentation devices. The Contractor shall replace, at his own expense, any instrumentation or equipment that has been damaged or become unreliable as a result of his operations prior to continuing with PVD installation or other construction activities.

5.5.4.9. Pre-Augering

(i) The Contractor shall be responsible for penetrating overlying fill material as necessary to satisfactorily install the PVD. Satisfactory installation may require clearing obstructions defined as any man-made or natural object or strata that prevents the proper insertion of the mandrel and installation of the PVD.

(ii) Where obstructions are encountered below the working surface which cannot be penetrated by the installation equipment, the Contractor shall complete the drain from the elevation of the working surface to the obstruction and notify the S.O. prior to installing any more PVD.

(iii) At the direction of the S.O. and under his review, the Contractor shall attempt to install a new PVD within 600mm horizontally from the obstructed PVD. A maximum of two attempts shall be made as directed by the S.O.. If the PVD still cannot be installed to the design tip elevation, the PVD location shall be abandoned and the installation equipment shall be moved to the next location, or other action shall be taken as directed by the S.O..

(iv) The Contractor may use augering, spudding, or other approved methods to loosen the soil and any obstructive material prior to the installation of PVD. The obstruction clearance procedure is subjected to the approval of the S.O.; however, such, approval shall not relieve the Contractor of his responsibility to clear obstructions in accordance with the specification.

(v) If augering is the selected method, the augers shall have a minimum outside diameter equal to the largest horizontal dimension of the mandrel, shoe or anchor, whichever is greater.

5.5.4.10. Splicing

Splicing of PVD material shall be done by stapling in a workmanlike manner and so as to ensure structural and hydraulic continuity of the drain. At the splice, the minimum overlap shall be 150mm and the lower portion of the jacket shall be external to the upper portion. A maximum of 1 splice per PVD installed will be permitted.

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5.5.5. Surcharge

This section shall be in accordance with sub-section 3..

5.6. As-Built Records

The Contractor shall submit to S.O. the daily installation record verified by S.O. representative, specialist contractor and main contractor on the next working day. The contractor shall submit as-built PVD treatment area plan certified by a Licensed Surveyor within fourteen (14) working days of completion of the last PVD. The as-built Drawing and records shall include the as-built position and depth of each PVD point noting any deviation outside specified tolerances.

6. Stone Columns

6.1. General

The work shall consist of the supply of equipment, labour and materials for the execution of stone column works for ground improvement. The stone column described in this Specification shall be carried out by deep vibratory compaction incorporating stone columns formed with imported granular backfill complying with the requirements of the latest version of *BS EN 14731*. This section shall be also in accordance with sub-section 5.1..

6.2. Soil investigation report

This section shall be in accordance with sub-section 5.2..

6.2.1. Pre-Treatment Soil Investigation

This section shall be in accordance with sub-section 5.2.1..

6.3. Method Statement for Construction Operations

6.3.1. Two (2) weeks before the commencement of the works, the Contractor shall submit to the S.O. a detailed method statement for the works. The method statement shall contain the following:

6.3.1.1. A detailed construction sequence;

6.3.1.2. Shop drawing showing details of all special requirements for the construction activities;

6.3.1.3. Design calculation of key temporary works endorsed by a P.E.;

6.3.1.4. Materials, plant and labour requirement at each construction stage;

6.3.1.5. Rate of production output based on resources allocated;

6.3.1.6. Environmental Management Plan in related with the works;

6.3.1.7. Other information relevant to the works.

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6.3.2. If requested by the S.O., the Contractor shall submit additional information pertaining to the method of construction.

6.3.3. The Contractor shall not change the methods which have been approved by the S.O.'s Approval. of the Contractor's proposed methods of construction shall not in any way relieve the Contractor of any of his duties or responsibilities under the contract.

6.4. Unexpected Ground Conditions

The Contractor shall report immediately to the S.O. any circumstances which, in the Contractor's opinion, indicate ground conditions that may differ from those expected by him from interpretation of the soil investigation report. The Contractor's report shall be in the form of written notice of which shall be given to the S.O. at the earliest possible time after encountering such conditions and obstructions. The report shall be accompanied by all information available to the Contractor which will materially assist the S.O. in verifying the conditions reported.

6.5. Adjacent Structures

6.5.1. The Contractor shall pay very careful attention to the construction constraints imposed by adjacent structures. The Contractor shall exercise extra care and implement adequate monitoring measures when carrying out the works so as not to disturb or damage the existing adjacent properties and foundations. The Contractor shall provide a proposal for monitoring adjacent properties for any detrimental effects arising out in execution of the works, so that appropriate and timely preventive action can be taken to minimise damage. The Contractor's proposal and monitoring program shall be certified by his Professional Engineer and approved by S.O..

6.5.2. The Contractor shall also carry out a condition survey of adjacent properties to establish the condition of the existing structures and facilities prior to commencement of work. Condition Survey shall be conducted by competent personnel and the result of the survey shall be submitted to the S.O. for record.

6.5.3. The Contractor shall be responsible for and shall bear the cost of such works and any claims of damage to adjacent structure and facilities arising from his execution of the works.

6.6. Existing Services

Prior to commencement of works, services in the ground and overhead shall be identified and clearly marked. The Contractor shall give all required notices to the appropriate utility authorities before commencement of works. The Contractor shall also locate existing services by piloting, protect existing services, rectify any damage or interference to them and provide temporary support while repairs are being carried out if so required.

6.7. Workmanship

6.7.1. The Contractor shall satisfy the S.O. regarding the suitability, efficiency and adequacy of the equipment to be employed. The Contractor shall state the type and number of rigs he intends to use.

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6.7.2. On completion of each area of stone column the Contractor shall grade debris and surplus material arising from the stone column to leave a reasonable firm and level working surface. On completion of the stone columns to the satisfaction of the S.O., the Contractor shall remove from the site all plant and unwanted material.

6.7.3. Installation of the stone columns shall be carried out by experienced Specialist Contractor approved by S.O.. The Specialist Contractor shall have the following experience and personnel: -

6.7.3.1. The Specialist Contractor shall employ personnel experienced in the construction of stone columns for this part of the Works.

6.7.4. For both dry and wet methods, the depth vibrator shall be sufficiently powerful to ensure:

6.7.4.1. The depth indicated in the Drawing may be reached; and

6.7.4.2. Adequate compaction of the stones can be achieved

6.7.5. For the avoidance of doubt, any equipment other than a depth vibrator as specified in the latest version of *BS EN 14731*, is non-complying and precluded.

6.8. Setting Out

Setting out shall be carried out by the Contractor from grid lines provided and maintained by the Contractor. Immediately before installation, the column position shall be marked with suitable identifiable pins, pegs or markers at least 300mm length. The pins, pegs or markers should be driven to ground level and the location marked with contrasting material.

6.9. Materials

6.9.1. Material used for forming stone columns shall consist of hard and durable stone so as to remain stable during column construction and the working life of stone columns. The material may be natural or crushed stones or recycled material based on availability at site, and shall conform to the following requirements:

6.9.1.1. The Aggregate Crushing Value (ACV) shall be not more than 30% (tested in accordance with latest version of *MS 30* or equivalent);

6.9.1.2. The Flakiness Index shall be not more than 30% (tested in accordance with latest version of *MS 30* or equivalent);

6.9.1.3. The average loss of weight in the sodium sulphate soundness test (5 cycles), shall not be more than 10% (tested in accordance with *AASHTO Test Method T104* or equivalent);

(i) The gradation shall comply with **Table V8** as appropriate.

The above tests shall be carried out on each of every source of material supplied to site.

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6.9.2. Material shall be used with a grading appropriate for compaction to form a dense column fully interlocking with surrounding ground. Material shall be compatible with the vibro plant used and flow freely within bottom and through feed delivery systems without arching, which may block these systems.

6.9.3. Material with particle size falling in the range of 20-40mm size (dry method) and 50-75mm size (wet method), its appropriate grading limit are as per **Table V8**. Quarry dust and other fine stone chippings shall be limited to not more than 5%. The material shall also be free of unsuitable material.

6.9.4. Prior to commencement of the works, the Specialist Contractor shall submit samples of the stone backfill from proposed source of supply to the S.O. for his approval.

6.9.5. Throughout the period of the works, when directed by the S.O., the Specialist Contractor shall be required to substantiate that the output from the approved sources of stone consistently conforms to the requirement of the Specifications and any conditions stipulated during the initial approval.

6.10. Stone Column Construction

6.10.1. The construction method may either be the wet or dry process. Generally, the wet process is suited for sites underlain by very soft to firm soils and a high ground water table. For dry process, it is suitable for soils with undrained shear strength of about 40-60kN/m^2 with relatively low ground water table. If the dry process is used it shall be demonstrated on site that the hole made by the machine will remain open to enable the stone to be placed cleanly to the bottom of the hole to form a continuous column to the surface.

6.10.2. Working platforms shall be designed, prepared and maintained by the Contractor in a manner suitable for the safe movement and working of the vibro plant. Material used to provide working platforms shall be granular, suitable for the ground conditions on which it is placed and shall not prevent poker penetration. Minimum thickness of the working platforms shall be at least 1000mm to ensure that stone compaction is effectively carried out to the ground surface.

6.10.3. Site working levels for the stone column shall be maintained throughout the duration of the Works. Where near surface obstructions occur, they shall be broken out prior to the commencement of the vibro works and the resulting voids shall be filled with granular material that can be penetrated and compacted by the vibrating poker.

6.10.4. The stone column shall be formed to the working surface without inclusion of clay or other unsuitable material preventing intergranular contact between stone particles.

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6.10.5. When the dry top-feed process is being used, the vibrator may be removed completely from the hole to allow access for the stone. Where the dry bottom-feed process is used, the depth vibrator shall not be removed from the ground during column construction. When the wet process is being used, the vibrator shall be kept in the hole at all times in order to maintain stability of the sides and to ensure that the stone shall reach the required depth via the annular space around the vibrator.

6.10.6. The Contractor shall provide a supply of water if the wet process is selected. The Contractor shall indicate the rate of water supply required and be responsible for checking that this is available. The Contractor shall be responsible for supplying any extra storage tanks and pumping as required.

6.10.7. Any unnecessary excavation on the stone column construction shall be avoided. Where this is not possible, excavation of the constructed stone columns shall be carried out with prior approval from the S.O. and under his strict supervision to minimize the disturbance on the constructed stone columns. Compaction by rolling or tamping rammer shall be carried out before foundation construction.

6.10.8. The Contractor shall be responsible for disposal of effluent from the works and complying with the Environmental Law and Regulations. The Contractor shall provide countermeasures as required by the Environmental Management Plan (EMP) and maintain silt traps required. On completion of the stone column the Contractor shall remove all such equipment and backfill any pits.

6.10.9. In ground conditions where pre-boring is deemed necessary, it shall be carried out by a method and to a sequence agreed by the S.O.. Pre-boring shall be carried out immediately before, or as near as practicable, to stone column construction to mitigate any safety issues associated with open excavations and prevent unnecessary deterioration of the underlying ground, for example due to water ingress.

6.10.10. Verticality

The maximum permitted deviation of the stone column from the vertical is 1 in 20.

6.10.11. Depth and Spacing

The depth and spacing of the stone columns shall be as shown in the Drawing and neither the depth nor spacing shall be varied without the prior agreement of the S.O.. Any variations in depth of stone columns due to site conditions not anticipated in the design shall be reported immediately to the S.O. who shall advise on any action to be taken.

6.10.12. Tolerances

All stone columns shall be located to within 150mm of the plan positions shown on the stone column layout Drawing.

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6.11. Construction Records

6.11.1. The Contractor shall keep records each of the stone column carried out as required by the S.O. and shall submit two signed copies of these records to the S.O. not later than at noon of the next working day after the stone column is completed. The duly signed records shall form part of the records for the works. Any unexpected conditions shall be noted in the records.

6.11.2. The Contractor shall ensure that the equipment to be used shall be instrumented with sensors and the data processed by a micro-processing unit to enable continuous monitoring and data capture of the following parameters during the construction of each stone column:

6.11.2.1. The depth of vibrator and vibrator movements (depth of penetration); and

6.11.2.2. Power consumption (compaction effort)

6.11.3. Data captured shall be continuously displayed on an LCD unit and graphical output (plots of depths versus time and power consumption) generated by an automated computerised recording device throughout the process of the stone column installation. This shall be done for each point and records shall be submitted to the S.O. by the next working day.

6.11.4. The records of each completed stone column shall contain but not limited to the following information where applicable: -

6.11.4.1. Identification number and location of stone column point

6.11.4.2. Date and time

6.11.4.3. Method of treatment

6.11.4.4. Equipment and personnel in-charge

6.11.4.5. Depth of penetration

6.11.4.6. Time required to reach maximum depth and withdrawal

6.11.4.7. Vibrator power consumption during penetration and compaction

6.11.4.8. Material consumption

6.11.5. Any observed ground heave or settlement during construction shall also be recorded and reported to the S.O..

6.12. Preliminary Stone Columns

Prior to commencement of actual stone column works, the Contractor shall carry out preliminary stone column as shown in the Drawing to establish the installation criteria for the subsequent stone column and for confirming the adequacy of the design, dimensions and working load through load test. The Contractor shall give at least three (3) days' notice of the commencement of construction of any preliminary stone column.

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6.13. Testing of Stone Column Works

6.13.1. To verify the design assumptions and working load, The Contractor shall carry out load test on stone column as shown in the Drawing or as instructed by S.O.. The testing procedures shall be submitted two (2) weeks before the commencement of load test for S.O. approval. Loading of a stone column shall not commence until seven (7) days have elapsed after completion of its installation.

6.13.2. Load testing for stone column can be carried using plate test or zone test as shown in the Drawing or as instructed by the S.O.

6.13.2.1. Plate test: A plate test is a loading test carried out using a plate on treated ground essentially used as a control of workmanship. It can be a single column plate load test or a group of four columns plate load test.

6.13.2.2. Zone test: A zone test is a loading test carried out over a large treated area, intended to test stone columns' performance over a wider and deeper zone than in the plate bearing test. A zone test is usually carried out by placing earth fill to simulate widespread loads, and the fill height will be determined to meet the required test pressures.

6.13.3. During the progress of a test, the testing equipment and all records of the test shall be available for inspection by the S.O..

6.13.4. Load Test Procedures

The plate load test shall be carried out in accordance with the latest version of *MS 2038*.

6.13.5. Submission of Results

6.13.5.1. Full test data and results shall be jointly signed in duplicate by the S.O.'s representative witnessing the test and the Contractor's authorized personnel immediately upon completion of the test. A copy of this records shall be kept by the S.O..

6.13.5.2. Within seven (7) days of the completion of the test, a complete test report inclusive of all necessary analysis shall be submitted to the S.O. This shall be as specified below for a plate bearing test or a zone test as appropriate.

6.13.5.3. Information on Tested Ground from Plate Tests

(i) The Contractor shall provide information about the tested ground in accordance with the following schedule where applicable:

a) General

i. Contract identification
ii. Date of test

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b) Test area Details

i. Identification of area relative to site layout drawing
ii. Brief description of position in structure
iii. Ground level at test position
iv. Excavated test level

c) Treatment Details

i. Date and time of treatment
ii. Unexpected circumstances or difficulties

d) Stone Columns

i. Identification numbers of stone columns
ii. Diameter and depth of stone columns exposed
iii. Spacing of adjacent columns
iv. Depth
v. Stone consumption

e) Test Procedure

i. Approximate weight of kentledge
ii. Date and times of load application

f) Test Results

i. Load and settlement with time reported in tabular form, and in graphical form, load and settlement being plotted against time, and load against settlement.

6.13.5.4. Information on Tested Ground from Zone Tests

The Contractor shall provide information about the tested ground in accordance with the following schedule where applicable:

(i) General

a) Contract identification
b) Date Of tests

(ii) Test Area Details

a) Identification of area relative to site layout drawing
b) Size and position of area
c) Ground level at test position
d) Excavated test level

(iii) Treatment Details

a) Date and time of treatment
b) Unexpected circumstances or difficulties
c) Identification number of stone columns
d) Depth of treatment
e) Stone consumption

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(iv) Test Details

a) Plan showing position and extent of zone test fill in reference to the stone columns and instrumentation layout

b) Method of load-measurement, if any (e.g. pressure cells, or earth fill field density tests)

c) Fill height measurements versus time (e.g. rod settlement gauges)

d) Dates and times of fill application, duration of instrumentation

e) Other instrumentation measurements over time (e.g. inclinometers, settlement markers)

(v) Test Results

a) Load and settlement with time reported in tabular form, and in graphical form, load and settlement being plotted against time, and load against settlement

6.13.6. Completion of a Test

Upon completion of a test, all temporary structures used in the testing (concrete slab or ground anchor etc.) shall be dismantled and removed from site. The ground shall be made good to the original commencing surface level.

6.14. As-Built Records

6.14.1. The Contractor shall submit an as-built stone column location plan certified by a Licensed Surveyor to the S.O. within fourteen (14) working days after the completion of the works. Partial as-built plan may be submitted throughout construction of the works for verification by the S.O..

6.14.2. The as-built Drawing shall include the following information:

6.14.2.1. The stone column identification number and corresponding as-built depth of each point;

6.14.2.2. Spatial coordinates of reference points delineating the treatment; and where stone columns positions were deviated on site due to obstructions or other reasons with the knowledge of the S.O., the new position coordinates shall be included.

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7. Deep Soil Mixing

7.1. General

The work shall consist of the supply of equipment, labour and materials for the execution of deep soil mixing (DSM) works. Deep soil mixing method shall comply to *BS EN 14679*. This section shall also be in accordance with sub-section 5.1..

7.2. Soil Investigation Report

This section shall be in accordance with sub-section 5.2..

7.2.1. Pre-Treatment Soil Investigations

7.2.1.1. This section shall be in accordance with sub-section 5.2.1..

7.2.1.2. The Contractor shall carry out chemical test to determine the types of chemical present in the soil for effective deep soil mixing. The Contractor shall provide Material Safety Data Sheet (MSDS) produced by the Manufacturer for the handling and storage of chemicals used. The use of chemicals shall be in accordance with *Standard Specification for Roadworks* "SECTION 18: SOIL STABILISATION".

7.3. Method Statement for Construction Operations

7.3.1. This section shall be in accordance with sub-section 6.3.. The method statement shall also include precautions against heave and settlement.

7.4. Unexpected Ground Conditions

This section shall be in accordance with sub-section 6.4..

7.5. Adjacent Structures

This section shall be in accordance with sub-section 6.5..

7.6. Existing Services

This section shall be in accordance with sub-section 6.6..

7.7. Specialist Contractors and Personnel

DSM works shall be carried out by experienced Specialist Contractor approved by the S.O.. The Specialist Contractor shall have the following experience and personnel:

7.7.1. Personnel experienced in the design, supervision and construction of DSM columns

7.8. Setting Out

This section shall be in accordance with sub-section 6.8..

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7.9. Material

7.9.1. Binder

7.9.1.1. Cementitious binders to be used shall be an approved variant of Portland cement, complying with *Standard Specification for Building Works* SECTION D: CONCRETING or as per *BS EN 197-1*. The cement shall be adequately protected from moisture and contamination in storage on the job site. Reclaimed cement containing lumps or deleterious matter shall not be used. Other binders shall be acceptable if the project requirements can be met with their use. Laboratory tests shall be required to verify the suitability and dosage of the other binder variants.

7.9.1.2. If other chemicals are proposed, the material shall be in accordance with *Standard Specification for Roadworks* "SECTION 18: SOIL STABILISATION".

7.9.2. Water

Freshwater, free of an excessive amount of deleterious substances that adversely affect the properties of the binder shall be used. It is the responsibility of the Contractor that the grout resulting from the water shall always meet the requirements of this specification.

7.9.3. Grout suspension

Grout suspension shall be prepared on site using binder(s) as described in sub-section 7.9.1. and other additives, wherever required, in water. The grout shall be pumpable and workable with the DSM injection equipment.

7.9.4. Additives

7.9.4.1. Admixtures may be used to enhance the workability or final properties of the treated soil. Conventional additives include bentonite, fly ash, lime, sodium silicate, a set retarder, alkali activator, etc. Additives may be added to the water or the grout. Notwithstanding, the use of additives is subjected to the approval of the S.O..

7.9.4.2. The Contractor shall provide Material Safety Data Sheet (MSDS) produced by the Manufacturer on the use of chemical additives to ensure the safety of the material used. The Contractor shall be made liable for any discrepancies that occur during the application of chemical additives in the absence of MSDS.

7.9.5. Soil Mixing Material

Soil-mixing material, resulting from the in-site mixing of soil with grout suspension (mainly for a wet method of mixing), should have a compressive strength as specified in the drawing. The factor of safety concerning the maximum characteristic stress acting on a single column shall be not less than 2.0.

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7.9.6. Steel Reinforcement

Steel reinforcement, if specified in the drawing shall comply with SECTION D: CONCRETING, relevant specifications and Malaysian Standards.

7.10. DSM Column Installation

7.10.1. General

The Contractor shall satisfy the S.O. regarding the suitability, efficiency and adequacy of the equipment to be employed based on soil conditions and the requirements defined herein and in the design. The equipment chosen for the installation of works shall be in full compliance with the provision of the *BS EN 14679*.

7.10.2. Drilling Equipment

7.10.2.1. Deep soil mixing equipment shall be capable of rotating down to the required depth or stiff layer through the weak soil and withdrawing the mixing tool by simultaneous rotation and mixing of the binder with in-situ soil.

7.10.2.2. Deep soil mixing machine shall have a single or multiple shaft(s) with cutting/mixing blades at the lower end.

7.10.2.3. Deep soil mixing machine shall be able to operate at different rotation and withdrawal rates within the required range as in the design to complete the work and produce the required cement columns, and as required by *BS EN 14679*.

7.10.2.4. The cutting/mixing blades shall have the minimum diameter as per design. The size of the mixing tool shall define the column diameter.

7.10.2.5. The mixing tools shall consist of a minimum of one nozzle for the binder delivery but shall be demonstrated that it is adequately sized to meet the binder dosage as required by design.

7.10.2.6. Real-time measuring and recording devices shall be provided throughout the mixing operation, to capture data e.g. column number, time, depth, pressure, feed rates, rotation speed, injection rate, injection volume, binder consumption, etc.

7.10.3. Binder Delivery Station

7.10.3.1. Dry Method

In the dry method, the deep soil mixing process shall be carried out by mixing the binder in powder form. The medium of transportation of binder is typically compressed air unless otherwise approved by the S.O.. Binder storage tank(s)/ silo(s) is generally on-board with the DSM machine or on a separate self-propelled chassis connected to the DSM machine.

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7.10.3.2. Wet Method

In the wet method, the deep soil mixing process shall be carried out by mixing the binder in slurry form. The medium of transportation of binder usually is water unless otherwise approved. The binder is generally prepared at the separate mixing and holding tanks and pumping station shall be required to deliver the binder to the DSM machine. The mixing and pumping station shall be able to produce enough volume of slurry required and enable continuous supply and controlled delivery of slurry.

7.10.4. Working Platform Preparation

Working platforms shall be designed, prepared and maintained by the Contractor in a manner suitable for the safe movement and working of the deep soil mixing equipment. The material used to provide working platforms shall be suitable for the ground conditions on which it is placed and shall not be detrimental to the drilling operation. Site working levels for the treatment shall be provided and maintained by the Contractor throughout the deep soil mixing works.

7.10.5. Soil Mixing Work

7.10.5.1. Unless otherwise specified, pressure feed of the binder shall be terminated approximately 0.5m to 1.0m below the working platform. Satisfactory quality shall not be relied on in the design over a depth of 1.0m below the working level, i.e. within the working platform material. If the deep soil mixing operation is interrupted for any reason, re-mixing or repositioning may be required upon confirmation from the S.O. on site.

7.10.5.2. The mixing tool rotation speed shall be adjusted to accommodate a constant rate of mixing as given in the design. The penetration/withdrawal rate of the mixing tool shall be maintained such that the proper amount of binder is added and the proper amount of mixing time is allowed as per design. Both the rotation speed for mixing tool and penetration/withdrawal rate can be adjusted according to drilling difficulty, upon confirmation from the S.O. on site.

7.10.5.3. The injection rate per vertical meter of column shall be predefined by the Contractor. The injection rate shall be adjusted accordingly, if necessary, with the working parameters in the paragraph above herein, throughout the work to achieve the requirement for the DSM columns. The injection rate of the binder shall be measurable and monitored with the appropriate device as proposed by the Contractor.

7.10.5.4. After completion, the DSM columns shall be left undisturbed for at least 14 days. The area of DSM columns shall not be driven over with heavy equipment.

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7.10.6. Obstruction

In the event of obstructions preventing the drilling and installation of DSM columns, the S.O. shall be informed immediately. Remedial options subject to approval from the S.O. shall include:

7.10.6.1. Reposition the column a short distance from the original position.

7.10.6.2. Additional DSM column(s) around the obstruction, if necessary.

7.10.6.3. Excavate, remove the obstruction, backfill and compact to the requirements of *Standard Specification for Building Works* SECTION B: EXCAVATION AND EARTHWORKS and reinstall the DSM column.

7.10.7. Verticality

The maximum permitted inclination of the DSM columns is 1 in 75.

7.10.8. Length, diameter and spacing

The length, diameter and spacing of the DSM columns shown in the Drawing shall be adjusted to suit site conditions when deemed necessary as instructed by the S.O..

7.10.9. Tolerances

The maximum permitted deviation of the centre of the DSM column from the centre point shown on the setting out drawing shall be 150 mm in any direction.

7.11. Construction Records

7.11.1. On the same day, a daily record shall be submitted to the S.O. summarizing the points done and depths of DSM column installed. Two (2) copies of signed records for each soil mixing element shall be submitted to the S.O. on the next working day.

7.11.2. The record shall include the following information, but not limited to: -

7.11.2.1. Column ID or reference number;

7.11.2.2. Depth of installation;

7.11.2.3. Column top and toe level;

7.11.2.4. Binder type and composition, injection rate and total injection volume;

7.11.2.5. Time for mixing during penetration and withdrawal;

7.11.2.6. Rotation of mixing tool versus depth and blade rotations by numbers;

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7.11.2.7. Weather report;

7.11.2.8. Any other information as may be required by the S.O..

7.12. Preliminary DSM Column(s)

7.12.1. Before commencement of the DSM works, the Contractor shall carry out field trial as shown in the Drawing. A total number of minimum four (4) numbers of preliminary columns shall be constructed to verify the deep soil mixing methodology, suitability of the mixing tool and the design parameters. The quality of DSM columns shall conform to the design requirements and shall be verified using the appropriate testing method, e.g. by the mean of the load test. Loading on the DSM column shall not commence until fourteen (14) days have elapsed after completion of its installation.

7.12.2. Where excavation is possible, assessment of the geometric and mechanical characteristics of the DSM column should be made by visual inspection. Coring can be made on the completed columns. Unconfined Compressive Strength Testing (UCS) on samples recovered by coring or excavation can be made to verify the soil-mixing material compressive strength as specified in the design. At least one (1) of the trial columns shall be sampled and UCS testing shall be carried out on three samples. The sampling and testing frequency may be varied based on project requirements or at the instruction of the S.O..

7.13. Quality Control and Quality Assurance

7.13.1. Quality Control

7.13.1.1. Before the commencement of all works, procedures for verification, control and acceptance shall be established in the method statement with reference to the drawing and specification.

7.13.1.2. Blade rotation number of soil mixing shall be used as a guide to verify the consistency of mixing and forming homogenous columns. Minimum blade rotation number in cohesionless soils shall be at least 300, whereas for cohesive soils it shall not be less than 400. For peaty and organic soils, the blade rotation number shall be at least 600. These requirements shall be followed unless otherwise stated in the project requirement or instructed by the S.O..

7.13.1.3. The construction process shall be controlled and monitored automatically, with the aid of a computerised system. The construction parameters and information as detailed in **Table V9** shall be monitored continuously during execution.

7.13.2. Sampling

7.13.2.1. The sampling of soil mixing improved ground shall be done by conventional vertical coring. Double tube sampling shall also be acceptable provided the Contractor can demonstrate that good sample recovery can be obtained. Wet grab sampling shall also be permitted, and samples shall be prepared from wet grabs at

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the instruction of the S.O.. The S.O. shall also instruct at what depth the sampling needs to be taken. Sampling shall ensure that the recovery ratio is at least 80% or otherwise instructed by the S.O..

7.13.2.2. At least 1% of the installed columns shall be sampled by coring, double tube or wet grabbing, unless otherwise stated in the drawing. Minimum three (3) samples from each sampled column shall be tested for UCS. The sampling and testing frequency may be varied based on project requirements or at the instruction of the S.O..

7.13.3. Unconfined Compression Test

7.13.3.1. Where necessary, the improvement from the treatment shall be tested by Unconfined Compression Test (UCT) of samples. The Unconfined Compressive Strength (UCS) of samples shall meet the requirements of the design, where the characteristic strength of samples shall be more than the project requirements.

7.13.3.2. UCT testing shall be done on cylindrical or cube samples having a minimum dimension of 50 mm diameter. Corrections to readings and reporting of values shall be as per *BS EN 12504-1*.

7.13.3.3. Where required the S.O. may specify additional tests to determine other engineering properties of the improved ground.

7.13.4. Load Test

This section shall be in accordance with sub-section 6.13..

7.13.5. Submission of Test Results

This section shall be in accordance with sub-section 6.13.5..

7.14. As-Built Drawing

7.14.1. The Contractor shall submit an as-built DSM columns location plan certified by a Licensed Surveyor to the S.O. within fourteen (14) working days after the completion of the works. Partial as-built plan may be submitted throughout construction of the works for verification by the S.O..

7.14.2. The as-built Drawing shall include the following information:

7.14.2.1. The DSM column identification number and corresponding as-built depth of each point;

7.14.2.2. Spatial coordinates of reference points delineating the treatment; and where DSM columns positions were deviated on site due to obstructions or other reasons with the knowledge of the S.O., the new position coordinates shall be included.

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8. Dynamic Compaction

8.1. General

The works shall consist of the supply of plant, equipment and specialist personnel for the execution of dynamic compaction (DC) works for ground improvement. This section shall also be in accordance with sub-section 5.1..

8.2. Specialist Contractor

DC works shall be carried out by experienced Specialist Contractor approved by the S.O.. The Specialist Contractor shall have the following experience and the personnel:

8.2.1. The Specialist Contractor shall employ competent and experienced geotechnical engineer who is capable of analyzing existing soil data, obtaining and interpreting additional data as required, performing field testing prior to, during and after DC works.

8.3. Soil Investigation Report

This section shall be in accordance with sub-section 5.2..

8.4. Method Statement for Construction Operations

This section shall be in accordance with sub-section 6.3..

8.5. Unexpected Ground Conditions

This section shall be in accordance with sub-section 6.4..

8.6. Adjacent Structures

8.6.1. This section shall be in accordance with sub-section 6.5..

8.6.2. At locations where acceptable peak particle velocity or acceleration are likely to be exceeded, cut off trenches or other protective measure shall be taken. Contractor shall demonstrate to the satisfaction of the S.O., by trials, that his proposal will reduce the maximum peak particle velocity or acceleration to acceptable values.

8.7. Existing Services

This section shall be in accordance with sub-section 6.6..

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8.8. Workmanship

8.8.1. Contractor shall satisfy the S.O. on the suitability and efficiency of the equipment to be employed.

8.8.2. The dynamic compaction (DC) works shall be performed by a qualified Contractor. The DC works shall be carried out up to the designed depth/compaction energy required to make sure the design criteria are achievable.

8.9. Setting Out

Contractor shall perform setting out from the temporary bench mark (TBM) provided and shall be maintained by the Contractor. The approximate limits of work shall be shown in the DC shop Drawing and the exact limit shall be determined by the Contractor upon completion of the pre-treatment testing. DC points shall be marked with suitable and identifiable markers.

8.10. Working Platform

The working platform shall be prepared and maintained by the Contractor and suitable for safe movement and working for the DC plant and equipment. The working platform shall be made of granular material and at least 1000 mm above the ground water level.

8.11. Spacing

The spacing of the DC point shall be shown in the construction drawing. This shall be confirmed by field calibration or field trial conducted as approved by S.O..

8.12. DC Field Trial Area

The Contractor shall perform at least one (1) DC field calibration or trial area prior to commencement of the full production DC works. Minimum trial area shall be 20m x 20m. The objective of the field trial is to determine the optimum compaction energy to be applied to the DC point and to confirm the technical data obtained is as per design.

8.13. Site Records

The Contractor shall keep and submit to the S.O. the following records:

8.13.1. Number of blows for each DC point for each phase of DC works.

8.13.2. DC pounder free fall height for each blow for each phase of DC works.

8.13.3. Ground level before and after DC works.

8.13.4. Any other record as required by the S.O..

8.14. Testing

8.14.1. Pre-Treatment Testing

8.14.1.1. The Contractor shall undertake soil testing prior to commencement of DC works to provide data for the purpose of

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refining the preliminary design to comply with the acceptance criteria as specified. The field testing shall include the following:

(i) Pressuremeter Tests (PMT) shall be performed at every meter vertical interval and at changes in strata in accordance with the method outlined in ASTM D4719 or the latest version of BS EN ISO 22476-4.

(ii) Cone Penetration Tests (CPT) shall be performed in accordance with ASTM D5778 or the latest version of BS EN ISO 22476-1.

8.14.1.2. The Contractor shall determine the total number of locations of pre-engineering tests necessary to analyse the soil conditions and to delineate the areas requiring DC works. Pre-engineering testing shall include the following as a minimum:

(i) A minimum of one PMT for every 2000m² of area marked for improvement in the Drawing.

(ii) A minimum of one CPT for every 2000m² of area marked for improvement in the Drawing.

8.14.1.3. The Contractor shall determine locations of any additional testing that may be required if conflicting test results are indicated by two adjacent tests or to delineate areas for ground improvement.

8.14.2. Final Acceptance Testing

8.14.2.1. The Contractor shall verify the ground improvements works for compliance with the acceptance criteria by in-situ tests of the improved soils and by analysis of the test results. The final testing shall be conducted at a minimum of one week after completion of the ground improvement works.

8.14.2.2. The final tests shall generally be at the locations of the pre-engineering test locations and shall include the following field tests:

(i) PMT shall be performed at every meter vertical interval and at changes in strata in accordance with the method outlined in *ASTM D4719* or the latest version of *BS EN ISO 22476-4.*

(ii) Cone Penetration Tests (CPT) shall be performed in accordance with ASTM D5778 or the latest version of BS EN ISO 22476-1.

8.14.2.3. Final testing shall include the following as a minimum:

(i) A minimum of one PMT for every 2000m² of area marked for improvement in the Drawing.

(ii) A minimum of one CPT for every 2000m² of area marked for improvement in the Drawing.

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8.14.2.4. Areas in which the specified criteria are not met shall be reworked by the Contractor until the specified requirements are met. The S.O., at his/her discretion, may check the Contractor's test results by conducting additional and independent testing.

8.14.2.5. If necessary, correlation between the CPT results with PMT results can be conducted to obtain the limit pressure and pressure meter modulus required for the engineering calculations.

8.15. Documents Submission

8.15.1. The contractor shall submit to S.O. documents regarding the DC works as follows:

8.15.1.1. Pre-treatment testing proposal – this document is a plan and schedule for pre-treatment testing and shall be submitted at least seven (7) days before the pre-treatment testing is scheduled to begin.

8.15.1.2. Pre-treatment testing report – this document shall be submitted not later than fourteen (14) days after completion of pre-treatment testing.

8.15.1.3. Interim progress report – this document stated the DC works operations, including pre-treatment testing, final acceptance testing, elevation measurements, quantities completed during month, cumulative quantities to date and a forecast of remaining work.

8.15.1.4. Final technical report – this document shall be submitted at the completion of the DC works. The report shall contain graphical presentation of all parameters used by the Contractor to accomplish the acceptance criteria including all pre-treatment testing and final testing results together with as built Drawing. The report shall be submitted in five copies duly endorsed by a Professional Engineer.

9. Piled Embankment

9.1. General

9.1.1. The works shall consist of all labour, materials, tools, transportation, instrumentation, etc. necessary to construct piled embankment in accordance to the Drawing and SECTION C: FOUNDATION WORKS AND WORKS BELOW LOWEST FLOOR LEVEL.

9.1.2. The works shall cover the following:

9.1.2.1. Mobilization and demobilization of all labour, plants, piling and drilling equipment on site.

9.1.2.2. Supply, handling, pitching and installation of piles to the pile lengths as specified in the Drawing.

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9.1.2.3. Lengthening of piles by jointing to detail.

9.1.2.4. Strip pile to cut-off level and check pile eccentricity.

9.1.2.5. Construct reinforced concrete slab as per the details in the Drawing.

9.1.2.6. Carry out pile testing in accordance to SECTION C: FOUNDATION WORKS AND WORKS BELOW LOWEST FLOOR LEVEL on working piles as specified.

10. Geotechnical Instrumentation

10.1. General

10.1.1. Instrumentation shall be installed to measure horizontal and vertical displacement of the subsoil or structures supported by the subsoil and water pressures within the works and shall remain operational both during and after the construction period specified in the contract.

10.1.2. The Contractor shall be responsible for and shall follow the instruction of the manufacturer and the requirements of this specification in the installation, calibration and testing of all measuring instruments and equipment, which shall be carried out under the direct supervision of the S.O.. The Contractor shall inform the S.O. at least 2 days prior to undertaking installation of the equipment. The Contractor shall make due allowances in his construction programme for any delays which may arise on account of the installation of the instruments.

10.1.3. Protection and Maintenance of Instruments

The Contractor shall take all necessary precautions to protect the instruments and maintain the instruments in good working order after commissioning. For all instruments which project through and above the fill, special precautions shall be taken to provide protection from vehicles and plant including substantial and readily visible barriers at a radius of 750mm around each instrument. Heavy compaction equipment shall not approach within 1.0m of projecting instruments. Damaged instruments shall be replaced or repaired by the Contractor at his own expense within seven days.

10.1.4. Stabilising Electronic Readout Devices

All electronic readout devices and transducers shall be shaded from direct sunlight during use. Probes which are used inside access tubes shall be placed inside the tube and allowed to come to a stable temperature for at least 10 minutes before use. Zero or starting values shall only be taken once temperature stabilization is complete. All readout units shall be calibrated at least once a year and the calibration certificates submitted to the S.O..

10.1.5. Personnel

10.1.5.1. The Contractor shall submit names and curricular vitae of personnel including instrumentation engineer and

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instrumentation technician to carry out the instrumentation and monitoring and a programme of their attendance for the approval of the S.O.. Deviation from the approved programme of attendance or the requirements given in this clause shall only be permitted with the approval of the S.O..

10.1.5.2. The instrumentation engineer shall be responsible for the overall planning, implementation and monitoring of the instruments. He shall be on site throughout installation, commissioning and initial monitoring. He shall be on site for the remaining monitoring on a basis to be agreed with the S.O..

10.1.5.3. All instrumentation and monitoring works shall be carried out by an experienced instrumentation technician. Instrument data obtained shall be verified by an instrumentation engineer.

10.1.6. Boreholes for Instruments

10.1.6.1. Boreholes for instruments may be drilled by any method provided that it results in a clean and stable hole of the required diameter to the correct depth. The method of forming boreholes, including the procedure for advancing casing, shall be submitted to the S.O. for approval before commencement of the works.

10.1.6.2. Boreholes shall be cased to their full depth unless strata are sufficiently competent for the hole to stay open under dry conditions. If boreholes are drilled using water as a flushing medium, clean water shall be used. Drilling mud or polymer additives shall only be used with the approval of the S.O.. In the case of installation of piezometers, drilling mud or polymer additives shall not be permitted.

10.1.6.3. During drilling care shall be taken to ensure that minimum material is lost from outside the casing. Surging of the casing shall not be allowed and flushing of drilling water outside the annulus of the casing shall be minimized.

10.1.7. Grouting of Boreholes

For all instruments placed in boreholes, grouting is required for part or the entire borehole during installation. The grout shall be a bentonite: cement mixture with sufficient water to achieve a pumpable mix. The proportions of the mix shall be such as to imitate as closely as possible the strength or consistency of the natural soils present. Unless otherwise stated in the Drawing, the Contractor shall propose the suitable bentonite: cement mixture to S.O.'s approval. Grout shall be pumped into boreholes using a tremie pipe.

10.1.8. Labelling and Marking of Instruments

All instruments shall be labelled with their reference numbers at the location where readings or measurements are taken. The labelling shall be permanent using a method or material to be agreed with the S.O..

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10.1.9. Survey Equipment and Survey Reference Station

10.1.9.1. The Contractor shall be responsible for establishing survey reference station at locations selected by the S.O. to monitor settlement markers, settlement plates, displacement markers and other instruments deemed necessary.

10.1.9.2. All survey equipment used in conjunction with the monitoring of instrumentation, including measuring tapes, levels and total stations shall be maintained and calibrated as required by the manufacturers and good surveying practice.

10.1.9.3. The survey reference station provides a reference for levelling or horizontal measurement to other points. The location of the survey reference station, shall be agreed by the S.O.. The coordinates and elevation of the survey reference station shall be surveyed in and submitted to the S.O..

10.1.9.4. The survey reference station shall be established on undisturbed ground clear of the embankment. The survey reference station shall be located on stable ground not affected by the Works, preferably away from the construction activities. The survey reference station is to be located on structures free of settlement and lateral movement or as agreed by the S.O..

10.1.9.5. The survey reference station may comprise of a steel rod of 20mm diameter, which shall be driven vertically into the undisturbed ground for a minimum distance of 1.0m and shall project approximately 75mm above ground surface. The rod shall be surrounded by not less than 0.03m^3 of concrete at surface level, and the top of the rod shall be carefully centre-punched.

10.1.9.6. The survey reference station shall be checked at intervals to be established by the S.O. to ensure that it is stable during the course of the monitoring works.

10.1.10. Deep Levelling Datum

10.1.10.1. A deep datum is required to provide a reference for measurement of ground levels in areas of soft ground.

10.1.10.2. The Contractor shall propose the location and depth of the deep levelling datum for the approval of the S.O..

10.1.10.3. The datum itself shall be fixed into hard ground with Standard Penetration Test (SPT) value more than 50 or rock and isolated from soft and compressible overlying strata. If the SPT value of more than 50 is not achievable at great depths, the contractor and the S.O. shall mutually agree on the termination depth.

10.1.10.4. A deep levelling datum shall consist of a 25mm galvanized iron (GI) pipe fixed into hard ground with cement grout. The datum pipe shall be isolated from the overlying soft ground by a 75mm GI pipe bedded into the top of the cement grout. The upper part of the 75mm pipe shall be surrounded by a square concrete

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plinth of not less than 0.03m^3 of concrete. The details of the deep levelling datum including its protective measures are as shown in the Drawing. The concrete shall be scored with the reference number of the datum.

10.1.10.5. The level of a deep levelling datum shall be established by standard levelling techniques from agreed bench mark in the vicinity. Levelling shall be closed back to the bench marks to check for accuracy. The level shall be measured three times soon after installation of the datum and shall be checked at intervals to be agreed by the S.O..

10.1.11. Instrumentation Equipment References

Details of equipment shall be submitted to the S.O. for approval. If the S.O. considers it necessary, demonstrations shall be arranged by the Contractor. Any supplier of geotechnical instrumentation shall demonstrate that the manufacturer operates an adequate system of product quality assurance.

10.2. Displacement Marker/Settlement Marker

10.2.1. Displacement marker/Settlement marker is required to monitor the horizontal and vertical movement of the ground or embankment surface. The Contractor shall be responsible for establishing settlement markers at locations as shown in the Drawing or as determined by the S.O..

10.2.2. The marker shall comprise of a steel rod of minimum 20mm diameter which shall be driven vertically into the embankment or undisturbed ground for a minimum depth of 1.0m and shall project approximately 75mm above the ground surface. The rod shall be surrounded by not less than 0.03m^3 of concrete at ground level, and the top shall be domed and centre-punched. The details of the installation are shown in the Drawing. The concrete shall be scored with the reference number of the marker.

10.2.3. For the settlement marker~~s~~, the level of the top of the rod shall be measured using standard precise levelling techniques, referencing and closing back to the survey reference station with instrument to a minimum of +1mm accuracy.

10.2.4. For the displacement marker~~s~~, the lateral movement shall be measured using a total station or other survey techniques agreed by the S.O..

10.3. Building Settlement Marker

10.3.1. Vertical deformation of adjacent structures shall be determined by means of precision devices to an accuracy of + 1.0mm. The Contractor shall install building settlement points at location as specified by the S.O..

10.3.2. The precise levels shall have robust tripods. Levelling studs are to be provided for the purpose of precise levelling. Levelling studs shall be: -

10.3.2.1. Manufactured from stainless steel.

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10.3.2.2. Fixed to the building lining in the same manner and standard.

10.3.2.3. Designed such that their use in conjunction with the appropriate precise instruments allow precision levelling to an accuracy of + 1.0mm.

10.3.2.4. Designed such that the heads of the levelling studs on the walls can be easily levelled without the studs being vulnerable to damage.

10.3.2.5. Designed such that the studs are safe from any hazards and to human life.

10.4. Rod Settlement Gauge

10.4.1. Rod settlement gauge is required to measure settlement beneath the embankment. The Contractor shall provide and install rod settlement gauge at location and level as shown in the Drawing or as specified by the S.O..

10.4.2. The details of the rod settlement gauge shall be as shown in the Drawing and the Contractor shall be responsible for the installation of all the gauges as work proceeds. The base plate and first length of the rod shall be placed as early as possible during earthworks, preferably before any significant filling has been placed. Extension lengths shall be installed when the level of compacted embankment is 250mm below the top of the preceding lengths.

10.4.3. Should a rod settlement gauge be damaged, or should the Contractor fail to extend the gauge when required, the Contractor shall stop all filling activities in the vicinity of the gauge until the necessary remedial works have been carried out. The Contractor shall be liable for any delay in his programme, or any additional works that need to be done as result of such damage.

10.4.4. Should any rod settlement gauge be damaged in such a way as to make it useless for its purpose and unable for S.O. to assess the settlement, the contractor shall engage a third-party specialist at his own cost to assess the settlement for measurement purposes and shall be agreeable and approved by S.O. as the final decision.

10.4.5. Rod settlement plates shall be monitored by standard precise levelling techniques, referencing and closing back to the survey reference station with instrument to a minimum of +1mm accuracy. Levels shall be taken at the top of rod itself and the fill adjacent to the gauge on each occasion. When rods are extended, levels shall be measured immediately before and immediately after adding the extension.

10.5. Inclinometer

10.5.1. Inclinometer provides a method of measuring a continuous profile of horizontal deflection both at the surface of and within a mass of soil. The Contractor shall install Inclinometer at locations and depths as specified by the S.O.. The details of the Inclinometer shall be as shown in the Drawing.

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10.5.2. Inclinometer access tube shall consist of broached polyvinyl chloride (PVC) tubing with four keyways set at right angles to each other and with couplings and end caps where necessary. The S.O. may instruct the Contractor to obtain spiral metric measurements of the keyways in the inclinometer tubing after installation. After that, assembly joints and rivets shall be wrapped in sealing tape. The tube shall be coated with thick grease over its upper part when it passes through compressible subsoils.

10.5.3. The assembled tube shall be lowered into borehole backfilled with a suitable bentonite: cement grout mix. Alternatively, the tube may be placed in an open borehole and grout placed afterwards. In granular material, the backfill may be sand or pea gravel. The keyways shall be orientated such that movements are measured parallel to and at right angles to the embankment axis.

10.5.4. Angular movements shall be measured by an inclinometer probe (torpedo) which shall be a biaxial type and the system shall be capable of measuring lateral deformation to an accuracy of ± 6mm over a depth of 25m.

10.5.5. The inclinometer data logger unit shall display the readings from the inclinometer torpedo on an alphanumeric display. The following facilities are also, required within the readout unit:

10.5.5.1. Scan stored data.

10.5.5.2. Display of face errors as readings are being obtained.

10.5.5.3. Display of mean deviation and cumulative deviation of anyone set of readings.

10.5.5.4. Backlit LCD display.

10.5.6. The readings shall be read at every 0.5m and stored in the data logger.

10.5.7. The level of the top of the access tube shall be measured by standard precise levelling techniques as and when necessary.

10.6. Horizontal Inclinometer

10.6.1. The horizontal inclinometer provides a method of measuring vertical displacement beneath an embankment. Readings are taken at regular intervals across the entire width of the embankment. The contractor shall install the horizontal inclinometer across the full width of the embankment at locations and with details as shown in the drawing.

10.6.2. The horizontal inclinometer shall be installed before earthworks commence as shown in the Drawing and shall consist of 70mm or 85mm inclinometer casing installed in a trench. The trench shall be filled with sand or the excavated material provided it is suitable fill and stone free, and approval is given by the S.O.. Each end of the inclinometer casing shall have an end cap and shall have an eye for retention of the instrument draw cord. Each end of the inclinometer casing shall also pass freely through a plastic protective cover set into a concrete pad. The concrete pads shall have minimum dimensions of 1.5m x 1.5m x 0.3m. They shall be located beyond the influence of the area causing

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settlement. At each concrete pad, a survey pin shall be cast into the concrete.

10.6.3. Sufficient inclinometer casing shall be installed to accommodate large relative movement of the ground.

10.6.4. The horizontal inclinometer readout unit shall have a resolution of ±0.02mm or better and a sensor accuracy of ±0.1mm or better.

10.6.5. Immediately before taking a set of readings, levels shall be taken of the two survey pins set into the concrete pads.

10.7. Hydrostatic Profile Gauges

10.7.1. The hydrostatic profile gauge provides a method of measuring vertical displacement beneath an embankment. Readings are taken at regular intervals across the full width of the embankment and provide a continuous profile of settlement. The Contractor shall install hydrostatic profile gauges at locations and with details as shown in the Drawing.

10.7.2. The hydrostatic profile gauge shall be installed before earthwork commences as shown in the Drawing and shall consist of semi rigid or high-density polyethylene (HDPE) profile tube with minimum outer diameter of 50mm installed in a trench. The trench shall be filled with sand or the excavated material provided it is suitable fill and stone-free, and approval is given by the S.O.. Each end of the access tube shall pass freely through a protective cover fabricated in plastic complete with solid PVC taper-threaded plug. The plug shall have an eye for retention of the instrument drawcord.

10.7.3. Each protective cover shall be set into a concrete pad. If the expected settlement is large such that the protective cover may not be long enough to accommodate the relative movement of the access tube, then the protective cover shall be extended using a suitable piece of plastic pipe. The concrete pads shall have minimum dimensions of 1.5m x 1.5m x 0.3m at both ends of the HDPE tube. The concrete pads shall be located beyond the influence of the located area causing settlement. A survey pin shall be cast into each of the concrete pad. Both ends of the access tube shall be covered with a suitable end cap at all times.

10.7.4. The readout device system shall be capable of measuring elevation with reference to the survey pin to an accuracy of ±1.0mm. Immediately before taking a set of readings with the hydrostatic profile gauge, levels shall be measured of the two survey pins set into the concrete pads.

10.8. Magnetic Extensometer

10.8.1. Magnetic extensometer provides a method of measuring settlement at a point or a series of points below the ground surface. The Contractor shall install magnetic extensometer at locations and as specified by the S.O.. The details of the magnetic extensometer shall be as shown in the Drawing.

10.8.2. The magnetic extensometer shall consist of an access tube and a series of magnetic targets which are free to slide down the tube, together with a datum magnet which is fixed to the tube near its base. The access tube

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shall be a rigid PVC tube with minimum 33mm outer diameter and 24mm inner diameter. External coupling shall be used to connect the access tube and this compression/extension coupling shall allow axial movement of access tubes to minimize distortion due to vertical strain. A rigid PVC endcap shall be fixed to the lower end of the series of tubes.

10.8.3. A datum ring magnet shall be fixed approximately 1m above the lower end of the tube. Spider magnets shall be used within the subsoil and plate magnets within fill.

10.8.4. The tubes and spider magnets shall be assembled prior to installation in such a way that the magnets remain in the correct position in relation to the tube.

10.8.5. It shall then be lowered together with all magnets and necessary accessories fixed in position into a 100mm diameter borehole backfilled with a suitable bentonite: cement grout mix. Once in position the spider magnets shall be released.

10.8.6. Where the access tube passes through fill which is being placed, the access tube and outer sleeve shall be extended as filling progresses. The top of the access tube, and the larger diameter sleeve where present, shall be protected with a suitable cover.

10.8.7. Magnetic extensometer shall be monitored by passing the probe down to the base of the access tube. The probe shall then be pulled upwards measuring the position of each magnet from the top of the tube. The position of each magnet shall be measured, once with the probe moving upwards from the base. Immediately before or after taking a series of readings, the level of the top of the access tube shall be measured by standard levelling techniques.

10.9. Combined Magnetic Extensometer and Inclinometers

10.9.1. Combined magnetic extensometer and inclinometer provide a method of measuring both vertical settlement and horizontal displacement at a series of points below the ground surface. The Contractor shall install combined magnetic extensometer and inclinometer at locations, and with depths and details as specified by the S.O or as shown in the Drawing or as specified by the S.O..

10.9.2. The specification for magnetic extensometer shall be referred to sub-section 10.8. and the specification for Inclinometer shall be referred to sub-section 10.5..

10.9.3. The magnets shall be positioned in relation to sleeved joints such that they can move downwards without obstruction sufficiently to monitor the expected settlement.

10.9.4. The borehole shall be 150mm diameter.

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10.10. Standpipe

10.10.1. Standpipe provides a method of monitoring the water table or ground water level. The Contractor shall install standpipe at locations and with depths and details as specified in the Drawing or S.O..

10.10.2. The standpipe shall be slotted unplasticised polyvinyl chloride (UPVC) tubing of nominal size 50mm diameter. The perforated part shall be wrapped with filter fabric as indicated in the Drawing.

10.10.3. The UPVC tubing shall be installed in not less than 3m lengths, except for one shorter length as required to suit the total standpipe dimensions. The concrete upper end of the tube shall be set in concrete.

10.10.4. The standpipe shall be placed in a 100mm diameter borehole backfilled with a graded filter sand (600 to 1200microns) to the depth indicated. The top of the hole shall be sealed with bentonite pellets, and with a concrete plug. A protective cover shall be set into the concrete with caps and air vents.

10.10.5. Depth to water in the standpipe shall be measured using a dipmeter.

10.11. Piezometers

10.11.1. Standpipe Piezometers

10.11.1.1. Standpipe piezometers give a measurement of piezometric level at a specific depth within a soil profile. They are generally used in soils of medium to high permeability. The Contractor shall install standpipe piezometer at locations, and with depth and details as shown in the Drawing or as directed by the S.O..

10.11.1.2. Standpipe piezometer shall be installed in boreholes at locations as shown in the Drawing or as instructed by the S.O.. The piezometer tip shall consist of a porous ceramic, plastic element or other suitable element not less than 150 mm long with minimum diameter of 25mm and shall be protected at each end by UPVC fittings. The filter element shall have a pore diameter of not more than 60 microns and a permeability of not higher than 3×10^{-4} m/s. The tubes shall be jointed together and to the porous element with threaded coupling or other approved coupling, tape and glue in such a manner that the joints remain leak proof under the anticipated head of water.

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10.11.1.3. The standpipe piezometer shall be installed in a borehole of minimum 76mm diameter. The sand filter surrounding the porous element shall be clean and fall wholly between the limits of grading 600 and 1200 microns. The contractor shall ensure that no sand adheres to the soil in the sides of the borehole. Where there is water in the borehole the contractor shall allow sufficient time for all sand to settle. The final level of the top of this sand shall be recorded. The porous element shall be placed in the hole and the remaining sand filter shall then be added as described above.

10.11.1.4. Seals consisting of bentonite pellets shall be placed above, and if necessary, below a sand filter. The remainder of the hole shall be filled with a bentonite: cement grout, and the top part with concrete with caps and air vents as indicated in the drawing. Before taking initial readings, the contractor shall carry out simple falling head test by raising the water level 1.5m above the static level, using an extension pipe if necessary.

10.11.1.5. The depth to water in the standpipe piezometer shall be measured using a dip meter.

10.11.2. Pneumatic Piezometers

10.11.2.1. Pneumatic piezometer is used to measure pore water pressures at specific depths within a soil profile. They can be used in a wide variety of soil types. The Contractor shall install pneumatic piezometers at locations, and with depths and details as shown in the Drawing or as directed by the S.O..

10.11.2.2. Pneumatic piezometer tips shall be of high air entry ceramic type with an average pore diameter of 1 micron using stainless steel. The piezometer system shall be capable of measuring water pressures to an accuracy of 0.2m head of water in the range 0-35m head of water.

10.11.2.3. The piezometers shall be connected to twin tubing with suitable brass couplings. Joints in the tubing other than at the piezometer tip or at the terminal point shall not be permitted. The tubing shall be connected either to suitable quick release couplings or a terminal point which shall be protected at all times. Where tubing is laid in trenches the backfill shall either be sand or excavated material provided it is suitable fill and stone-free. The tubing shall be laid with sufficient slack to take up any lateral movements that are expected to occur due to settlement of embankments or structures.

10.11.2.4. Before installation and taking initial readings, the Contractor shall conduct a pressure test on the pneumatic piezometer tip in a container of water after connection to the tubing to check for leaks or poor connections. The ceramic element shall be workable under vacuum and precautions shall be taken to ensure that it remains saturated during installation. During

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installation, readings shall be taken when the piezometer tip is lowered down the borehole, when it is pushed in or placed in the sand pocket and at various times after installation to check the response of the piezometer and help find the static pressure value before the initial base readings are taken.

10.11.2.5. Readings shall be taken by and stored on the readout device. Care shall be taken to ensure that the flow and return leads are connected correctly.

10.11.3. Vibrating Wire Piezometer (VWP)

10.11.3.1. The Vibrating Wire Piezometer is used to measure water pressure at specific depths in variety of soil types. The Contractor shall install vibrating wire piezometer at location, and with depths and details as specified by the S.O.. Prior to the installation of the VWP, the Contractor shall submit all required technical specifications, including a calibration certificate for S.O.'s approval.

10.11.3.2. VWP is used to monitor pore water pressures in soils. The VWP converts water pressure signal via components of VWP, include a porous tip containing a pressure-sensitive diaphragm; a pre-tensioned steel wire; and an electro-magnetic coil, one end of which is connected to the diaphragm, and the other to the body of the piezometer.

10.11.3.3. The VWP tip shall be of high air entry ceramic type with an average pore diameter of 50 micron using a stainless steel body. The piezometer system shall have a pressure range with an accuracy of 0.1% of full scale.

10.11.3.4. The cable shall be laid with sufficient slack to take up any lateral movements that are expected to occur due to settlement of embankments or structures.

10.11.3.5. During installation, readings shall be taken when the piezometer tip is lowered down the borehole, when it is pushed in or placed in the sand pocket and at various times after installation to check the response of the piezometer and help find the static pressure value before the initial base readings are taken.

10.11.3.6. Readings shall be taken by connecting the signal cable to the readout unit and the data shall be stored in the readout unit.

10.11.4. Installation of Piezometer (All Types)

10.11.4.1. The piezometer shall be installed in a borehole of not less than 76mm diameter. The drilling medium shall be water and extra care and attention shall be given during boring to ensure that the borehole is as vertical as possible to the required depth. Steel casing shall be used to prevent the collapse of the borehole. The borehole shall be flushed clean with water prior to installation.

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10.11.4.2. Before installation the piezometer element shall be immersed in de-aired water for at least 24 hours to saturate the element. De-aired water shall be prepared by boiling, and subsequently allowing the water to cool before use.

10.11.4.3. The piezometer tip shall be installed in a borehole backfilled with graded sand filter to the depth indicated. The sand filter surround to the porous element shall be clean and fall wholly between the limits of grading 600 and 1200 microns. The contractor shall ensure that no sand adheres to the soil in the sides of the borehole. The Contractor shall allow sufficient time for all sand to settle. The final level of the top of the sand shall be recorded. The porous element shall be placed in the hole and the remaining sand filter shall then be added as described above.

10.11.4.4. Seals consisting of bentonite pellets shall be placed above, and if necessary, below the sand filter. The remainder of the hole shall be filled with a bentonite: cement grout, and the top part with a concrete plug. The bentonite: cement grout mix shall be designed to mimic the surrounding soil or as shown in the Drawing. A protective cover shall be set into the concrete with caps and air vents as indicated in the Drawing.

10.12. Commissioning and Base Readings

10.12.1. After installation the functioning of each instrument shall be demonstrated to the S.O. including the recording of measured values using the appropriate readout device. As part of the commissioning three sets of readings shall be taken and compared. This three sets of readings shall be taken immediately after installation of the instruments. If there are significant differences or anomalies, further readings shall be taken. Once three sets of comparable readings have been taken, these shall be averaged to form the base readings.

10.12.2. In cases where instruments are installed during earthworks, three sets of readings shall be taken in quick succession and the results compared. These results shall be used to provide base readings in a manner to be agreed with the S.O..

10.13. Readings

10.13.1. The measured values shall be recorded on a record sheet. for readings that are recorded on data loggers, a record sheet shall be required giving references to the data stored. The format of plotted results shall be submitted to the S.O. for approval. Details of information and values to be stored on each record sheet in addition to the general information required but not limited to the details in **Table V10**.

10.13.2. The Contractor shall submit to the S.O. the specified number of copies of each record sheet with necessary raw data within one working day of taking the readings.

10.13.3. If any anomalous readings are detected and verified to be correct, the S.O. shall be informed immediately.

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10.13.4. Frequency of Readings

Each instrument shall be read immediately before and after each change in loading (i.e. each layer of embankment or structural fill, etc.) unless otherwise shown in the Drawing or as directed by the S.O. Any instruments found to be faulty shall be promptly brought to the S.O.'s attention so that remedial measures can be implemented.

10.13.5. Anomalous Readings

Whenever sets of data are measured, they shall be compared to previous sets of data. If anomalous readings are present which differ from the expected values or trends, then further readings shall be taken immediately and the S.O. shall be informed. If the anomalous values persist, then the S.O. shall be informed and an investigation shall be carried out to find the reason(s) for the anomalous readings.

10.14. Report

10.14.1. General Information on All Records

All records of instrumentation including installation, readings or monthly summaries, shall contain the following information:

(i) Project name

(ii) Contract name and number

(iii) Instrument reference number and type

(iv) Dates and times of installation and completion,

(v) Summary of reading

(vi) Chainage and offset / coordinates in WGS 84

(vii) Personnel names, roles and responsibilities

(viii) Relevant comments or remarks

10.14.2. Installation Records and Reports

The Contractor shall prepare an installation record sheet for each instrument to be installed and submit to the S.O. for approval at least two weeks before installation commences.

10.14.3. Monthly Monitoring Reports

10.14.3.1. A sample of the format of the report shall be submitted to the S. O. including all graphical presentations for approval at least one month before submission of the first monthly report unless specified by S.O. Each monthly report shall include:

(i) A description/scope of monitoring works

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(ii) Information on reading anomalies or corrections, if any, and factors which may influence measured data

(iii) Observations or remarks

(iv) A Drawing showing installed locations of instrumentation

(v) Data tabulations or plots of instrument readings include but not limited to the details in **Table V11**

10.14.3.2. The Contractor shall submit four sets of report (hardcopy and softcopy) within 7 days after the end of each calendar month of monitoring.

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Table V1. Sampling Frequency and Testing Requirements for Geotextile

Area of Geotextile (m^2)	Number of Rolls to be Sampled Representing the Area of Geotextile	Testing by the Contractor	
		Non-Woven Geotextile	High Strength Woven Geotextile
Initial 10,000 or part thereof	1	Tensile strength, Elongation, CBR puncture, Permeability, Effective Opening Size (O_{90}) or Apparent Opening Size (O_{95})	Tensile strength, Elongation
Each subsequent 100,000 or part thereof	1		

Table V2. Sampling Frequency and Testing Requirements for Geogrid

Area of Geogrid (m^2)	Number of Rolls to be Sampled Representing the Area of Geogrid	Testing by the Contractor
		Geogrid
Initial 10,000 or part thereof	1	Tensile strength, Elongation
Each subsequent 100,000 or part thereof	1	

Table V3. Guidelines for Geotextile Overlap Requirements as a Function of (Foundation Soil) Strength

Soil CBR	Minimum Overlaps
>3	0.3 – 0.45 meter
1 – 3	0.6 – 1 meter
0.5 – 1	1 meter or sewn
< 0.5	sewn

(Source: AASHTO M288-06,2007)

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Table V4. Properties of Non-woven Geotextile

Item	Properties	Test Standard	Unit	Types of Non-Woven (NW) Geotextile			
				NW 9	NW 13	NW 19	NW 24
1.	Wide width tensile strength	ISO 10319 or ASTM D4595	kN/m	≥ 9	≥ 13	≥ 19	≥ 24
2.	Wide width elongation at break	ISO 10319 or ASTM D4595	%	≥ 35			
3.	CBR puncture resistance	ISO 12236 or ASTM D6241	N	≥ 1500	≥ 2100	≥ 2850	≥ 3850
4.	Cone drop	ISO 13433	mm	≤ 40	≤ 25	≤ 20	≤ 15
5.	Permeability at 50mm head	ISO 11058 or ASTM D4491	$l/m^2/s$	≥ 90	≥ 70	≥ 55	≥ 45
6.	Effective opening size, $O_{90,}$	ISO 12956	µm	≤ 120	≤ 100	≤ 90	≤ 90
	or						
	Apparent Opening Size, O_{95}	ASTM D4751	µm	≤ 270	≤ 240	≤ 190	≤ 180
7.	UV resistance	EN 12224	% retained after 430 hours	≥ 70			
		or					
		ASTM D4355	% retained after 500 hours				

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Table V5. Properties of High Strength Woven Geotextile

Item	Properties	Test Standard	Unit	Types of High Strength (HS) Woven Geotextile*					
				HS 100/50	HS 200/50	HS 300/50	HS 400/50	HS 600/50	HS 800/50
1.	Characteristics Short Term Strength – MD**	ISO 10319 or ASTM D4595	kN/m	≥ 100	≥ 200	≥ 300	≥ 400	≥ 600	≥ 800
2.	Characteristics Short Term Strength at 5% elongation – MD**	ISO 10319 or ASTM D4595	kN/m	≥ 45	≥ 90	≥ 135	≥ 180	≥ 270	≥ 360
3.	Characteristics Short Term Strength – CD***	ISO 10319 or ASTM D4595	kN/m	≥ 50					
4.	Elongation at Characteristics Short Term Strength – MD**	ISO 10319 or ASTM D4595	%	≤ 10					
5.	Long Term Design Strength at 120 years design life****	BS 8006	kN/m	≥ 55	≥ 110	≥ 170	≥ 220	≥ 355	≥ 475

* For high strength woven geotextile with required strength more than 800 kN/m, special design and specification shall be discussed with the designer

** MD: Machine Direction

*** CD: Cross Direction

****The long-term design strength assessment should take into consideration of reduction factors for creep, installation damage, environmental effects and extrapolation of data

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Table V6. Properties of Geogrid

Item	Properties	Test Standard	Unit	Types of Geogrid (GD)*						
				GD 40	GD 60	GD 80	GD 100	GD 130	GD 150	GD 200
1.	Characteristics Short Term Strength – MD**	ISO 10319 or ASTM D4595	kN/m	≥ 40	≥ 60	≥ 80	≥ 100	≥ 130	≥ 150	≥ 200
2.	Characteristics Short Term Strength at 5% elongation – MD**	ISO 10319 or ASTM D4595	kN/m	≥ 20	≥ 30	≥ 40	≥ 50	≥ 65	≥ 75	≥ 100
3.	Characteristics Short Term Strength – CD***	ISO 10319 or ASTM D4595	kN/m	≥ 30						
4.	Elongation at Characteristics Short Term Strength – MD**	ISO 10319 or ASTM D4595	%	≤ 10						
5.	Long Term Design Strength at 120 years design life ****	BS 8006	kN/m	≥ 20	≥ 30	≥ 40	≥ 50	≥ 75	≥ 80	≥ 105

* For geogrid with required strength more than 800 kN/m, special design and specification shall be discussed with The designer

** MD: Machine Direction

*** CD: Cross Direction

****The long-term design strength assessment should take into consideration of reduction factors for creep, installation damage, environmental effects and extrapolation of data

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Table V7. Properties of Prefabricated Vertical Drain

Item	Properties		Test Standard	Unit	Types of PVD	
					Type A*	Type B**
	Material	Core Filter			Continuous plastic drain core wrapped in non-woven geotextile material	
1.	Dimension of drain	Width		mm	100 ± 3	
		Thickness		mm	4 to 5	
2.	Coefficient of permeability of drain filter		ASTM D 4491	m/s	≥ 1 x 10^{-4}	
3.	Discharge Capacity at Pressure, P=240kN/m^2 and Hydraulic Gradient, i=1		ASTM D 4716	m^3/s	≥ 25 x 10^{-6}	≥ 100 x 10^{-6}
4.	Apparent Opening Size, O_{95}		ASTM D 4751	μm	≤ 90	≤ 90
5.	Tensile strength of entire drain		ASTM D 4595	N	≥ 2500	≥ 2800
6.	Tensile strength of filter		ASTM D 4595	N/m	≥ 3000	≥ 6000
7.	Tensile elongation of entire drain at 1000N		ASTM D 4595	%	≤10	≤ 10

* PVD Type A: For common application where soft soil depth is generally <25m and less compressible soil [Vertical strain (Settlement) < 15%].
** PVD Type B: For more critical application such as when soft soil depth is generally ≥25m, highly compressible soil like peat or gyttja [Vertical strain (Settlement) ≥ 15%], PVD associated with vacum preloading method or other special considerations based on engineering judgement of the designer.

Table V8. Typical Gradings Used with the Different Processes for Stone Column

Process	Grading in mm
Dry top-feed process	40 to 75
Wet process	25 to 75
Dry bottom-feed process	8 to 50

Table V9. Construction Parameters to be monitored during DSM Installation

Dry Method	Wet Method
• Air tank pressure • Time vs depth (penetration and retrieval rate) • Rotation speed (revs/min during penetration and retrieval) • The quantity of binder per meter of depth during penetration and retrieval	• Slurry pressure; air pressure (if any) • Time vs depth (penetration and retrieval rate) • Rotation speed (revs/min during penetration and retrieval) • The quantity of slurry per meter of depth during penetration and retrieval

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Table V10. Data Required for Each Instrument

Instrument	Data Required
Displacement marker	- distance from fixed point (m) (details to be given) including base reading - change in distance from fixed point relative to base readings (mm)
Settlement marker	- reduced level of top of rod (mRL) including base reading - change in reduced level of top of rod relative to base readings and previous reading (mm)
Building Settlement Marker	- reduced level of stud (mRL) including base reading - change in reduced level of stud relative to base readings and previous reading (mm)
Survey reference station	- chainage, offset, coordinates (in WGS 84) and reduced level of top of rod (m)
Deep levelling datum	- reduced level of datum (mRL)
Rod settlement gauge	- reduced level of top of rod (mRL) including base reading - original ground level at gauge location (mRL) - reduced level of ground adjacent to gauge (mRL) - record of fill placed (m) - total thickness of fill (m) - record of extensions (m) - settlement of plate relative to base readings and previous reading (mm)
Hydrostatic profile gauge	- reduced levels of survey pins (mRL) - original ground level every 10.0m along line of gauge (mRL) - level of fill every 10.0m along line of gauge (mRL) - thickness of fill along the line of the - gauge (m) - distance from end of access tube to point used as reference for longitudinal measurement (m) - listing of elevation of access tube relative to survey pin at 1.0m intervals (mRL) - graph of settlement of access tube relative to base readings and thickness of fill against distance along the tube - maximum settlement relative to base readings and previous reading and its location (mm)
Horizontal Inclinometer	- reduced levels of survey pins (mRL) - original ground level every 10.0m along line of gauge (mRL) - level of fill every 10.0m along line of gauge (mRL) - thickness of fill a long line of gauge (m) - distance from end of access tube to point used as reference for longitudinal measurement (m) - listing of elevation of access tube relative to survey pin at 0.5m intervals (mRL) - graph of settlement of access tube relative to base readings and thickness of fill against distance along the tube - maximum settlement relative to base readings and previous reading and its location (mm)

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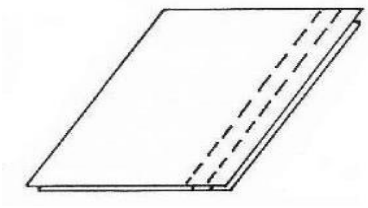
Instrument	Data Required
Magnetic extensometer	- reduced level of top of access tube (mRL) - reduced level of ground adjacent to access tube (mRL) -distance of each magnet from top of tube (m) - reduced level of each magnet (mRL) - settlement of each magnet relative to base readings (mm)
Inclinometers	- reduced level of top of access tube (mRL) - reduced level of ground adjacent to access tube (mRL) - graph and listing of horizontal movement of access tube relative to base readings against depth
Combined magnetic extensometer and inclinometer	- reduced level of top of access tube (mRL) including base reading - reduced level of ground adjacent to access tube (mRL) -distance of each magnet from top of tube (m) - reduced level of each magnet (mRL) - settlement of each magnet relative to base readings (mm) - graph and listing of horizontal movement of access tube relative to base readings against depth depth to water from top of tube (m)
Standpipe piezometers	- depth to water from top of tube (mRL) including base reading - reduced level of top of tube (mRL) - reduced level of ground adjacent to standpipe (mRL) - water head (mRL) - change in water head relative to base readings (m)
Pneumatic piezometers	- water pressure reading (m water) including base reading - reduced level of piezometer tip as installed (mRL) - water head (mRL) - change in water head relative to base readings (m)
Vibrating wire piezometer	- water pressure reading (m water) including base reading - reduced level of piezometer tip as installed (mRL) - water head (mRL) - change in water head relative to base readings (m)

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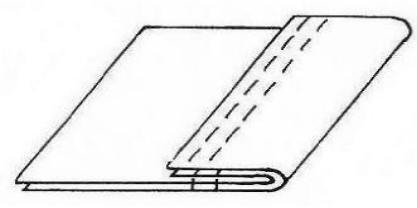
Table V11. Data Required for Each Instrument

Instrument	Data Required Plots and Summaries Required
Displacement marker	- deflection vs. time indicating direction of movement (tabulation and plot)
Settlement marker	- settlement vs. time (tabulation and plot)
Building settlement marker	- settlement vs. time (tabulation and plot)
Survey reference station	- chainage, offset coordinates and reduced level (tabulation)
Deep levelling datum	- reduced level (tabulation)
Rod settlement gauge	- thickness of fill and settlement of plate vs. time (tabulation and plot)
Hydrostatic profile gauge	- latest graph of settlement of access tube relative to base readings and fill thickness against distance along the tube - maximum gauge settlement and corresponding fill thickness vs. time (tabulation and plot)
Horizontal inclinometer	- latest graph of settlement of access tube relative to base readings and fill thickness against distance along the tube maximum gauge settlement and corresponding fill thickness vs. time (tabulation and plot)
Magnetic extensometer	- settlement of each magnet vs. time (tabulation and plot) - settlement of each magnet vs. depth for latest set of readings (plot)
Inclinometer	- latest graph of horizontal movement of access tube relative to base readings against depth - Maximum horizontal movement relative to base readings vs. time (tabulation and plot)
Combined Magnetic Extensometer Inclinometer	- as per magnetic extensometer and inclinometer described above
Standpipe piezometer /Pneumatic piezometer/ Vibrating wire piezometer	- water head vs. time (tabulation and plot) - excess water head vs. time (tabulation and plot) - all instruments in a profile plotted on the same graph

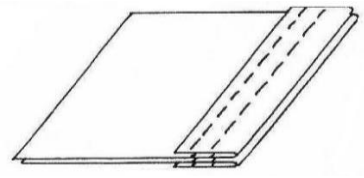
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(i) Prayer Seam



(ii) J Seam



(iii) Butterfly Seam

Figure V1. Types of Seam with Double Thread Lock Stitch

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SECTION W: HYDROSEEDING	PAGE
1. Hydroseeding	W/1

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1. Hydroseeding

1.1. General

This works shall consist of slope surface preparation and hydroseeding work including supply of all necessary equipment, manpower and materials on location of slopes in cut and fill areas as shown in drawings or as directed by the S.O.. Method Statement with specific equipment, personnel, materials, works output, sequence and procedure of works plus quality control requirements, etc., showing compliance of the specification shall be sent to the S.O. for prior approval before commencement of work. Equipment with details such as model, type, capacity with catalogue and photos shall be included. Names of key personnel including operator, supervisor manager and their experiences shall be included. Source of supply of materials including material specification, guarantee, expiry dates, test certificates, guide of application shall also be included. Only Contractor with suitable equipment, materials and qualified and experienced personnel plus track records will be considered for approval.

1.2. Seeding

1.2.1. Seeding or hydroseeding shall be carried out as soon as practicable on slopes and other areas as shown on the Drawings and/ or directed by the S.O. Unless otherwise approved by the S.O., hydroseeding shall be carried out within 7 days after the slope is cut or filled. The surface before hydroseeding shall be free of loose or soft materials. Cut slope surface shall have some horizontal grooves (about 20mm deep) at about 200mm intervals. Vertical grooves shall be avoided.

1.2.2. Seeding shall be carried out by means of a proper hydroseeder where approved slurry of seeds, mulch, fertilisers, binders and organic matter is sprayed on to the prepared soil surface.

1.3. Seed Mixtures

1.3.1. Application rate for grass seeds (dry weight) shall be 30 ± 50g/m2. The seed mixtures shall comprise the following combinations (by dry weight) or similar as instructed by the S.O..

1.3.1.1. Seed Combination A for normal soil at upper cut slopes (Grade 6/5) and lower embankment slope

(i) Japanese millet (Echinochloa Utilis) 15%

(ii) Bermuda grass (Cynoden dactylon) 25%

(iii) Signal grass (Brachiaria Desumbars) 50%

(iv) Centro (Centrosuma pubescens) 10%

1.3.1.2. Seed Combination B for normal soil at Lowest cut slope (Grade 3/4/5) and uppermost embankment slope

(i) Bermuda grass (Cynoden dactylon) 50%

(ii) Carpet grass broadleaf (Axonopus compressus) 50%

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1.3.1.3. Seed Combination C for hard material of cut slope (SPT N value greater than 50)

(i) Centro (Centrosuma pubescens) 30%

(ii) Signal grass (Brachiaria decumbars) 70%

1.3.1.4. Fertilisers and Soil Amenders

(i) The amount of lime or other chemicals (if any) to be applied to improve the soil before, during and/or after hydroseeding shall be submitted in advance for S.O. approval.

(ii) The NPK fertilisers and soil amenders shall be mixed in the hydroseeder and the application rate shall be 100 ± 5g/m2.

(iii) Not less than 90% of the GML (Ground Magnesium Lime) soil amender shall pass through a 40-mesh sieve and 50% shall pass through a 100-mesh sieve. (About ± 50g/m2).

1.3.1.5. Mulchfibres

(i) For normal soil, the following mulchfibres shall be mixed in the hydroseeder:

Table W1. Mulchfibres Application Rate for Normal Soil

Type	Rate of Application (g/m^2)
Coconut or oil palm fibre or paddy straws	60
Newsprint fibre	60

(ii) For hard material (SPT N value greater than 50) the rate of application of mulchfibres shall be as shown in Table W2

Table W2. Mulchfibers Application Rate for Hard Material

Type	Rate of application (g/m^2)
Coconut or oil palm fibre or paddy straws	90
Newsprint fibre	90

1.3.1.6. Binder

(i) The binder must be able to fix all ingredients onto the soil surface and to protect the areas treated against erosion until complete establishment of the vegetation cover. It may be of organic or mineral origin but must be non-polluting and having no delaying action on the germination of the seeds. The binder shall be bio gradable.

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(ii) The Contractor shall submit to the S.O. for his consideration and prior written approval the type and amounts of binding agent to be applied with the seeds, mulch, fertilisers, etc.

1.3.1.7. Mixtures

(i) All above ingredients shall be mixed with water to form homogeneous slurry and kept agitated until finally applied to the slope surface. All water used shall be free of injurious chemicals and other toxic substances harmful to plant life.

(ii) The pH value of the water shall be above 6.0. The Contractor shall test the different water points to control the quality.

(iii) All mixtures shall be used within 4 hours from the time they are mixed.

1.4. Spraying Equipment

1.4.1. The equipment shall consist of a water tank or container fitted with an engine; agitator and high-pressure pump with sufficient power to reach the slope surface. The mechanical power drive agitator shall be capable of keeping all ingredients in suspension at all times.

1.4.2. All pump passage and pipe lines shall be capable of providing a clearance of solids of minimum 15mm.

1.4.3. At least two different types of nozzles (long range and close range) shall be supplied so that the mixture may be properly sprayed over distances varying from 5 to 60m. The nozzles shall be connected to the nozzle pipe or to the eventual extension hoses by quick release couplings.

1.5. Biodegradable Mat (BM)

1.5.1. Biodegradable Mat shall be from local manufacturers with ISO certification and laboratory test facilities for necessary inspection by the S.O.. Test certificates from reputable or accredited laboratories approved by the S.O., showing the material's compliance to the specification, shall be submitted to the S.O. for verification and approval.

1.5.2. Biodegradable Mat (BM) should be machine made comprising of paddy straw or coconut/ oil palm coir bonded to a light weight polypropylene or polyester geogrids with minimum tensile strength 2.0kN/m (ASTM D4595) and should have the following measurements:

1.5.2.1. Nominal mass (ASTM D3776) : Not less than 150g/m2 or as shown on drawing

1.5.2.2. Thickness (ASTM D1777) : Not less than 3mm or as shown on drawing

1.5.2.3. Roll width : 2.0 to 3.5m

1.5.2.4. Roll size: 50 to 200m2

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1.5.2.5. The nominal mass of BM shall be determined at oven dry condition as defined in B.S.1377

1.6. Installation of BM Blanket

1.6.1. Prior to installation of BM, the slope or other soil surface shall be prepared as in sub-section 1.6 and seeded as in sub-section 1.2 and 1.3.

1.6.2. To install the BM, unroll the mat with the netting facing upwards and the paddy straw or coconut coir palm pal fibre in contact with the soil. BM shall be installed immediately after seeding. The mat shall be unrolled vertically to the contour. The ends and the sides of adjoining mats shall be overlapped with a minimum of 50mm.

1.6.3. BM shall be anchored to the ground with the use of U-shaped staples, length 100-150mm, 6mm diameter steel bars. Where the soil is very sandy the steel staples shall be replaced by bamboo sticks of at least 250mm long.

1.7. Preparation of the soil surface prior to hydroseeding

1.7.1. Vertical striations or grooves shall be absent from the final trimmed slope. Instead a rough textured surface shall be prepared. Where the surface microtophography varies by ± 20mm from the formation level, an acceptable treatment is to provide horizontal grooving with semicircular or “v” shaped groove, 20mm depth, at an interval of 200mm downslope on all cut slopes comprising soft material. Any surface rills on newly cut slopes in excess of 25mm shall be rectified by retrimming.

1.7.2. Gullies or localized washouts shall be backfilled with suitable material placed in layers of up to 200mm thick, each layer being compacted by hand ramming or by lightweight vibration plate compactors. For localized washout exceeding 1m3 backfilling shall be by sand bags or rock pitching or as shown on drawing.

1.7.3. Large clods of earth and stones greater than 50mm shall be removed.

1.7.4. Slopes that have been exposed for a long time must be trimmed and scaled to remove the oxidised layer prior to hydroseeding.

1.8. Protection of trimmed slopes

1.8.1. All cut and fill slopes shall be treated by hydromulching (and BM where specified) within 14 days of initiating the final trim. Any area of cut or fill of over 6m vertical height shall also be protected within 14 days.

1.8.2. Temporary and/ or permanent drainage systems shall be installed immediately after the final trim is made to a slope, and before hydromulching and the application of BM.

1.8.3. The contractor shall ensure that his sequence of earth moving operations is such that suitable access is available for plant, labour and materials to enable installation of erosion protection measures.

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1.9. Maintenance during liability period

The Contractor shall carry out daily watering (except lancing days) for at least 1 week is to ensure the full establishment of rooting and ground cover by taking the necessary maintenance procedures such as regular, fertilising, and reseeding of failed areas. The Contractor shall guarantee the success of the seeding work. Any dead grass spot shall be immediately replaced or resprayed at contractors' own expenses. In areas where rooting and ground cover cannot be established even after several trials, the Contractor shall report to the S.O. for necessary direction.

1.10. Quality Control

1.10.1. The following quality controls and acceptance criteria shall be complied and approved by the S.O.:

1.10.1.1. The rate of application of grass seeds, fertilisers, mulch etc shall be verified at field by 1m x 1m plywood and field records. (minimum 1 test daily or per 3,000m2). The whole slope shall be resprayed if any test result is found below the value specified in sub-section 1.3.. pH value of water used shall be checked daily.

1.10.1.2. Certificates related to type, origin, quality and validity of seeds for EACH source or supplier. All seeds and fertilizers shall be from suppliers approved by the S.O..

1.10.1.3. Calibrated weighting machine/balance with 1% or ± 2g accuracy shall be used for all weighting.

1.10.1.4. Minimum one sample per 5000m2 of Biodegradable mat (BM) shall be sampled by the S.O. for measurements/prospective verification at site to ensure compliance of specification as per sub-section 1.5.. All rolls of BM shall be tested if any sample fails any requirement. Rolls of BM below specification shall be rejected and removed from the site.

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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 Superintending Officer (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 drawing 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 wall, 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).

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1.12. The Contractor shall submit the as-built drawing, 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 1 to Figure 4 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 X1.**

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Table X1. 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.

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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 X2**:

TABLE X2. 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 X3** and **Table X4**:

TABLE X3. 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

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80	1.65	3.0
100	1.9	3.0

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

TABLE X4. 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 Institude. (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.

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.

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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.

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

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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)

2.6.7.1. Air vent and pressure reducing valve shall be installed at 30 meter 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 in 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 Meter

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

2.7. Water Tank

2.7.1. Water Tank Material

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

2.7.2. Fibreglass Reinforced Plastic (FRP) Water Tank

2.7.2.1. The tanks shall be scribbled 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.

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2.7.2.4. The panel shall be of hot press moulded and fabricated from fiberglass reinforced plastic (FRP) of dimension 1meter x 1meter 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 tank 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 X5**:

TABLE X5. Physical Properties of FRP Panel

Parameter	Results
Tensile strength	>70 MN/m²
Bending strength	>100 MN/m²
Elastic modulus in bend	>6,000 MN/m²
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 coats of non-toxic, non-corrosive paint and external one coat primer and two coats of non-corrosive paint to S.O. approval.

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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 to 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 X6**:

TABLE X6. 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

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)

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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 / labeled on the external upper part of the tank body according to the following information:

(i) Manufacturer's name and/or trade mark

(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.

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 in the approved drawing.

(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 two (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

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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 meters to suit the depth of the tank as shown in 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 - ≥ 1” diameter

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 in 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

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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 centers 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)

2.7.9.1. 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.

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 coat primer and two coats finish subject to S.O.'s approval.

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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

2.8.4.1. 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.

3.2. Material Standard

3.2.1. Pipework for sanitary plumbing shall be to the dimensions shown in 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.

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3.2.4. The following standards in their latest edition as shown in **Table X7** shall apply:

TABLE X7. Standard for Different Types of Sanitary Pipe

Item	Standard
Unplasticized polyvynil chloride (uPVC)	MS 1063, BS EN 1329-1, BS 4514, MS 628, BS EN ISO 1452-2:2009
Unplasticized polyvynil chloride (uPVC) (Underground)	MS 979: Part 1 (∅100mm & ∅155mm) MS 979: Part 2 (∅200mm 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

3.3.1.1. 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.

3.4. Sanitary Discharge System

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

3.4.2. The discharge system can be classified as follows:

3.4.2.1. 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.

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3.4.2.2. 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.

3.4.2.3. 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.

3.4.2.4. 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 in 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.

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 complied to MS 1063 or BS EN 1329 Part 1 or BS 4514 (size ∅82mm only).

3.5.1.3. Pipes, fittings and the system of unplasticized polyvinyl chloride (uPVC) piping systems shall comply to MS 1063; or BS EN 1329: Part 1; or BS 4514 (size ∅82mm 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").

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(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

(i) "D" code – brown

(i) "BD" code - white

3.5.1.5. All underground sewerage pipe and fittings of ∅ 4" (100mm) diameter and ∅ 6" (150mm) diameter shall be of uPVC Brown complied to MS 979: Part 1; and for size ∅ 200mm 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 drawing.

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 X8**:

TABLE X8. 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*

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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 (∅100mm and ∅155mm) and MS 979: Part 2 (∅200mm 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 X9**:

TABLE X9. 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 meter centre for soil, 2 meter centre for waste and between fixed points over 1 meter centre.

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3.5.1.11. Cast Iron/Galvanized Iron Pipe

(i) Where shown or stated in 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:

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3.6.4.1. Horizontal Position

TABLE X10. 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 Institude. (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 discharge 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.

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.

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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

3.9.1. 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

3.10.1. 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

3.11.1. 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

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

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 Pipeworks (Ingress of Contaminants)

3.15.1. 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.

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3.16. Inspection Chamber / Gully Trap

3.16.1. The works shall include the construction of all inspection chambers / gully trap generally as shown in 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

3.17.3.1. 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 or brick, concrete base and angle blocks shall be used support for the laying of piping.

TABLE X12. 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

3.17.4.1. 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.

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

3.17.6. Backfilling of Trenches

3.17.6.1. 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 Commisionning (TABC)

4.1. General

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

4.2. Internal Cold Water Plumbing System

4.2.1. 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.

4.2.2. 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.

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

4.2.4. 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.

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

4.2.6. 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.

4.2.7. 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.

4.2.8. 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.

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4.2.9. Testing of Internal Pipework

4.2.9.1. 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.

4.2.9.2. 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

b) Head at pump discharge outlet

c) Current consumed

d) Voltage

4.2.9.3. 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.

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(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.

4.2.9.4. Balancing

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

4.2.9.5. 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.

4.2.10. Testing of Storage Water Tank

4.2.10.1. 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.

4.2.10.2. 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.

4.2.11. Testing of Pump (If Applicable)

4.2.11.1. 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.

4.2.12. Post Occupancy Testing, Adjusting, Balancing and Commissioning

4.2.12.1. 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

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use during the defects liability period. The cost of the adjustment shall be included in the tender.

4.3. Sanitary Plumbing System

4.3.1. 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.

4.3.2. Water Test

4.3.2.1. 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.

4.3.3. Air Test

4.3.3.1. 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.

4.3.3.2. 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 manometer 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 manometer scale.

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

4.3.4. Smoke Test

4.3.4.1. 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.

4.3.4.2. The pressure on the smoke shall be maintained for three (3) minutes after the last opening has been sealed.

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

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

4.3.5. Hydraulic Performance

4.3.5.1. Hydraulic performance discharge tests shall be made from all appliances singly and correctively. Obstruction in any of the

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pipe lines 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..

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.

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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 pipe line 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.

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)

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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.

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.

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5.8.4. Service and maintenance records shall be properly updated and kept by Contractor or as instructed by 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 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 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..

5.10.2. All repairs on the complete internal cold water and sanitary plumbing system shall be guaranteed by the Contractor against defects in workmanship and materials for a period of one year to take effect from date of completion of the repairs. During the guarantee period, the Contractor shall rectify defects in repairs carried out by him with no additional charge to the government.

5.11. Service and Maintenance Records

5.11.1. The Contractor shall provide a service and maintenance record book for the complete internal cold water and sanitary plumbing system being serviced and maintained by the Contractor. This record book shall be kept in the plant or maintenance room of internal cold water and sanitary plumbing system being serviced and maintained, and brief details of all services, maintenance and repairs carried out The address and telephone number of the Contractor's personnel and person in charge shall also be recorded into this record book to facilitate emergency service call.

5.11.2. The Contractor shall also keep an accurate detailed record in duplicate of all service, maintenance and repair work carried out by him on the complete internal cold water and sanitary plumbing system as well as ancillary equipment. This record shall be in the form of a Maintenance/Repair Sheet, and shall be countersigned by the S.O. each

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time the internal cold water and sanitary plumbing system as well as ancillary equipment is attended to by the Contractor.

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APPENDIX X1

Limit of Mechanical Scope of Design (Civil and Mechanical)

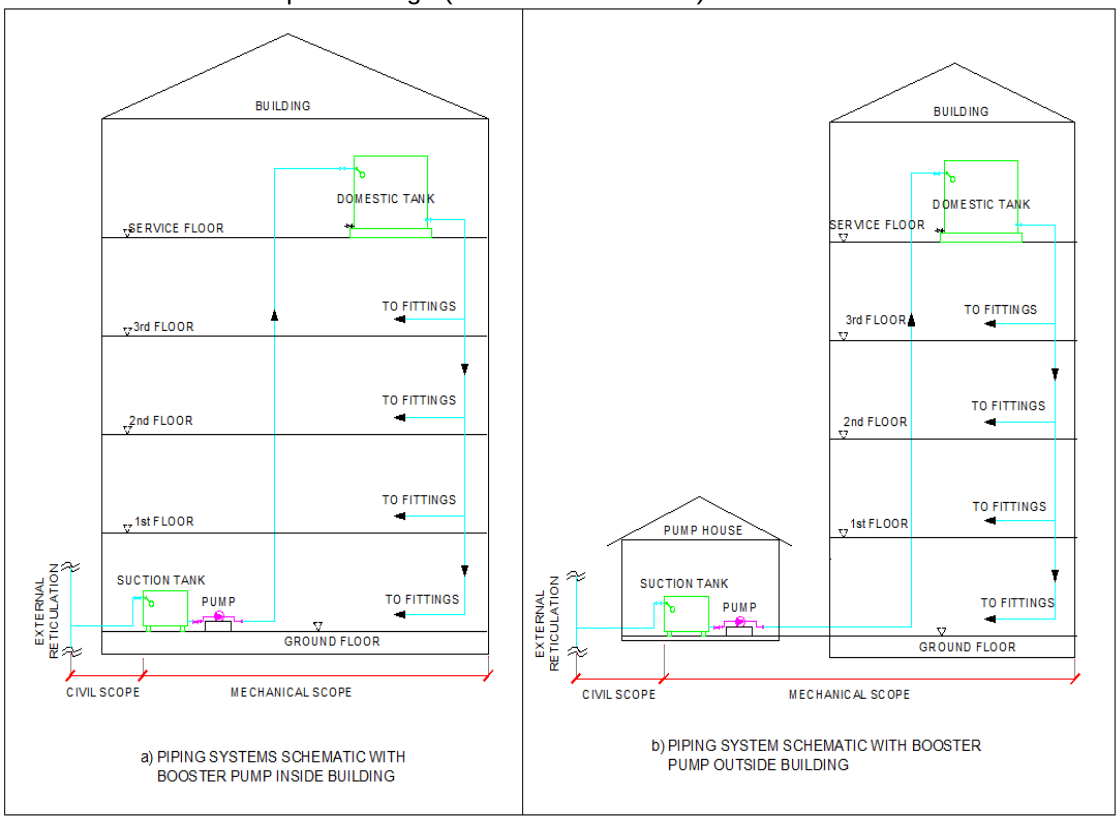


Figure X1. Indirect Feed System

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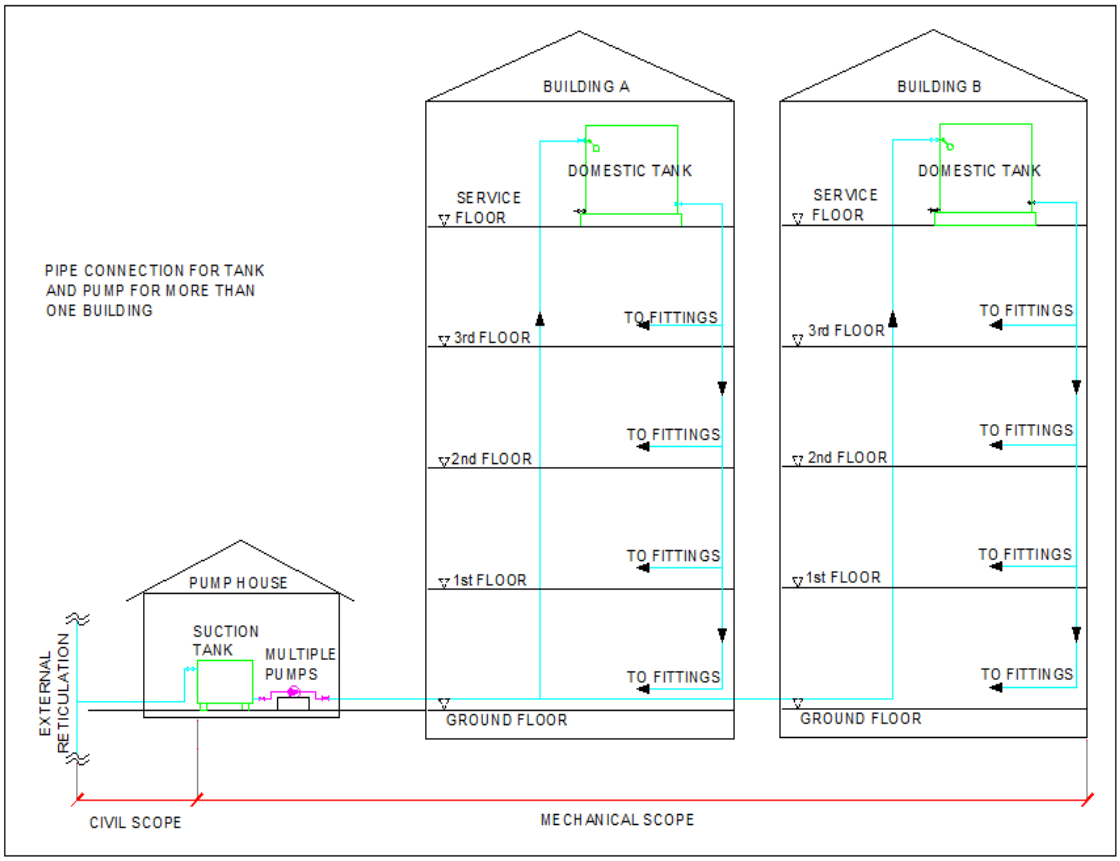


Figure X2. Pumping to Multiple Building Blocks

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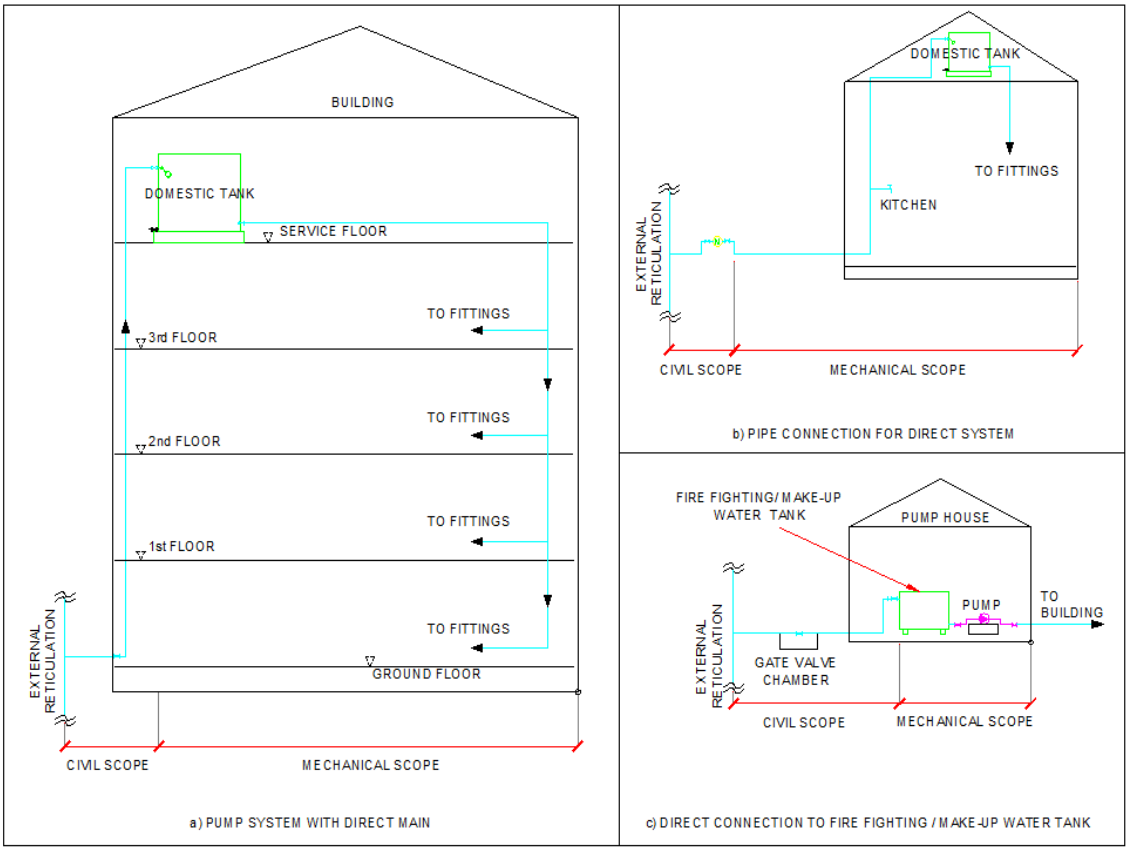


Figure X3. Direct Feed from Main Water Pipe

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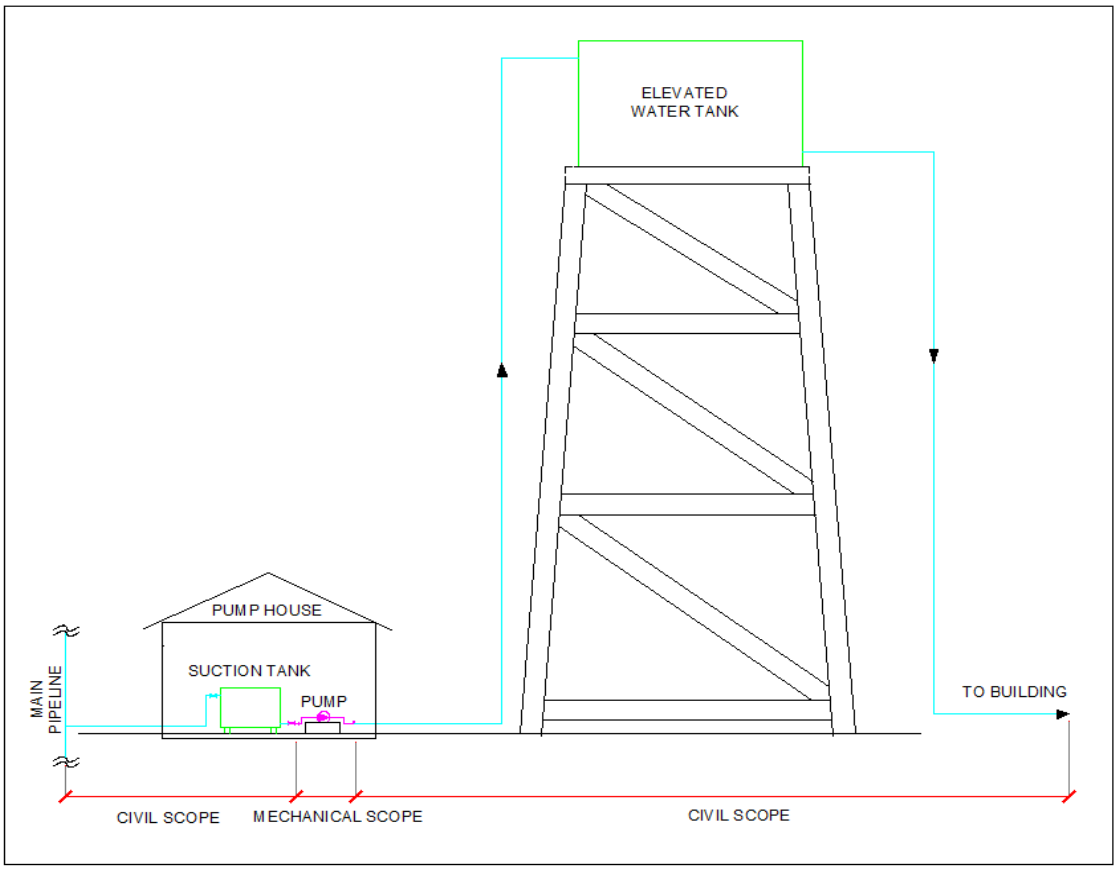


Figure X4. Pumping to Elevated Water Tank

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1. General

The sanitary fitting works shall be executed by personnel with valid permits issued by SPAN as stipulated under *Water Service Industry Act 2006*. The Contractor shall be responsible for employing such personnel and all the work performed by them.

2. Products and Materials

2.1. All products and materials to be incorporated in the work shall be new and unused. Materials to be used within the scope of work shall be those approved by SPAN. When the quality of a material or process is not specifically set forth in the approved products and materials list, the Drawings, or the Specifications, the best available quality of the material or process shall be provided, subject to the approval of the S.O..

2.2. All products and materials shall be supplied by suppliers registered with SPAN. The Contractor shall provide proof to the S.O. in the form of a valid Confirmation Letter or Certificate of Registration issued by SPAN to the supplier. The products and materials shall also be subjected to other terms and conditions mentioned in these specifications.

2.3. All products and materials shall be of the makes and models tested and approved for use. It is the Contractor's responsibility to verify that products and materials received for the job conform to the current approved products and materials supplied by SPAN registered suppliers.

2.4. All products and materials furnished shall be subject to inspection for compliance with these specifications and all other appropriate specifications. The Contractor shall make application to the S.O. for inspection at least five (5) days in advance of starting any work.

3. Sanitary Fittings

3.1. Fittings

3.1.1. Unless otherwise shown on the Drawings, all fittings including all necessary brackets and accessories shall be as scheduled in **TABLE Y/1** hereinafter. The Contractor shall be responsible for determining the type of trap required for each fitting. All necessary concrete backing shall be provided to fittings secured to floors.

3.1.2. Unless otherwise shown on the Drawings, the colour of sanitary ware shall be in white.

3.2. Vanity tops

3.2.1. Unless otherwise shown on the Drawings, a minimum thickness of 12mm vanity tops of approved manufacture and colour shall be installed in accordance with the manufacturer’s instructions. It shall be moulded as one solid piece with it’s top sloping gently towards the wash hand basin and having a slight upturn or kerb as its outer edges including backsplash to prevent water damage to wall and vanity back.

3.2.2. It shall be manufactured from non-porous composite product composed of polyester resin and calcium carbonate marble dust with the permanence

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of stone and an aesthetic appeal of natural marble or granite. The slab surface shall have a glossy finish and protected by suitable polymer to ensure durability and impermeability. It shall be stain- and chemical-resistant, and UV stabilised.

3.3. Type of Sanitary Fittings and Description

3.3.1. Unless otherwise shown or/and specified in the Drawings, the sanitary fittings shall be of the following:

3.3.1.1. All sanitary fittings shall be of white in colour, from an approved manufacturer, generally ensuite and complete with all necessary fittings.

3.3.1.2. Waste and bath overflow, chains and stays, shall be chromium plated brass to BS EN 274 Part 1-3.

3.3.1.3. Taps and combination tap assemblies shall be chromium plated brass to BS EN 200.

3.3.1.4. All sanitary fittings shall comply with Water Services Industry Act 2006 and Water Services Industry (Water Reticulation and Plumbing) Rules 2014.

3.4. Wash Basin

3.4.1. Unless otherwise specified, wash basin for public buildings shall be 600mm x 410mm x 200mm earthenware plain edge sink in white fireclay complete with chromium plated tap, blank tap hole stopper, 30mm ‘p’ trap with 40mm seal, waste fittings, plug with chain and painted bracket supports to S.O.’s approval.

3.4.2. Where shown wash basins shall be to MS 147 of the following types as specified:

3.4.2.1. Under counter basin with overflow.

3.4.2.2. Wall hung basin with or without pedestal as specified.

3.4.2.3. Semi-recessed basin with or without overflow as specified.

3.4.2.4. Counter top basin with or without overflow as specified.

3.4.2.5. Handicap basin.

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TABLE Y1: Sanitary Fittings

No.	Item	Description
1	Wash Basin	Wash basin for domestic purposes shall be 560mm x 410mm in approved colour vitreous china complete with chromium plated tap, blank tap hole stopper, 30mm 'p' trap with 40mm seal, waste fittings with chrome-plated brass pop up waste and painted bracket supports. Clinical wash hand basins shall be wall hung vitreous type and not less than 600mm in width complete with a wall mounted 175mm long elbow action lever mixer with premix function. Clinical wash hand basins shall not have any overflow outlet, soap recess nor basin plug.
2	Vanity tops	Vanity top as specified, with integrated sink as shown in the Drawings, complete with chromium-plated tap, blank tap hole stopper, 30mm 'p' trap with 40mm seal, waste fittings with chrome-plated brass pop up waste. Vanity top as specified, but with holes pre-punched to receive an under-counter vanity basin and tap respectively, as shown in the Drawings, complete with 555mm x 415mm under-counter vanity basin in vitreous china, complete with chromium-plated tap, 30mm 'p' trap with 40mm seal, waste fittings with chrome-plated brass pop up waste and painted bracket supports.
3	Sinks	915mm x 460mm, single bowl single drainer stainless steel sinks shall be to BS 1244, stainless steel grade 304 (0.8 to 0.9mm) minimum thick, with satin finish to the size and configuration shown on the drawings with overflow and sound deadening pads under the sink and drainers. Metal sinks in stainless steel to size and shape as shown in the Drawings, complete with chromium plated tap as required, 40mm waste water outlet, chrome-plated brass pop up waste and painted mild steel frames support.
4	Water closet	Unless otherwise specified, water closet shall be pedestal closet in white vitreous china conforming to MS 1522 complete with pedestal pan, 'p' trap and ventilation outlet, plastic hinged seat and rubber buffers. Squatting closet in white vitreous china conforming to MS 1522 complete with pair of raised foot treads in white fire clay with 'p' trap and 40mm diameter uPVC flush pipe.
5	Urinal	Single urinal bowl in white vitreous china conforming to MS 1799 and MS 147 complete with back inlets, hangers and steadying brackets, 40mm outlet with hinged gratings and 50mm uPVC waste pipe, chromium plated flush pipes and spreaders to suit the number of appliances. Urinal range of 2 or more bowls as (a) but with white vitreous china division between bowls.

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		Urinal shall give a single flush of not exceeding 2.5 litres per stall or per 600 millimetres width of slab and not exceeding 2.5 litres for wall hung urinals in compliance with Water Services Industry Act 2006 and Water Services Industry (Water Reticulation and Plumbing) Rules 2014.
6	Cistern for Water Closet	Dual-flush cistern with a nominal volume of a full and partial flush not exceeding 6 and 3 litres respectively in compliance with Water Services Industry Act 2006 and Water Services Industry (Water Reticulation and Plumbing) Rules 2014. WC Cistern shall conform to MS 795 with 40mm flush pipe, water inlet valve, 20mm diameter overflow for discharge externally and chrome flushing lever handle. WC shall be of vitreous china cistern conforming to MS 795 with 40mm flush pipe, water inlet valve, 20mm diameter overflow for discharge externally and chromed lever handle. Each flush cistern for w/c shall be tested as stipulated in the requirements of MS 795.
7	Cistern for urinal	Single flush 2.5 litre urinal flushing cistern in white vitreous china conforming to MS 795 complete with chromium plated flushing inlet pipe, 20mm diameter overflow for discharge externally and chrome lever handle in compliance with Water Services Industry Act 2006 and Water Services Industry (Water Reticulation and Plumbing) Rules 2014.
8	Flush valve for Water Closet	Unless specified, W/C flush valve shall be low pressure single flush 6 litres gravity flush water closet valve. It shall have a non-hold-open feature or an automatic shut-off system in compliance with Water Services Industry Act 2006 and Water Services Industry (Water Reticulation and Plumbing) Rules 2014. Vacuum Breaker is optional, only applicable to w/c flush valves intended to be connected to direct potable water mains. Its performance requires proper match of valve and w/c pan conforming to MS 1522. Each flush valve shall be made of metal (preferably copper alloy) and corrosion resistant. All exposed surfaces to the users shall be chromed plated or made of stainless steel.
9	Flush valve for urinal	Urinal flush valve shall be Single flush 2.5 litres gravity flush valve. It shall have a non-hold-open feature or an automatic shut-off system in compliance with Water Services Industry Act 2006 and Water Services Industry (Water Reticulation and Plumbing) Rules 2014. Each urinal flush valve shall be made of metal (preferably copper alloy) and corrosion resistant. All exposed surfaces to the users shall be chromed plated or made of stainless steel.

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10	Shower fittings	Shower fittings shall be approved chromium plated brass easy clean valve, with 3" diameter shower face and Chromium plated stainless steel grade 304 arm.
11	All types of taps	Unless otherwise specified, taps shall be approved chromium plated brass/ ABS chrome plated taps conforming to BS EN 200 - testing method and have SIRIM certification with minimum 5 years warranty. All taps shall be fitted with aerator in compliance with Water Services Industry Act 2006 and Water Services Industry (Water Reticulation and Plumbing) Rules 2014.
12	Hand Bidet	Unless otherwise specified, bidet shall be chromium plated copper alloy nozzle, 1.2 m heavy duty double interlock stainless steel grade 304 flexible hose, chromium plated ABS plastic wall hanger and quarter turn angle valve. OR Bidet shall be chromium plated ABS nozzle with 1.2 m heavy duty ABS flexible hose, chromium plated ABS plastic wall hanger and quarter turn angle valve.
13	Sanitary appliances	Unless otherwise specified or shown on the Drawings, the sanitary appliances shall be: Floor trap, Robe Hook, Towel Rail, Safety Grab Bar and Handicap Safety Grab Bar shall be in stainless steel grade 304 chrome plated. Soap Dispenser shall be in uPVC (LEAD-FREE). Soap holder and toilet roll holder shall be in white earthenware (ceramic).

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